LEED® Canada
Reference Guide for Green Building Design and Construction 2009

LEED® Canada

CANADA GREEN BUILDING COUNCIL • CONSEIL DU BÂTIMENT DURABLE DU CANADA •

PREFACE FROM THE CAGBC

The built environment has a profound impact on our natural environment, economy, health, and productivity. Breakthroughs in building science, technology, and operations are now available to designers, builders, operators, and owners who want to build green and maximize both economic and environmental performance.

The green building movement offers an unprecedented opportunity to respond to the most important challenges of our time, including global climate change, dependence on non sustainable and expensive sources of energy, and threats to human health. The work of innovative building professionals is a fundamental driving force in the green building movement. Such leadership is a critical component to achieving the Canada Green Building Council's (CaGBC's) vision of a transformed built environment leading to a sustainable future.

CaGBC Membership

The CaGBC's greatest strength is the diversity of our membership. CaGBC is a balanced, consensus based not-for-profit with more than 2,300 member companies and organizations. Since its inception in 2002, CaGBC has played a vital role in providing a leadership forum and a unique, integrating force for the building industry. CaGBC's programs have three distinguishing characteristics:

Committee-based

The heart of this effective coalition is our committee structure, in which volunteer members work with staff and expert consultants to design and implement strategies. Our committees provide a forum for members to resolve differences, build alliances, and forge cooperative solutions for influencing change in all sectors of the building industry.

Member-Driven

Membership is open and balanced and provides a comprehensive platform for carrying out important programs and activities. We target the issues identified by our members as the highest priority. We conduct an annual review of achievements that allows us to set policy, revise strategies, and devise work plans based on members' needs.

Consensus-Focused

We work together to promote green buildings and, in doing so, we help to foster greater economic vitality and environmental health at lower costs. We work to bridge ideological gaps between industry segments to develop balanced policies and programs that benefit the entire industry.

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*Credit not applicable to all Rating Systems, please refer to the credit for more details.

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INTRODUCTION

I. WHY MAKE YOUR BUILDING GREEN?

The environmental impact of the building design, construction, and operations industry is enormous. Green building practices can substantially reduce or eliminate negative environmental impacts through high-performance, market-leading design, construction, and operations practices. As an added benefit, green operations and management reduce operating costs, enhance building marketability, increase workers' productivity, and reduce potential liability resulting from indoor air quality problems.

Throughout this reference guide, information is presented on the environmental impact buildings can have as well as practical solutions to limit negative impacts. As well, case studies of high performing buildings are shown as real world examples.

BENEFITS OF GREEN BUILDINGS

Green buildings are superior to their conventional counterparts; typically including features such as:

- Landscaping that requires little or no irrigation or application of synthetic chemicals, manages and treats stormwater and non-point-source pollution onsite, and replenishes groundwater supplies.
- Locations that support efficient travel options for building users.
- Durable, thermally efficient roofs, walls and windows that reduce heating and cooling and enhance thermal comfort.
- Building form, orientation and thermal mass optimized for solar gains, natural ventilation and daylighting for free heating, cooling, ventilation and lighting.
- Significantly smaller and more efficient HVAC and electrical lighting systems.
- Water efficient supply and waste fixtures.
- Adaptable interior designs, providing visual access to the outdoors and access to daylight.
- Interior finishes and installation methods having lower toxic emissions.

Throughout their lifecycle, green buildings use less energy and water, generate less greenhouse gases and other pollutants, use materials wisely, and produce less waste. They cost less to operate, are more adaptable to new uses and typically have longer economic lives. Occupants are more comfortable in green buildings with their excellent ventilation, thermal comfort, and abundant natural light. Green buildings are healthier for occupants and workers who process building materials, by minimizing use of materials made with harmful chemicals and indoor air pollutants, and reducing the risks of biological contamination. The satisfaction and lives of occupants are greatly enhanced by providing restorative views, plentiful outdoor air, and greater personal control of internal conditions. Providing healthy indoor environments reduce sick building syndrome as well as the risks of litigation. A growing body of research links the high quality indoor environments of green buildings to gains in productivity, decreased absenteeism and improved employee morale. Green design has environmental, economic, and social benefits for all stakeholders, including owners, occupants and the general public. Green buildings are essential to support sustainable patterns of living.

II. LEED® GREEN BUILDING RATING SYSTEM

BACKGROUND ON LEED

Growing awareness and concern with the environmental and health impacts of buildings in Canada has led to widespread demand for a common method of independently certifying the merits of a given building. In response to this demand, the Canada Green Building Council (CaGBC) has adapted several rigorous Canadian green rating systems based on the U.S. Green Building Council's (USGBC) LEED® system. The aim has been to create rating tools that both recognize high health, energy and environmental performance, while being practical and easy to apply by Canadian building projects.

The first LEED rating system adapted for Canada-wide use was the *LEED® Canada for New Construction and Major Renovations version 1.0*, launched in December 2004. This system was adapted from the USGBCs *LEED for New Construction and Major Renovations* version 2.1 (2002), tailored specifically for Canadian climates, construction practices and regulations. This first version also incorporated planned changes for the release of USGBC's *LEED for New Construction and Major Renovations* version 2.2 in 2005. In 2007, the CaGBC released an addendum to the *LEED Canada for New Construction and Major Renovations* version 1.0 Rating System and Reference Guide, introducing new compliance paths and adaptations from the release of USGBC's *LEED for New Construction and Major Renovations* version 2.2, as well as incorporating changes based on the experience of Canadian users.

The USGBC released *LEED for Core and Shell* version 2.0 in 2006 after a pilot. Due to its similarities to *LEED for New Construction and Major Renovations*, CaGBC released the new rating system as an adaptation to *LEED Canada for New Construction and Major Renovations* version 1.0 in 2008. This allowed an expedited release process and allowed building owners to switch between rating systems if tenant expectations change.

In 2009, the USGBC re-launched its suite of rating systems and aligned *LEED for New Construction and Major Renovations* (NC) and *LEED for Core and Shell Development* (CS) into one reference guide. The CaGBC is following suit and re-launching *LEED Canada NC 2009* and *LEED Canada CS 2009*, merged not only in one rating system document but also in this reference guide for ease of use.

LEED Canada for New Construction and Major Renovations 2009 and *LEED Canada for Core and Shell Development 2009* also incorporates CaGBC's application guides on the previous versions:

- Application Guide for Multi-Unit Residential Buildings in LEED Canada-NC (September 2005),
- Application Guide for Campuses and Multiple Building Projects in LEED Canada-NC (February 2008),
- Application Guide for Core and Shell Buildings and Leased Tenant Space in LEED Canada-NC (July 2008).

By incorporating these application guides into one package, it provides for a far more streamline approach for users.

The green design field is growing and changing daily. New technologies and products are coming into the marketplace, and innovative designs are proving their effectiveness. The rating systems and the reference guides are evolving as well. Teams wishing to certify their projects with LEED must use the version of the rating system that is current at the time of their registration. CaGBC highlights new developments on its website on a continual basis; see www.cagbc.org.

FEATURES OF LEED®

The LEED Green Building Rating Systems are voluntary, consensus-based, and market-driven. Based on existing and proven technology, they evaluate environmental performance from a whole building perspective over a building's life cycle, providing a definitive standard for what constitutes a green building in design, construction, and operation.

The LEED rating systems are designed for rating new and existing commercial, institutional, and residential buildings. They are based on accepted energy and environmental principles and strike a balance between known, established practices and emerging concepts. Each rating system is organized into 5 environmental categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality. An additional category, Innovation in Design (or Operations), addresses sustainable building expertise as well as measures not covered under the 5 environmental categories. Regional bonus points are another feature of LEED and acknowledge the importance of local conditions in determining best environmental design and construction practices.

THE LEED CREDIT WEIGHTINGS

In LEED 2009, the allocation of points between credits is based on the potential environmental impacts and human benefits of each credit with respect to a set of impact categories. The impacts are defined as the environmental or human effect of the design, construction, operation, and maintenance of the building, such as greenhouse gas emissions, fossil fuel use, toxins and carcinogens, air and water pollutants, and indoor environmental conditions. A combination of approaches, including energy modeling, life-cycle assessment, and transportation analysis, is used to quantify each type of impact. The resulting allocation of points among credits is called credit weighting.

LEED 2009 uses the U.S. Environmental Protection Agency's TRACI[1] environmental impact categories as the basis for weighting each credit. TRACI was developed to assist with impact evaluation for life-cycle assessment, industrial ecology, process design, and pollution prevention. LEED 2009 also takes into consideration the weightings developed by the National Institute of Standards and Technology (NIST); these compare impact categories with one another and assign a relative weight to each. Together, the 2 approaches provide a solid foundation for determining the point value of each credit in LEED 2009.

The LEED 2009 credit weightings process is based on the following parameters, which maintain consistency and usability across rating systems:

- All LEED credits are worth a minimum of 1 point.
- All LEED credits are positive, whole numbers; there are no fractions or negative values.
- All LEED credits receive a single, static weight in each rating system; there are no individualized scorecards based on project location.
- All LEED rating systems have 100 base points; Innovation in Design (or Operations) and Regional Priority credits provide opportunities for up to 10 bonus points.

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[1] Tools for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI). U.S. Environmental Protection Agency, Office of Research and Development. http://www.epa.gov/nrmrl/std/sab/traci/.

Given the above criteria, the LEED 2009 credit weightings process involves 3 steps:

A reference building is used to estimate the environmental impacts in 13 categories associated with a typical building pursuing LEED certification.

The relative importance of building impacts in each category are set to reflect values based on the NIST weightings.[2]

Data that quantify building impacts on environmental and human health are used to assign points to individual credits.

Each credit is allocated points based on the relative importance of the building-related impacts that it addresses. The result is a weighted average that combines building impacts and the relative value of the impact categories. Credits that most directly address the most important impacts are given the greatest weight, subject to the system design parameters described above. Credit weights also reflect a decision by LEED to recognize the market implications of point allocation. The result is a significant change in allocation of points compared with previous LEED rating systems. Overall, the changes increase the relative emphasis on the reduction of energy consumption and greenhouse gas emissions associated with building systems, transportation, the embodied energy of water, the embodied energy of materials, and where applicable, solid waste.

The details of the weightings process vary slightly among individual rating systems. For example, *LEED Canada for Existing Buildings: Operations & Maintenance* includes credits related to solid waste management but *LEED Canada for New Construction and Major Renovations* does not. This results in a difference in the portion of the environmental footprint addressed by each rating system and the relative allocation of points.

USGBC's weightings process for each rating system is fully documented in a weightings workbook. The credit weightings process will be re-evaluated over time to incorporate changes in values ascribed to different building impacts and building types, based on both market reality and evolving scientific knowledge related to buildings. A complete explanation of the LEED credit weightings system is available on the USGBC website, at www.usgbc.org.

[2] Relative impact category weights based on an exercise undertaken by NIST (National Institute of Standards and Technology) for the BEES program. http://www.bfrl.nist.gov/oae/software/bees/.

III. OVERVIEW AND PROCESS

The *LEED Canada New Construction and Major Renovations* Green Building Rating System and the *LEED Canada for Core and Shell Development* Green Building Rating System are a set of performance standards for certifying the design and construction of commercial or institutional buildings and high-rise residential buildings of all sizes, both public and private. The intent is to promote healthful, durable, affordable, and environmentally sound practices in building design and construction.

Prerequisites and credits in *LEED Canada for New Construction and Major Renovations 2009* and in *LEED Canada for Core and Shell Development 2009* address 7 topics:

- Sustainable Sites (SS)
- Water Efficiency (WE)
- Energy and Atmosphere (EA)
- Materials and Resources (MR)
- Indoor Environmental Quality (IEQ)
- Innovation in Design (ID)
- Regional Priority (RP)

LEED prerequisites and credits have identical structures; see Section XI of this introduction.

MINIMUM PROGRAM REQUIREMENTS

There are seven Minimum Program Requirements for projects certifying under *LEED Canada for New Construction and Major Renovations 2009* and under *LEED Canada for Core and Shell Development 2009*. These must be adhered to by all projects. See Section IV of this Introduction for more details.

WHEN TO USE LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS

LEED Canada for New Construction and Major Renovations was designed primarily for new commercial office buildings, but it has been applied to many other building types by LEED practitioners. All commercial buildings, as defined by standard building codes, are eligible for certification as *LEED Canada for New Construction and Major Renovations* buildings. Examples of commercial occupancies include offices, institutional buildings (libraries, museums, churches, schools, etc.), hotels, and multi-unit residential buildings (MURBs) other than those covered by Part 9 of the National Building Code. MURBs under Part 9 of the National Building Code and single-occupancy residential buildings wishing to obtain a LEED certification, should apply under *LEED Canada for Homes 2009*. However, Part 9 buildings that are a part of mixed-use projects in which the majority of the floor area is eligible for *LEED Canada for New Construction and Major Renovations certification* are allowed to be part of the latter project. Note that there is no separate LEED for Schools rating system in Canada. Instead schools wishing to obtain LEED certification for new buildings must apply under *LEED Canada for New Construction and Major Renovations*. Some special allowances for schools have been noted within the credits.

LEED Canada for New Construction and Major Renovations addresses design and construction activities for both new buildings and major renovations of existing buildings. For a major renovation of an existing building, *LEED Canada for New Construction and Major Renovations* is the appropriate rating system; refer to the "How to apply as a major renovation" section below for important details. If the project scope does not involve significant design and construction activities and focuses more on operations and maintenance activities, *LEED Canada for Existing Buildings: Operations &*

Maintenance is more appropriate because it addresses operational and maintenance issues of working buildings. If the project's scope is mostly limited to interior renovations, *LEED Canada for Commercial Interiors* is more appropriate. It is the responsibility of the applicant to ensure the project can achieve all prerequisites and sufficient credits for certification when selecting an appropriate rating system to use.

Some projects are designed and constructed to be partially occupied by the owner or developer, and partially occupied by other tenants. In such projects, the owner or developer has direct influence over the portion of the work that they occupy. For such a project to pursue *LEED Canada for New Construction and Major Renovations* certification, at least 50% of the building's floor area must be fit-up for the certification application. Projects in which 50% or less of the building's floor area is fit-up (and is not under the design and construction control of the owner or developer) should pursue *LEED Canada for Core and Shell Development* certification.

WHEN TO USE LEED CANADA FOR CORE AND SHELL DEVELOPMENT

The *LEED Canada for Core and Shell Development* Rating System is a market-specific application that recognizes the unique nature of core and shell development. The *LEED Canada for Core and Shell Development* Rating System acknowledges the limited level of influence a developer can exert in a speculatively developed building.

LEED Canada for Core and Shell Development was developed to serve the speculative development market, in which project teams do not control all scopes of a whole building's design and construction. Depending on how the project is structured, this scope can vary significantly from project to project. *The LEED Canada for Core and Shell* Rating System addresses a variety of project types and a broad project range.

LEED Canada for Core and Shell Development can be used for projects in which the developer controls the design and construction of the entire core and shell base building (e.g., mechanical, electrical, plumbing, and fire protection systems) but has no control over the design and construction of the tenant fit-up. Examples of this type of project can be a commercial office building, medical office building, retail center, warehouse, and lab facility.

If a project is designed and constructed to be partially occupied by the owner or developer, then the owner or developer has direct influence over that portion of the interior build-out work. For these projects to pursue *LEED Canada for Core and Shell Development* certification, the owner must occupy 50% or less of the building floor area. Projects in which more than 50% of the building floor area is occupied by an owner should pursue *LEED Canada for New Construction and Major Renovations* certification.

Note that the final project name must reflect the Core and Shell building rather than the tenant space, even if it is included in the common name of the building. The tenant space must not appear to be certified under LEED Canada if it in fact has not been. For example, a developer creates a small building which eventually houses a bank and a coffee shop. Since fit-up for the core and shell project did not include those tenant spaces, the LEED project title may not indicate the name of the bank and coffee shop.

HOW TO APPLY WITH LEASED TENANT SPACES UNDER LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS

Although *LEED Canada for Core and Shell Development* is designed specifically for projects with leased tenant space where the owner cannot control the fit-up (i.e., interior build-out work), projects with leased tenant space can still apply for *LEED Canada for New Construction and Major Renovations* certification as noted above. The following conditions have to be met for projects applying for *LEED Canada for New Construction and Major Renovations* certification:

- the base building and all interior areas to be occupied by the owner or developer must be fit-up to comply with the *LEED Canada for New Construction and Major Renovations* requirements;
- at least 50% of the building area must be fit-up to *LEED Canada for New Construction and Major Renovations* requirements before the project applies for certification; and,
- the remaining leased tenant space must have mandatory lease agreements that require the fit-up of tenant spaces to comply with the *LEED Canada for New Construction and Major Renovations* requirements. An exemption may be allowed for up to 10% of the building floor area, or 20% in the case of mixed-use projects.

The 10% fit-up exemption recognizes the difficulty in getting multiple tenants to comply with LEED requirements. However, this exemption is extended to 20% for mixed-use projects, recognizing the complexities and barriers that mixed-use projects face. Note that the exemption does not apply to base building elements and special directions are provided for specific credits where tenant use must be accounted for, such as WE Credit 3 (Water Use Reduction).

Tenant spaces are evaluated in their entirety on a tenant-by-tenant basis. That is, the 10% (or 20%) exemption must be applied to an entire tenant space(s) and cannot be made up of portions within tenant space(s). Furthermore, the tenant space(s) selected for demonstrating LEED compliance must be the same across all LEED credits.

For areas fit-up for the certification application (i.e., at least 50% of the building floor area), the submission demonstrates compliance through the submittal requirements as outlined in the LEED Letter Templates and as noted through the specific prerequisites and credits. However, for unfinished space, compliance must be demonstrated through Tenant Lease or Sales Agreements (i.e., mandatory lease agreements), along with a letter from the owner showing commitment to use those lease agreements. See the Interpretation sections of applicable prerequisites and credits for further guidance as well as the Leased Tenant Space Appendixes. Independent verification of construction documents or activities by a LEED Accredited Professional, although encouraged, is not required.

Projects with leased tenant space should review the Leased Tenant Space Appendixes, described briefly in Section X of this Introduction.

HOW TO APPLY WITH LEASED TENANT SPACES UNDER LEED CANADA FOR CORE AND SHELL DEVELOPMENT

For projects to pursue *LEED Canada for Core and Shell Development* certification, the owner must be unable to control the fit-up for 50% or more of the building floor area. However these two requirements must still be met:

- the base building and all interior areas to be occupied by the owner or developer must be fit-up to comply with the *LEED Canada for New Construction and Major Renovations* requirements; and,

- any materials installed as part of the base building contract in leased tenant spaces must comply with the *LEED Canada for Core and Shell Development* requirements. Otherwise the fit-up of leased tenant spaces are exempt from most LEED credit requirements (see the Leased Tenant Space Appendixes for further details on project scope as well as direction within the prerequisites and credits).

LEED Canada for Core and Shell Development project teams should review the Leased Tenant Space Appendixes, described briefly in Section X of this Introduction.

HOW TO APPLY AS A MAJOR RENOVATION UNDER LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS

A "major renovation" to an existing building includes extensive alteration work in addition to work on the exterior shell of the building and/or primary structural components and/or the core and peripheral MEP (mechanical – electrical – plumbing). Typically, the extent and nature of the work is such that the primary function space cannot be used for its intended purpose while the work is in progress and where a new certificate of occupancy is required before the work area can be reoccupied. If the project does not meet this definition, it may be more appropriate for the project to certify under *LEED Canada for Existing Buildings: Operations & Maintenance* or under *LEED Canada for Commercial Interiors*. It is the responsibility of the applicant to ensure the project can achieve all prerequisites and sufficient credits for certification when selecting an appropriate rating system to use. The overall project narrative in the submission for application should clearly outline how the project meets this definition of a major renovation.

HOW TO APPLY AS A LEED MULTIPLE BUILDING PROJECT

A LEED Multiple Building Project is a project made up of several buildings sharing a campus that wish to apply for LEED certification as if they are a single building. The overall project narrative in the submission for application should clearly outline how the project meets the conditions noted.

For Multiple Building Projects to be eligible to certify as a single building they must:

- Be designed by the same team (minor variations are permitted);
- Be constructed by the same team (minor variations are permitted);
- Be constructed concurrently or consecutively;
- Be part of a Campus-like site (i.e., share a single site);
- Share hard & soft landscape surfaces, open space and parking; and,
- Have LEED documentation completed as if they were a single building.

Note:

- When multiple buildings are treated as one project, the prerequisite or credit requirements need only be met at the project level, not at the individual building level (e.g., the energy cost of the individual buildings are added together to show compliance to EA Prerequisite 2 Minimum Energy Performance).
- Throughout this reference guide, the "LEED project" is often referenced as the "LEED building." For the case of a multiple building project, instances where "LEED building" is used may be interpreted as "LEED project."

HOW TO APPLY USING THE CAMPUS APPROACH

It is recognized that LEED projects may be part of a larger campus with shared amenities. *LEED Canada for New Construction and Major Renovations 2009* and *LEED Canada for Core and Shell Development 2009* provide special allowance pathways for these projects primarily through the Requirement sections of the Prerequisites and Credits.

The use of the term "campus" is not solely for university campus projects. For LEED Canada, projects may apply under campus allowances in settings such as corporate, military, institutional or private sites that are under single ownership or property management control. A campus may include existing buildings, new or major renovations of buildings pursuing LEED certification, and new or major renovations of buildings not pursuing LEED certification.

The campus boundaries that are being used for credit achievement may be defined by the applicant for the purposes of certification, and its boundaries need not include the entire portfolio of existing buildings owned or controlled by an organization, but rather may be part of a larger site of which a portion is being developed (e.g., LEED-certified buildings in a small precinct of a full university or office park). In addition, the campus site chosen for a credit need not be consistent with the campus application for a separate credit. For example, the campus site boundary used under SS Credit 1 (Site Selection) may be a much larger area then that used to achieve SS Credit 3 (Brownfield Redevelopment).

The campus allowances are intended to reduce environmental impact by encouraging owners and developers to take a broader approach to green infrastructure and project development. Green features developed on a district scale have, potentially, far greater environmental benefit over small-scale features on individual disconnected sites. In addition, the campus allowances can provide for improved efficiency for both applicants and LEED review teams with repetitive or shared LEED elements within a campus.

Many site related credits have campus-wide compliance paths which can be used to demonstrate that the entire defined campus achieves the credit. Projects can apply for a campus-wide precedent on the LEED Letter Templates when the first project of the campus is submitted for certification. If the credit is achieved for the campus, subsequent projects on that campus need only indicate the CaGBC project ID number of the initial project to achieve the credit and a declaration that the submission has not changed since that achievement. This simplifies the application for campus projects. An example of this situation is SS Credit 1 (Site Selection) where the entire campus can achieve the requirements campus-wide.

However, there are additional interpretations for campuses that pertain to sharing infrastructure or to handling specific campus elements, such as exclusion of primary roads in a campus for select credit achievement. For more information on these allowances, see the Interpretation section of the credits. Sharing of energy-related systems is handled separately in the *LEED Canada Interpretation Guide for District Energy Systems*.

REGISTRATION

Project teams interested in earning LEED Canada certification for their buildings must first register the project with the CaGBC. Projects can be registered on the CaGBC website (www.cagbc.org). Registering early in the development process ensures the maximum potential for achieving high building performance, and establishes contact with the CaGBC.

Registration of a *LEED Canada NC* or *LEED Canada CS* project provides online access to essential information, software tools and communications for LEED users, such as the LEED Canada NC / CS

Letter Templates and Scorecard spreadsheet, and allows the team to submit Credit Interpretation Requests (CIRs).

The CaGBC website (www.cagbc.org) contains additional registration details as well as the online form used to register projects.

CERTIFICATION SUBMITTAL DOCUMENTATION

Once a project is registered and design begins, teams should also begin to collect information and perform calculations to ensure that the project meets the requirements for the prerequisites and credits. Once submitted to the CaGBC, this documentation becomes the proof behind declarations made in the LEED certification application.

It is best to start and continue preparing LEED certification submittals from project onset, having reviewed this reference guide and the LEED Letter Templates spreadsheet for each prerequisite and credit, to understand the information required and the formats that will satisfy LEED Canada prerequisite and credit certification review. Note that additional documentation may be necessary to demonstrate credit achievement if applying an interpretation from this reference guide, if using a Credit Interpretation Request, or under any other special circumstance. Project teams must provide narratives to cover these special allowances, as well as any supporting documentation that would assist in demonstrating achievement.

It is helpful to have a LEED consultant (who has achieved a LEED Accredited Professional designation) assigned as the project contact and team member responsible for coordinating the certification process. Most project team members have submittals to prepare, and having an experienced LEED Accredited Professional designated to assist and coordinate efforts has proven to make the process much easier and more efficient.

LEED LETTER TEMPLATES

The LEED Letter Templates are the primary resource for managing the LEED Canada documentation process. The LEED Letter Templates provide a tool for project teams to manage project details; verify compliance with and complete documentation requirements for LEED credits and prerequisites; and provide professional declarations of achievement. The LEED Letter Templates are ultimately submitted with applications for LEED certification. All project teams pursuing LEED certification are required to use the LEED Letter Templates and the submittal documentation paths outlined within. LEED Letter Template submittals are instrumental in demonstrating credit compliance because they contain all the documentation requirements for any given LEED credit. Additionally, the LEED Letter Templates contain embedded calculators and tables to ensure that the submittal package delivered to CaGBC is complete and accurate.

The LEED Letter Templates must be signed by the individual responsible for the portion of the design or construction referred to by the credit or prerequisite. The signatory should be knowledgeable of the prerequisite or credit requirements and by signing certifies that the project meets those requirements. The intention is for the individual who performed the calculations to sign rather than the company signatory or overall LEED Consultant. The LEED Letter Templates default to the project team member who most regularly would meet these criteria. A single signatory for the entire LEED Letter Template package is not acceptable.

CREDIT INTERPRETATION REQUESTS AND RULINGS

In some cases, a LEED project team may encounter challenges when interpreting the requirements of a prerequisite or credit for their project, perhaps because the reference guide does not sufficiently address a specific issue or a conflict requires resolution. To address such issues, the CaGBC allows project teams to submit Credit Interpretation Requests (CIRs).

Each CIR must request guidance on a single credit or prerequisite (unless there is technical justification to do otherwise). CIRs should contain one concise question. Once a response to a CIR is posted, it is applicable to all projects submitting for certification thereafter, regardless of the project's registration date.

CIR rulings are intended to provide assistance to project teams by clarifying credit requirements and/or providing acceptable alternate compliance paths that meet the credit's intent. Project teams may implement CIR rulings at their discretion.

The credit interpretation process is as follows:

1. Before submitting a CIR:
   a. Review the intent of the credit or prerequisite in question and self-evaluate whether the project meets this intent.
   b. Consult this reference guide for more detailed explanation, instructions, calculations and guidance.
   c. Review the CIR database on the CaGBC website (www.cagbc.org) to see if the same inquiry has been answered previously, or if there are relevant CIRs that can help you deduce the answer. Many questions can be resolved by reviewing existing CIRs. Note:
      - CIR rulings for other rating systems, previous versions of rating systems and from the USGBC are not necessarily applicable.
      - This reference guide incorporated all appropriate CIR rulings from *LEED Canada NC version 1.0* posted by August 2009.
2. If a CIR is needed, submit a new credit interpretation request using the online form. Guidance for submitting a CIR can be found on the CaGBC website (www.cagbc.org).

Credit interpretation rulings do not guarantee credit award; the project applicant must still demonstrate and document achievement during the LEED Certification application process.

Credit language or achievement thresholds cannot be changed through the CIR process.

A project applying any CIR must note that CIR number on the LEED Letter Template in their submission declaration in order to ensure effective credit review. Include any supporting documentation necessary to support use of the CIR.

REVIEW AND CERTIFICATION

To earn LEED certification, the project must satisfy all the prerequisites and credits worth the minimum number of points to warrant the desired project rating under *LEED Canada for New Construction and Major Renovations* or *Core and Shell Development*. (Note: Projects must meet all prerequisites and achieve 40 points from other credits before they may earn any points from Regional Priority credits.) Project teams are subject to the Rating System and Reference Guide addenda requirements based on the project's registration date. Rating System and Reference Guide addenda can be found on CaGBC's website (www.cagbc.org).

Applications for certification (submittals) should follow the requirements noted on the CaGBC website and within the *LEED Canada for New Construction and Major Renovations* or *LEED Canada for Core and Shell Development* Rating System, this reference guide and LEED Letter Templates.

FEES

Information on certification fees can be found on the CaGBC website (www.cagbc.org). The CaGBC will acknowledge receipt of the application and proceed with application review when all project documentation and payments have been submitted. Registration fees, certification fees, and appeal review fees are not refundable.

APPEALS

Appeals may be filed after receipt of the final review report. Please see the CaGBC website (www.cagbc.org) for more information on appeals.

UPDATES AND ADDENDA

This is the first edition of the *LEED Canada Reference Guide for Green Building Design and Construction 2009*, dated June 2010. As building science and technology continue to improve and evolve, updates and addenda will be made available. The CaGBC cannot be held liable for any criteria set forth herein that may not be applicable to later versions of LEED rating systems. Updates and addenda will be accumulated between revisions and will be formally incorporated in major revisions. In the interim, between major revisions, the CaGBC may issue updates or addenda to clarify criteria.

The prerequisites, credits, amendments and addenda current at the time of project registration will continue to guide the project throughout its certification process.

USES OF SUBMITTAL DOCUMENTATION AND INTELLECTUAL PROPERTY PROTECTION

CaGBC is committed to the furtherance of green building research and program development. Currently and in the future, such efforts rely heavily on the collection and distribution of data collected from green buildings. In consideration of this pressing need, as a condition to participation in the LEED certification process, project teams must agree to provide CaGBC ownership of all data and underlying information that is submitted to CaGBC in accordance with the LEED project requirements. This requirement does not include any plans, drawings, schema or designs submitted to CaGBC. In accordance with these property rights, CaGBC may share such data with third parties to further research pertaining in general to green buildings and in particular LEED Certified projects.

Project Teams must also provide CaGBC with authorization to provide all submitted information to third parties for the purposes of carrying out certification reviews, project credit interpretation requests and appeals as required to carry-out the LEED certification process.

Projects may elect to have their information kept confidential at any time, through their online project profile. Information from such projects will only be used in anonymous fashion, except where required for the purposes of performing certification.

IV. MINIMUM PROGRAM REQUIREMENTS (MPRS)

There are seven minimum program requirements for projects certifying under *LEED Canada for New Construction and Major Renovations 2009* and *LEED Canada for Core and Shell Development 2009*. These must be adhered to by all projects. If it becomes known that a LEED project is or was in violation of these minimum program requirements, certification may be revoked, or the certification process may be halted. These situations will be handled on a case-by-case basis by the CaGBC.

The Minimum Program Requirements (MPRs) are:

1. MUST COMPLY WITH ENVIRONMENTAL LAWS.

The LEED project building or space, all other real property within the LEED project site boundary, and all project work must comply with applicable federal, provincial, and local building-related environmental laws and regulations in place where the project is located. This condition must be satisfied from the date of LEED project registration or the commencement of schematic design, whichever comes first, up to and until the date that the building receives a certificate of occupancy or similar official indication that it is fit and ready for use.

The project must comply with all building-related environmental laws that impact that project. A lapse in a project's compliance with a building-related environmental law or regulation that results from an unforeseen and unavoidable circumstance shall not necessarily result in non-compliance with this requirement. Such lapses shall be excused so long as they are remediated as soon as feasibly possible.

In no way will CaGBC act as law enforcement. With this minimum requirement, CaGBC is using established laws only to ascertain that the LEED project is meeting a minimum environmental standard.

Intent:

- The purpose of this requirement is to highlight the importance of environmental laws and regulations that apply to LEED projects. While all building projects ought to comply with all legal requirements, as the LEED rating systems are standards for excellence in green building, it is appropriate and logical to specifically require LEED certified buildings to comply with applicable environmental laws and regulations. Such legislation establishes a baseline standard for sustainability.

Exceptions:

- If the project is granted an exemption from a building-related environmental law from governmental authorities for any reason, then that project is exempt from this minimum requirement in regards to that particular law. In the event that this occurs, a description of the situation leading to the exemption and proof of the exemption (such as an official letter from the granting authority) must be provided with the certification submission.

2. MUST BE A COMPLETE, PERMANENT BUILDING OR SPACE.

All LEED projects must be designed for, constructed on, and operated on a permanent location on already existing land. LEED projects shall not consist of mobile structures, equipment, or vehicles. No building or space that is designed to move at any point in its lifetime may pursue LEED Certification.

LEED Projects must include the new, ground-up design and construction, or major renovation, of at least one commercial, institutional, or high-rise residential building in its entirety.

Intent:

- The LEED rating systems were designed to evaluate complete buildings and spaces in fixed locations. Partial buildings or spaces are unsuitable for LEED certification because, when analyzed under the requirements of LEED prerequisites and credits, they create results inconsistent with those of whole buildings or spaces. Also, partial certification can easily appear to encompass an entire building or space, sending a false message to users.

- Permanency is an important requirement because a significant percentage of LEED prerequisites and credits are dependent on location, making a mobile building or space unacceptable. The stipulation for already existing land responds to the fact that artificial land masses disrupt marine ecosystems. Buildings that generate the need to develop such land do not meet the overall intent of the LEED rating system. Anything less than a distinct, complete, and permanent project on existing land will not be able to accurately demonstrate compliance with LEED.

Exceptions:

- Prefabricated or modular structures and moveable building elements of any variation may be certified once installed and/or established as part of the LEED project building. If such a structure is moved, the LEED certification no longer applies.
- Certification of temporary structures is permissible. The amount of time that a building or space is intended to remain standing does not affect compliance with this requirement.
- Artificial land mass or support structures:
    - o Buildings located on previously constructed docks, piers, jetties, infill, and other manufactured structures in or above water or other bodies are permissible, provided artificial land is previously developed, i.e., previously supported hardscape or another building before the development of the LEED project.
    - o Buildings cantilevered over water, highways, or other bodies are acceptable.
    - o Existing land to which soil or other material has been added is acceptable.
- Buildings vertically connected to, but physically distinct from public infrastructure such as a transportation hub, may be considered a building in its entirety and certified independently of the infrastructure.
- Horizontally and vertically attached buildings may be certified independently, provided the following conditions are met:
    - o They are physically distinct; i.e.,
        - Exterior walls are party walls or are separated from adjoining buildings by air space;
        - Lighting, HVAC, plumbing, and other mechanical systems are separate from the systems of adjoining buildings. If the thermal energy serving the structure

is to be sub-metered, exceptions will be made for buildings served by a common chiller plant or hot water/steam heating system.

- They have unique addresses or names.

If these conditions are not met, the structure is considered a single building and must be certified as such.

- Additions to existing buildings (defined as buildings completed five years prior to the new addition) may certify as independent structures even if the additions do not meet the above requirements for attached buildings. This is to encourage owners as they move forward with new developments where existing structures limit design approaches.

Additional Clarifications

- Moveable buildings
  - Structures not compliant with this MPR include cars, motor homes, trains, boats, ships, planes, and transient exhibits of any kind.
  - If, for any reason, a LEED Canada NC (or CS) 2009 certified building is moved from the location cited at the time of LEED certification, it will no longer be in compliance with this MPR.
- No exceptions for projects with IEQ Prerequisite 2 conflicts
  - Some project buildings, such as casinos, typically have difficulty achieving LEED certification due to a smoking policy that conflicts with IEQ Prerequisite 2 (Environmental Tobacco Smoke Control). There will be no exceptions to this MPR to allow for partial building certification of such buildings. Project teams are encouraged to carefully review option 2 in IEQ Prerequisite 2 to explore opportunities to achieve LEED certification despite a smoking room located within a project.

3. THE PROJECT MUST USE A REASONABLE SITE BOUNDARY.

The LEED project site boundary must include all contiguous land that is associated with and supports normal building operations for the LEED project building, including all land that was or will be disturbed for the purpose of undertaking the LEED project.

The LEED project site boundary may not include land that is owned by a party other than that which owns the LEED project unless that land is associated with and supports normal building operations for the LEED project building.

LEED projects located on a campus must have project boundaries reasonable to that project (e.g., the construction boundaries of the project).

Gerrymandering of a LEED project boundary is prohibited: the boundary may not unreasonably exclude sections of land to create boundaries in unreasonable shapes for the sole purpose of complying with prerequisites or credits.

Intent:

- In order to ensure fair and consistent evaluation for all projects under the Sustainable Sites credit category, it is necessary to have guidelines for an acceptable LEED project boundary.

Exceptions:

- Non-contiguous parcels may be included in the LEED project site boundary if the following conditions are met:
    - o The parcels are separated only by land that is owned and operated by an entity different than the owner of the land that the LEED project building sits on.
    - o All parcels separate from the parcel that the LEED building sits on must directly support or be associated with normal building operations.
    - o Non-contiguous parcels are no more than 0.40 kilometres (1/4 mile) walking distance apart.
    - o There is a clear walking path between the parcels.
    - o The site boundary is consistent for the application of all credits.
    - o All land within the LEED project site boundary is governed by a common regulatory jurisdiction and is owned, leased, or managed by the same organizational entity.
    - o A description is provided of the non-contiguous parcels of land within the LEED project site boundary, the land between them, and compliance with the above points.
- Land needed to demonstrate compliance with stormwater management need not be part of the LEED project site boundary but see SS Credit 6 for further details.
- Facilities needed to show compliance to a LEED credit but that exist offsite are individually handled within specific credits. However, the offsite facilities do not need to be within the LEED project site boundary.
- Land that the LEED project owner leases or has an easement on may be included within the LEED project site boundary.
- For projects with multiple phases of the same building, or buildings located on land that is part of an already certified LEED project, overlapping LEED project boundaries is inevitable and thus allowed. Note that the purpose of this exception is to protect the integrity of certified LEED projects while allowing the future projects to successfully pursue LEED certification. An example of protecting the integrity of an earlier LEED project is that the green space preserved under SS Credit 5 (Site Development) for the first project cannot be used for the second as it was already allocated to achieve this credit.
- Land which is covered by a city easement may be included in the LEED project site boundary.
- If a LEED project building shares use of a parking lot, parking garage, or other amenity with another building, then those amenities must be allocated according to the percentage of use for each building.
- Infrastructure supporting the LEED project building may be omitted from the LEED project boundary if it is not owned by the LEED project owner AND if it is not included in the scope of construction work for the LEED project. This omittance must be done consistently throughout the submission.

- Projects may exclude land used for construction staging areas that will not be used to support the LEED project building once operational. However, these areas must be included in the requirements for SS Prerequisite 1 (Construction Activity Pollution Prevention).
- Associated service buildings that do not meet the minimum project size noted in requirement #4 below do not need to be included in the LEED project site boundary.

4. THE LEED PROJECT MUST INCLUDE A MINIMUM OF 93 SQUARE METERS (1000 SQUARE FEET) OF BUILDING FLOOR AREA.

Intent:

- The thresholds and calculations that make up the system of evaluation in LEED begin to break down and lose meaning once the building or space being evaluated reaches relatively diminutive proportions. A building or space that is too small would compromise the integrity of the LEED certification system.

5. THE LEED PROJECT MUST COMPLY WITH MINIMUM OCCUPANCY RATES.

Full Time Equivalent Occupancy - The LEED project must serve 1 or more Full Time Equivalent (FTE) occupant(s), calculated as an annual average, in order to use LEED in its entirety. If the project serves less than 1 annualized FTE, optional credits from the Indoor Environmental Quality category may not be earned (the prerequisites must still be earned).

Intent:

- Many credits and prerequisites throughout the LEED rating systems evaluate the impact of the LEED project building on the building users, particularly those in the Indoor Environmental Quality credit category. CaGBC believes it is appropriate and necessary to require that a minimum number of people benefit from the strategies implemented in order to earn the credits.

Exceptions:

- This requirement does not apply to leased space not yet tenanted, but intended for occupancy.

6. MUST ALLOW CAGBC ACCESS TO WHOLE BUILDING ENERGY AND WATER USAGE DATA.

At this time, the CaGBC does not require projects to provide the CaGBC with access to actual whole building energy and water usage data. However, the CaGBC recognizes that the goal of decreased energy and water use consumption is a major component of LEED certification. Tracking actual building consumption and comparing it to the usage proposed in design cases, is essential to the individual success of each LEED certified building and the ongoing evaluation and development of the LEED program. The CaGBC encourages project teams to consider monitoring building performance through the use of industry benchmarking databases.

7. MUST COMPLY WITH A MINIMUM BUILDING AREA TO SITE AREA RATIO.

The building floor area of the LEED project building must be no less than 2% of the gross land area (site area including building footprint) within the LEED project boundary.

Intent:

- Because LEED is a rating system for buildings, it is appropriate to restrict the amount of land associated with a LEED certified project. While it is recognized that large sections of real estate may be affected by human activity generated by a building as well as an owner's general land use decisions, this stipulation has been put into place to ensure that an overabundance of land associated with a LEED certification does not occur and certain Sustainable Sites credits are awarded fairly.

Additional Clarifications:

- Calculation method for determining gross floor area to site area ratio

  [Building Floor Area (m^2) / Site Area (m^2)] x 100

V. LEED DOCUMENTATION REQUIREMENTS

All *LEED Canada for New Construction and Major Renovations*, and *Core and Shell Development*, certification applications must include the required LEED Letter Templates and all supporting documentation as noted on those templates.

GENERAL REQUIREMENTS

LEED certification application requires the submission of an overall project narrative with the completed LEED Letter Template documentation requirements. The project narrative describes the applicant's organization, project, site, and program, as well as key green features of the project. This narrative helps CaGBC staff and the LEED review team understand the major elements of the project and building performance.

The LEED Letter Templates workbook also includes additional submission requirements beyond the specific prerequisite and credits. This information includes the basic details pertaining to project site conditions, construction scope and timeline, occupant and usage data, and project team identification. Project teams must address all the elements in the general documentation requirements, providing details and clarifications where appropriate, and they may include any optional elements that are helpful in describing the project. Requirements for photos and drawings are also noted in the LEED Letter Templates, as well as confirmation that the Minimum Program Requirements are met. In addition, see the CaGBC website (www.cagbc.org) for further guidance.

Where a project team is applying for a prerequisite or credit with special circumstances (through a Credit Interpretation Request or an Interpretation of this reference guide) applications must provide additional documentation to demonstrate credit achievement. Project teams must provide narratives to cover these special allowances and any supporting documentation that would assist in demonstrating achievement.

LICENSED PROFESSIONAL EXEMPTION

The Licensed Professional Exemptions can be used by a project team's registered professional engineer or registered architect as a streamlined path for documenting certain credits, or bypassing otherwise-required submittals. License information and an Exemption Signature in the LEED Letter Templates are required to document each exemption the project team wishes to claim. Credits eligible for exemption are noted in the LEED Letter Templates.

CREDIT SUBSTITUTION

Projects registering under the LEED Canada 2009 rating systems are not allowed to substitute prerequisites or credits from another version. However, projects registered under previous *LEED Canada for New Construction and Major Renovations* or *Core and Shell Development* versions may be able to substitute LEED 2009 credits (generally where the whole credit change is adopted). Due to changes in the credit weighting, only select compliance paths may be substituted. See the allowance table on the CaGBC website (www.cagbc.org) for a list of acceptable substitutions. Note that this pathway is not encouraged due to the confusion added in maintaining multiple LEED versions of requirements and documentation. It is being allowed out of recognition of the improved requirements in LEED 2009 that previous project teams may be eager to use even though they are prevented from fully adopting LEED 2009 due to the project's current stage of development. However, if a project is able to, it can switch to the new version in its entirety.

VI. CERTIFICATION APPLICATION

LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS AND CORE AND SHELL DEVELOPMENT CERTIFICATION APPLICATION

To earn LEED certification, the applicant project must satisfy all the prerequisites and qualify for a minimum number of points to attain the established project ratings as listed below. Having satisfied the basic prerequisites of the program, applicant projects are then rated according to their degree of compliance within the rating system. (Note: Projects must meet all prerequisites and achieve 40 points from other credits before they may earn any points from Regional Priority credits.)

After registration, the project design team should begin to collect information and perform calculations to satisfy the prerequisite and credit documentation requirements. Because documentation should be gathered throughout design and construction, it is helpful to designate a LEED team leader (generally a LEED Consultant) who will be responsible for managing its compilation.

At the completion of construction, the project team submits all attempted credits for review. Upon receipt of the full certification application and fee, a screening review (completeness check) will be conducted to ensure the application is complete. Following the screening review, a first review is conducted by a contracted LEED review team, overseen by the CaGBC. A project team receives a formal first review response from the CaGBC; this review report designates prerequisites and credits as Prerequisite / Credit Achievement Anticipated, Prerequisite / Credit Pending, or Prerequisite / Credit Denied. The reviewer may ask clarifying questions of the applicant or request a Data Check of select items.

The concept of Data Check was implemented to streamline applications. For the majority of credits all required documentation is submitted with the initial submission. For several credits, however, the volume of documentation required makes this undesirable. For these credits, a Data Check may be performed to verify select items at the reviewer's discretion. The LEED Letter Templates indicate which credits are subject to a Data Check and the documentation that needs to be provided. Project teams must not claim credit performance for products and materials that cannot be verified in the supporting documentation reserved for a Data Check.

In the final (second) submission, the applicant provides responses to all prerequisites and credits pending additional information, either to respond to the reviewer's clarifying questions or to provide the requested Data Check materials. For credits denied in this first review, applicants are welcomed to respond to the denial with additional documentation. A final review is conducted and sent from the CaGBC to the applicant. All credits will be designated as either awarded or denied. If any prerequisites are denied or if insufficient credits are awarded, the project fails the certification review and no LEED rating will be awarded.

Project teams have an opportunity to appeal denied prerequisites and credits at this stage. See the CaGBC website (www.cagbc.org) for additional details on the appeal process.

PREREQUISITES AND CREDITS

Prerequisites and credits are the core criteria of LEED rating systems, and define requirements that must be met to be eligible for certification:

- Prerequisites define the minimum requirements in a particular LEED category.
- Meeting the requirements of a prerequisite does not contribute points to a project's score.
- All prerequisite requirements must be met for a project to be eligible to receive LEED Canada certification.
- Credits are the fundamental LEED criteria that describe practices deemed to reduce the project's environmental, health and resource impacts. Each credit has a defined number of possible points that may be awarded upon successful review of submittal documents demonstrating the credits' requirements were followed. Documented achievement of the requirements in each credit is rewarded by a number of points that contribute to the overall rating for the project. Credits and available points in each credit are shown in section XIII below.
- A credit can consist of several "sub-credits," each of which adds further requirements that, with documented submittals, may be rewarded with additional points.
- Application of any particular credit to the defined LEED project is at the discretion of the project's design and construction team responding to the project's unique constraints and opportunities.
- Projects must meet all prerequisites and achieve 40 points from other credits before they may earn any points from Regional Priority credits.

Points are earned by implementing the requirements laid out in each credit, and documenting that implementation with that credit's defined submittals noted in the LEED Letter Templates. The total number of points awarded across all credits and categories determines the overall rating of Certified, Silver, Gold, or Platinum. The table below outlines the point thresholds for each LEED Certification rating. Project ratings are certified by the CaGBC based on the total point score, following an independent review of the documentation submitted by a design and construction team. With four possible levels of certification, LEED is flexible enough to accommodate a wide range of green building strategies that best fit the constraints and goals of particular projects.

LEED Canada for New Construction and Major Renovations and *Core and Shell Development* certifications are awarded according to the following scale:

LEED® Canada Certification Levels	Number of LEED® Canada Points Required
Certified	40 – 49 points
Silver	50 – 59 points
Gold	60 – 79 points
Platinum	80+ points

The CaGBC recognizes projects that achieve a specific rating level with a final review report, final scorecard, formal certificate of recognition and a LEED Canada plaque. Projects are further recognized on the CaGBC website (www.cagbc.org).

VII. CERTIFICATION STRATEGY

TIMELINE AND PROJECT DESIGN PHASES

Project teams should study the principles and objectives of LEED as early in the site selection and design process as possible. The project design phases mentioned throughout this reference guide correspond to the architectural design and planning steps commonly used in the construction industry:

1. **Predesign** entails gathering information, recognizing stakeholder needs, and establishing project goals.
2. **Schematic design** explores several design options and alternatives, with the intent to establish an agreed-upon project layout and scope of work.
3. **Design development** begins the process of spatial refinement and usually involves the first design of a project's energy systems.
4. **Construction documents** carry the design into the level of details for all spaces and systems and materials so that construction can take place.
5. **Construction**.
6. **Substantial completion** is a contractual benchmark that usually corresponds to the point at which a client could occupy a nearly completed space.
7. **Final completion.**
8. **Certificate of occupancy** is the official recognition by a local building department that a building conforms to applicable building and safety codes.

RELATED CREDITS

When pursuing LEED certification, it is important to consider how credits are interconnected and how their synergies and trade-offs will ultimately affect both the project and the other credits the team may consider pursuing. Consult the Related Credits section of each prerequisite and credit to help inform design and construction decisions leading to certification.

CONSISTENT DOCUMENTATION ACROSS CREDITS

Several kinds of project information are required for consistent LEED documentation across various credits. Pay special attention to overlapping project data; doing so will help the application and review process go smoothly. The most common inconsistency is with occupancy numbers. However, take note of where there are different methodologies for calculating occupancy. For example, peak transient users is employed in SS Credit 4.2 (Alternative Transportation: Bicycle Storage and Changing Rooms) but transients can be calculated in the same way as Full Time Equivalents under WE Prerequisite 1 (Water Use Reduction).

OPERATIONS AND MAINTENANCE IN *LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS AND CORE AND SHELL DEVELOPMENT* CERTIFIED BUILDINGS

The *LEED Canada Reference Guide for Green Building Design and Construction* contains information on operations and maintenance to help project teams streamline green O&M practices once the LEED design and construction project has been completed. Although not required as part of the LEED certification process, upfront planning for green operations and maintenance can help building owners, operators, and maintenance staff ensure that the building continues to operate in a sustainable manner.

VIII. EXEMPLARY PERFORMANCE STRATEGIES

Exemplary performance strategies result in performance that greatly exceeds the performance level or expands the scope required by an existing *LEED Canada for New Construction and Major Renovations* or *Core and Shell Development* credit. To earn exemplary performance credits, teams must meet the performance level defined by the next step in the threshold progression.

The credits for which exemplary performance points are available through expanded performance are noted throughout this reference guide.

IX. REGIONAL PRIORITY CREDITS

To provide incentive to address geographically specific environmental issues, CaGBC is providing an opportunity for LEED Canada project teams to propose existing credits as Regional Priority credits. For a list of eligible credits and guidance regarding Regional Priority, refer to the CaGBC website (www.cagbc.org).

X. LEASED TENANT SPACE APPENDIXES

Appendix 1

Default Occupancy Counts: presents default occupancy counts for Core and Shell projects. Because of the nature of core and shell development, the project team may not know the tenant makeup and occupancy during the building's design phase. For some credits, the team will need to refer to the default occupancy count table to determine credit compliance. The occupancy counts must be consistent across all credits. *LEED Canada for New Construction and Major Renovations* projects with leased tenant space may also find this information useful for determining occupancy.

Appendix 2

Leased Tenant Space Energy Modelling Guidelines: gives guidelines for energy modelling for projects with leased tenant space. These guidelines are intended to ensure that projects in different markets approach the energy modelling requirements in a similar manner and to establish a minimum benchmark for energy optimization. Consult this appendix when modelling both the designed core and shell spaces and the tenant spaces that are not part of the project design and construction scope.

Appendix 3

Core and Shell Project Scope Checklist: contains a checklist for tenant interiors to help Core and Shell teams define the owner-tenant division in the project design and certification review process. *LEED Canada for New Construction and Major Renovations* projects with leased tenant space may also find this information useful for determining scope.

Appendix 4

Tenant Lease or Sales Agreement: offers a way for projects with leased tenant space to earn points by making prerequisite / credit requirements part of a binding sales agreement or tenant lease (e.g., mandatory lease agreement). This expands the area of project owner and design team "control" from design and construction to tenant sales and lease agreement negotiation, and is designed to give projects with a limited scope of work the ability to achieve credits that would otherwise be beyond their control, by committing the tenant(s) to green building practices in the tenant's scope of work.

XI. TOOLS FOR REGISTERED PROJECTS

LEED offers additional resources for LEED project teams on the CaGBC website, at www.cagbc.org. The CaGBC website provides resources for starting the project, including a LEED project checklist, the LEED Letter Templates, Credit Interpretation Request rulings, certification methodology and rating system errata and addenda.

XII. HOW TO USE THIS REFERENCE GUIDE

The *LEED Canada for Green Building Design and Construction Reference Guide* is a supporting document to the *LEED Canada for New Construction and Major Renovations* and *Core and Shell Development* rating systems. The guide helps project teams understand the criteria, the reasons behind them, strategies for implementation, and general documentation requirements (the LEED Letter Templates contain the full documentation requirements). It includes examples of strategies that can be used in each category, case studies of buildings that have implemented these strategies successfully, and additional resources. It does not provide an exhaustive list of strategies for meeting the criteria or all the information that a project team needs to determine the applicability of a credit to the project.

RATING SYSTEM PAGES

The rating system, published in its entirety on the CaGBC website, is imbedded in this reference guide. Each prerequisite and credit discussion begins with a page that mirrors the rating system's Intent and Requirements. This reference guide addresses the Intents and Requirements for the following Rating Systems: *LEED Canada for New Construction and Major Renovations 2009* and *LEED Canada for Core and Shell Development 2009*. These rating systems were also released in a combined rating system document.

In instances where a particular rating system has a unique intent and/or requirements, the rating system pages will highlight the requirements, noting if the requirement is solely for *New Construction and Major Renovations (NC)* projects or for *Core and Shell Development (CS)*.

PREREQUISITE AND CREDIT FORMAT

Each prerequisite or credit is organized in a standardized format for simplicity and quick reference. The first section summarizes the main points regarding the green measure and includes the intent, requirements, required submittals for certification, and a summary of any referenced industry standard. Subsequent sections provide supporting information to help interpret the measure and offer links to resources and examples. The sections for each credit are described in the following paragraphs.

Intent identifies the main sustainability goal or benefit of the prerequisite or credit.

Requirements specifies the criteria that satisfy the prerequisite or credit and the number of points available. The prerequisites must be achieved; the credits are optional, but each contributes to the overall project score. Some credits have 2 or more paths from which the project team must choose. For example, Energy & Atmosphere Credit 1, Optimize Energy Efficiency Performance, has 3 options, but a project can apply for only 1, depending on the type of building.

Interpretations are unique to LEED Canada. Interpretations incorporate previous *LEED Canada for New Construction and Major Renovations version 1.0* Credit Interpretation Requests which were deemed useful to users of this new version. Interpretations also include pathways from previous LEED Canada application guides developed through market experience generally unique to Canada. Interpretations also highlight key technical issues that needed further clarification from the requirements.

Benefits and Issues to Consider addresses the environmental benefits of the activity encouraged by the prerequisite or credit, and economic considerations related to first costs, life-cycle costs, and estimated savings.

Related Credits acknowledges the trade-offs and synergies within the LEED rating system credit categories. Achieving a particular credit may make it worthwhile and comparatively easy to pursue related credits; the converse is also possible.

The **Summary of Referenced Standards**, where applicable, introduces the required standards used to measure achievement of the credit intent. Teams are strongly encouraged to review the full standard and not rely on the summary.

Implementation discusses specific methods or assemblies that facilitate achievement of the requirements.

Timeline and Team guides the project team by identifying who should lead an effort and when the tasks should begin.

Calculations offers sample formulas or computations that determine achievement of a particular prerequisite or credit. Most calculations are facilitated in the LEED Letter Templates.

The **Documentation Guidance** section provides the first steps in preparing to complete the LEED Letter Templates documentation requirements.

Examples illustrates strategies for credit achievement.

Exemplary Performance, if applicable, details the level of performance needed for the award of points in addition to those for credit achievement.

Regional Variations outlines concerns specific to the geographic location of the building.

Resources offers suggestions for further research and provides examples or illustrations, detailed technical information, or other information relevant to the prerequisite or credit. The resources include websites, online materials, and printed books and articles that can be obtained directly from the organizations listed.

Definitions clarifies the meaning of certain terms relevant to the prerequisite or credit. These may be general terms or terms specific to *LEED Canada for New Construction and Major Renovations* and *Core and Shell Development.* A complete glossary is found at the end of this reference guide.

Case Studies are only available for select credits. They provide information on how past certified projects achieved the credit under a previous rating system (generally *LEED Canada NC, version 1.0* with or without addendum).

Throughout these sections, the rating system specific information is called out; the relevant rating systems are identified by NC (New Construction and Major Renovations), or CS (Core and Shell Development). This method provides clarity to the credit discussions and provides the relevant information needed for different project types where necessary. Finally, certain credits are specific to each rating system and are identified by the point-weighting table on the first page of each credit.

XIII. REFERENCE TABLES

LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009 PROJECT CHECKLIST

SUSTAINABLE SITES		26 POSSIBLE POINTS
❐ Prereq 1	Construction Activity Pollution Prevention	Required
❐ Credit 1	Site Selection	1
❐ Credit 2	Development Density and Community Connectivity	3, 5
❐ Credit 3	Brownfield Redevelopment	1
❐ Credit 4.1	Alternative Transportation: Public Transportation Access	3, 6
❐ Credit 4.2	Alternative Transportation: Bicycle Storage and Changing Rooms	1
❐ Credit 4.3	Alternative Transportation: Low-Emitting and Fuel-Efficient Vehicles	3
❐ Credit 4.4	Alternative Transportation: Parking Capacity	2
❐ Credit 5.1	Site Development: Protect and Restore Habitat	1
❐ Credit 5.2	Site Development: Maximize Open Space	1
❐ Credit 6.1	Stormwater Design: Quantity Control	1
❐ Credit 6.2	Stormwater Design: Quality Control	1
❐ Credit 7.1	Heat Island Effect: Non-Roof	1
❐ Credit 7.2	Heat Island Effect: Roof	1
❐ Credit 8	Light Pollution Reduction	1

WATER EFFICIENCY		10 POSSIBLE POINTS
❐ Prereq 1	Water Use Reduction	Required
❐ Credit 1	Water Efficient Landscaping	2, 4
❐ Credit 2	Innovative Wastewater Technologies	2
❐ Credit 3	Water Use Reduction	2-4

ENERGY AND ATMOSPHERE		35 POSSIBLE POINTS
❐ Prereq 1	Fundamental Commissioning of Building Energy Systems	Required
❐ Prereq 2	Minimum Energy Performance	Required
❐ Prereq 3	Fundamental Refrigerant Management	Required
❐ Credit 1	Optimize Energy Performance	1-19
❐ Credit 2	On-Site Renewable Energy	1-7
❐ Credit 3	Enhanced Commissioning	2
❐ Credit 4	Enhanced Refrigerant Management	2
❐ Credit 5	Measurement and Verification	3
❐ Credit 6	Green Power	2

MATERIALS AND RESOURCES		14 POSSIBLE POINTS
❐ Prereq 1	Storage and Collection of Recyclables	Required
❐ Credit 1.1	Building Reuse: Maintain Existing Walls, Floors, and Roof	1-3
❐ Credit 1.2	Building Reuse: Maintain Interior Non-Structural Elements	1
❐ Credit 2	Construction Waste Management	1-2
❐ Credit 3	Materials Reuse	1-2
❐ Credit 4	Recycled Content	1-2
❐ Credit 5	Regional Materials	1-2
❐ Credit 6	Rapidly Renewable Materials	1
❐ Credit 7	Certified Wood	1

INDOOR ENVIRONMENTAL QUALITY		15 POSSIBLE POINTS
❒ Prereq 1	Minimum Indoor Air Quality Performance	Required
❒ Prereq 2	Environmental Tobacco Smoke (ETS) Control	Required
❒ Credit 1	Outdoor Air Delivery Monitoring	1
❒ Credit 2	Increased Ventilation	1
❒ Credit 3.1	Construction Indoor Air Quality Management Plan: During Construction	1
❒ Credit 3.2	Construction Indoor Air Quality Management Plan: Before Occupancy	1
❒ Credit 4.1	Low-Emitting Materials: Adhesives and Sealants	1
❒ Credit 4.2	Low-Emitting Materials: Paints and Coatings	1
❒ Credit 4.3	Low-Emitting Materials: Flooring Systems	1
❒ Credit 4.4	Low-Emitting Materials: Composite Wood and Agrifibre Products	1
❒ Credit 5	Indoor Chemical and Pollutant Source Control	1
❒ Credit 6.1	Controllability of System: Lighting	1
❒ Credit 6.2	Controllability of System: Thermal Comfort	1
❒ Credit 7.1	Thermal Comfort: Design	1
❒ Credit 7.2	Thermal Comfort: Verification	1
❒ Credit 8.1	Daylight and Views: Daylight	1
❒ Credit 8.2	Daylight and Views: Views	1

INNOVATION IN DESIGN		6 POSSIBLE POINTS
❒ Credit 1	Innovation in Design	1-5
❒ Credit 2	LEED® Accredited Professional	1

REGIONAL PRIORITY		4 POSSIBLE POINTS
❒ Credit 1	Durable Building	1
❒ Credit 2	Regional Priority Credit	1-3

LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009

100 base points, plus 6 possible Innovation in Design points and 4 possible Regional Priority points

Certified	40–49 points
Silver	50–59 points
Gold	60–79 points
Platinum	80 points and above

Note that projects must meet all prerequisites and achieve 40 points from other credits before they may earn any points from Regional Priority credits.

LEED CANADA FOR CORE AND SHELL DEVELOPMENT 2009 PROJECT CHECKLIST

SUSTAINABLE SITES			28 POSSIBLE POINTS
❐	Prereq 1	Construction Activity Pollution Prevention	Required
❐	Credit 1	Site Selection	1
❐	Credit 2	Development Density and Community Connectivity	3, 5
❐	Credit 3	Brownfield Redevelopment	1
❐	Credit 4.1	Alternative Transportation: Public Transportation Access	3, 6
❐	Credit 4.2	Alternative Transportation: Bicycle Storage and Changing Rooms	2
❐	Credit 4.3	Alternative Transportation: Low-Emitting and Fuel-Efficient Vehicles	3
❐	Credit 4.4	Alternative Transportation: Parking Capacity	2
❐	Credit 5.1	Site Development: Protect and Restore Habitat	1
❐	Credit 5.2	Site Development: Maximize Open Space	1
❐	Credit 6.1	Stormwater Design: Quantity Control	1
❐	Credit 6.2	Stormwater Design: Quality Control	1
❐	Credit 7.1	Heat Island Effect: Non-Roof	1
❐	Credit 7.2	Heat Island Effect: Roof	1
❐	Credit 8	Light Pollution Reduction	1
❐	Credit 9	Tenant Design and Construction Guidelines	1

WATER EFFICIENCY			10 POSSIBLE POINTS
❐	Prereq 1	Water Use Reduction	Required
❐	Credit 1	Water Efficient Landscaping	2, 4
❐	Credit 2	Innovative Wastewater Technologies	2
❐	Credit 3	Water Use Reduction	2-4

ENERGY & ATMOSPHERE			37 POSSIBLE POINTS
❐	Prereq 1	Fundamental Commissioning of Building Energy Systems	Required
❐	Prereq 2	Minimum Energy Performance	Required
❐	Prereq 3	Fundamental Refrigerant Management	Required
❐	Credit 1	Optimize Energy Performance	3-21
❐	Credit 2	On-Site Renewable Energy	2, 4
❐	Credit 3	Enhanced Commissioning	2
❐	Credit 4	Enhanced Refrigerant Management	2
❐	Credit 5.1	Measurement and Verification: Base Building	3
❐	Credit 5.2	Measurement and Verification: Tenant Submetering	3
❐	Credit 6	Green Power	2

MATERIALS AND RESOURCES			13 POSSIBLE POINTS
❐	Prereq 1	Storage and Collection of Recyclables	Required
❐	Credit 1	Building Reuse: Maintain Existing Walls, Floors, and Roof	1-5
❐	Credit 2	Construction Waste Management	1-2
❐	Credit 3	Materials Reuse	1
❐	Credit 4	Recycled Content	1-2
❐	Credit 5	Regional Materials	1-2
❐	Credit 6	Certified Wood	1

INDOOR ENVIRONMENTAL QUALITY		12 POSSIBLE POINTS
❒ Prereq 1	Minimum Indoor Air Quality Performance	Required
❒ Prereq 2	Environmental Tobacco Smoke (ETS) Control	Required
❒ Credit 1	Outdoor Air Delivery Monitoring	1
❒ Credit 2	Increased Ventilation	1
❒ Credit 3	Construction Indoor Air Quality Management Plan: During Construction	1
❒ Credit 4.1	Low-Emitting Materials: Adhesives and Sealants	1
❒ Credit 4.2	Low-Emitting Materials: Paints and Coatings	1
❒ Credit 4.3	Low-Emitting Materials: Flooring Systems	1
❒ Credit 4.4	Low-Emitting Materials: Composite Wood and Agrifibre Products	1
❒ Credit 5	Indoor Chemical and Pollutant Source Control	1
❒ Credit 6	Controllability of System: Thermal Comfort	1
❒ Credit 7	Thermal Comfort: Design	1
❒ Credit 8.1	Daylight and Views: Daylight	1
❒ Credit 8.2	Daylight and Views: Views	1

INNOVATION IN DESIGN		6 POSSIBLE POINTS
❒ Credit 1	Innovation in Design	1-5
❒ Credit 2	LEED® Accredited Professional	1

REGIONAL PRIORITY		4 POSSIBLE POINTS
❒ Credit 1	Durable Building	1
❒ Credit 2	Regional Priority Credit	1-3

LEED CANADA FOR CORE AND SHELL DEVELOPMENT 2009

100 base points, plus 6 possible Innovation in Design points and 4 possible Regional Priority points

Certified	40–49 points
Silver	50–59 points
Gold	60–79 points
Platinum	80 points and above

Note that projects must meet all prerequisites and achieve 40 points from other credits before they may earn any points from Regional Priority credits.

SUSTAINABLE SITES (SS)

OVERVIEW

The selection and development of a building's site are fundamental components of sustainable building practices. Environmental damage caused by construction may take years of work to remedy.

The Sustainable Sites credit section addresses environmental concerns related to building landscape, hardscape, and exterior building issues. The LEED® Sustainable Sites credits for New Construction and Core & Shell promote the following measures:

SELECTING AND DEVELOPING THE SITE WISELY

Buildings affect ecosystems in a variety of ways. Development of a greenfield, or previously undeveloped site, consumes land. Development projects may also encroach on agricultural lands and wetlands or water bodies and compromise existing wildlife habitats. Choosing a previously developed site or even a damaged site that can be remediated reduces pressure on undeveloped land. Developing a master plan for the project site helps engrain environmental considerations as adaptations or expansions of site facilities occur over time. Planning for joint use of facilities integrates the project into the surrounding community and conserves material and land resources though optimized use of infrastructure.

REDUCING EMISSIONS ASSOCIATED WITH TRANSPORTATION

Environmental concerns related to buildings include vehicle emissions and the need for vehicle infrastructure as building occupants travel to and from the site. Emissions contribute to climate change, smog, acid rain, and other air quality problems. Parking areas, roadways, and building surfaces increase stormwater runoff and contribute to the urban heat island effect. In 2006, 65% of commuters in Canada ages 15 and older drove to work alone. Of the remaining 35% who used alternative means of transportation (including working from home), only 11% used public transportation and 16% carpooled.[1] Locating the project near residential areas, providing occupants with cycle racks, changing facilities, preferred parking, and access to mass transit and alternative-fuel fuelling stations can encourage use of alternative forms of transportation. Promoting mass transit reduces the energy required for transportation as well as the space needed for parking lots, which encroach on green space.

PLANTING SUSTAINABLE LANDSCAPES

Conventional plant designs and landscape maintenance practices often require irrigation and chemicals. Sustainable practices minimize the use of irrigation, fertilizers, and pesticides and can prevent soil erosion and sedimentation. Erosion from precipitation and wind causes degradation of property as well as sedimentation of local water bodies—and building sites can be major sources of sediment. Loss of nutrients, soil compaction, and decreased biodiversity of soil organisms can severely limit the vitality of landscaping. Sedimentation caused by erosion increases turbidity levels, which degrades aquatic habitats, and the buildup of sediments in stream channels can lessen flow capacity, increasing the possibility of flooding. Sustainable landscaping involves using or restoring native and adapted plants, which require less maintenance and irrigation and fewer or no applications of chemical fertilizers and pesticides compared with most introduced species. Sustainable landscaping thus reduces maintenance costs over the life of the building.

PROTECTING SURROUNDING HABITATS

Development of building sites can encroach on agricultural lands and adversely affect wildlife habitat. As animals are displaced by development, they become crowded into increasingly smaller spaces, and eventually the population exceeds the carrying capacity of the area. Overall biodiversity, as well as individual plant and animal species, may be threatened. Preserving and restoring native and adapted vegetation and other ecological features on the site provide wildlife habitat.

MANAGING STORMWATER RUNOFF

As areas are developed and urbanized, surface permeability is reduced, which in turn increases the runoff transported via pipes and sewers to streams, rivers, lakes, bays, and oceans. Impervious surfaces on the site may cause stormwater runoff that harms water quality, aquatic life, and recreation opportunities in receiving waters. For instance, parking areas contribute to stormwater runoff that is contaminated with oil, fuel, lubricants, combustion by-products, material from tire wear, and de-icing salts. Runoff accelerates the flow rate of waterways, increasing erosion, altering aquatic habitat, and causing erosion downstream. Effective strategies exist to control, reduce, and treat stormwater runoff before it leaves the project site.

REDUCING THE HEAT ISLAND EFFECT

The use of dark, nonreflective surfaces for parking areas, roofs, walkways, and other surfaces contributes to the heat island effect. These surfaces absorb incoming solar radiation and radiate that heat to the surrounding areas, increasing the ambient temperature. In addition to being detrimental to site habitat, this increase raises the building's external and internal temperature, requiring more energy for cooling. A study conducted in Toronto indicates that rate payers in the Greater Toronto Area could potentially save over $11 million in energy cost savings through heat island reduction strategies.[2]

ELIMINATING LIGHT POLLUTION

Poorly designed exterior lighting may add to nighttime light pollution, which can interfere with nocturnal ecology, reduce observation of night skies, cause roadway glare, and hurt relationships with neighbours by causing light trespass. Reducing light pollution encourages nocturnal wildlife to inhabit the building site and causes less disruption to birds' migratory patterns. Thoughtful exterior lighting strategies may also reduce infrastructure costs and energy use over the life of the building.

SUMMARY

The LEED Sustainable Sites credits for New Construction and Core & Shell promote responsible, innovative, and practical site design strategies that are sensitive to plants, wildlife, and water and air quality. These credits also mitigate some of the negative effects buildings have on the local and regional environment. Project teams undertaking building projects should be cognizant of the inherent impacts of development on land consumption, ecosystems, natural resources, and energy use. Preference should be given to buildings with high-performance attributes in locations that enhance existing neighbourhoods, transportation networks, and urban infrastructures. During initial project scoping, give preference to sites and land-use plans that preserve natural ecosystem functions and enhance the health of the surrounding community.

LEED PROJECT BOUNDARY

For single-building developments, the LEED submittal typically covers the entire project scope and is generally limited to the site boundary. However, in some cases a project is a portion of a larger multiple-building development. In these situations, the project team may determine the limits of the project submitted for LEED certification differently from the overall site boundaries (see Introduction). This LEED project boundary is the portion of the project site that is submitted for LEED certification and must be used consistently across all Sustainable Sites prerequisites and credits.

CREDIT	TITLE	NC	CS
SS Prerequisite 1	Construction Activity Pollution Prevention	Required	Required
SS Credit 1	Site Selection	1 point	1 point
SS Credit 2	Development Density and Community Connectivity	3, 5 points	3, 5 points
SS Credit 3	Brownfield Redevelopment	1 point	1 point
SS Credit 4.1	Alternative Transportation—Public Transportation Access	3, 6 points	3, 6 points
SS Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1 point	2 points
SS Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3 points	3 points
SS Credit 4.4	Alternative Transportation—Parking Capacity	2 points	2 points
SS Credit 5.1	Site Development—Protect or Restore Habitat	1 point	1 point
SS Credit 5.2	Site Development—Maximize Open Space	1 point	1 point
SS Credit 6.1	Stormwater Design—Quantity Control	1 point	1 point
SS Credit 6.2	Stormwater Design—Quality Control	1 point	1 point
SS Credit 7.1	Heat Island Effect—Nonroof	1 point	1 point
SS Credit 7.2	Heat Island Effect—Roof	1 point	1 point
SS Credit 8	Light Pollution Reduction	1 point	1 point
SS Credit 9	Tenant Design and Construction Guidelines	NA	1 point

SS	
NC	Prerequisite 1
CS	Prerequisite 1

CONSTRUCTION ACTIVITY POLLUTION PREVENTION

	NC	CS
Prerequisite	SS Prerequisite 1	SS Prerequisite 1
Points	Required	Required

INTENT

To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation.

REQUIREMENTS: NC & CS

Create and implement an erosion and sedimentation control (ESC) plan for all construction activities associated with the project. The plan must conform to the erosion and sedimentation requirements of the 2003 U.S. EPA Construction General Permit OR local standards and codes, whichever is more stringent. The plan must describe the measures implemented to accomplish the following objectives:

- To prevent loss of soil during construction by stormwater runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse.
- To prevent sedimentation of storm sewer or receiving streams.
- To prevent pollution of the air with dust and particulate matter.

The U.S. EPA's construction general permit outlines the provisions necessary to comply with Phase I and Phase II of USA's National Pollutant Discharge Elimination System (NPDES) program. While the permit only applies to construction sites greater than 0.40 hectares (1 acre), the requirements are applied to all projects for the purposes of this prerequisite. Information on the U.S. EPA construction general permit is available at: http://cfpub.epa.gov/npdes/stormwater/cgp.cfm.

INTERPRETATIONS

There are no interpretations for this credit.

SS	
NC	Prerequisite 1
CS	Prerequisite 1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

The loss of topsoil is the most significant on-site consequence of erosion. Topsoil is biologically active and contains organic matter and plant nutrients. Loss of topsoil greatly reduces the soil's ability to support plant life, regulate water flow, and maintain the biodiversity of soil microbes and insects that control disease and pest outbreaks. Loss of nutrients, soil compaction, and decreased biodiversity can severely limit the vitality of landscaping. This can lead to additional site management and environmental concerns, such as increased use of fertilizers, irrigation, and pesticides, as well as increased stormwater runoff that adds to the pollution of nearby lakes and streams.

The off-site consequences of erosion from developed sites include a variety of water quality issues. Runoff from developed sites carries pollutants, sediments, and excess nutrients that disrupt aquatic habitats in the receiving waters. Nitrogen and phosphorus from runoff hasten eutrophication by causing unwanted plant growth in aquatic systems, including algal blooms that alter water quality and habitat conditions. Such growth can also decrease recreation potential and diminish the population diversity of indigenous fish, plants, and animals.

Sedimentation also contributes to the degradation of water bodies and aquatic habitats. The buildup of sediments in stream channels can lessen flow capacity as well as increase flooding and turbidity levels. Turbidity reduces sunlight penetration into water and leads to reduced photosynthesis in aquatic vegetation, causing lower oxygen levels that cannot support diverse communities of aquatic life.

Airborne dust from construction activity can have both environmental and human health impacts. Fine dust particles enter airways and lungs with ease and have been linked to numerous health problems including asthma, decreased lung function, and breathing difficulties. In addition, dust particles can travel long distances before settling in water bodies, increasing the acidity of lakes and streams and changing nutrient balances.

ECONOMIC ISSUES

Erosion and sedimentation control measures are required by local building codes in most areas to minimize difficult and expensive mitigation measures in receiving waters. The cost will include some minimal expense associated with installing and inspecting the control measures, particularly before and after storm events, and will vary depending on the type, location, topography, and soil conditions of the project.

2. RELATED CREDITS

Minimizing site disturbance during construction and carrying out site restoration efforts to prevent erosion and sedimentation will also contribute to achievement of the following credits:

- SS Credit 5.1: Site Development—Protect or Restore Habitat
- SS Credit 5.2: Site Development—Maximize Open Space

Limiting the disruption of a site's natural hydrology and adopting a low-impact development strategy will assist projects in achieving the following credits:

- SS Credit 6.1: Stormwater Design—Quantity Control
- SS Credit 6.2: Stormwater Design—Quality Control

SS	
NC	Prerequisite 1
CS	Prerequisite 1

3. SUMMARY OF REFERENCED STANDARDS

2003 US EPA Construction General Permit

U.S. Environmental Protection Agency (EPA) Office of Water
http://cfpub.epa.gov/npdes/stormwater/cgp.cfm

The construction general permit outlines a set of provisions construction operators must follow to comply with NPDES stormwater regulations. The permit covers any site 1 acre or larger as well as smaller sites that belong to a larger common plan of development or sale. It replaces and updates previous EPA permits.

4. IMPLEMENTATION

Erosion typically occurs when foot traffic, runoff, or vehicle traffic damages vegetation that would otherwise hold the soil. Identifying and eliminating these and other causes will minimize soil loss and preserve receiving water quality.

This prerequisite effectively extends the USA's National Pollutant Discharge Elimination System (NPDES) requirements for construction activities (which currently apply only to projects of 1 acre or larger) to all projects pursuing LEED Certification. Typically, the civil engineer or landscape architect identifies erosion-prone areas and outlines soil stabilization measures. The contractor then adopts a plan to implement those measures and responds to rain and other erosion-causing events accordingly. The erosion and sedimentation control plan should be incorporated into the construction drawings and specifications, with clear instructions regarding responsibilities, scheduling, and inspections.

If a stormwater pollution prevention plan is required for the project by local regulations, an erosion and sedimentation control plan may already exist. In that case, to meet this prerequisite, confirm that the plan meets the prerequisite's requirements and is implemented. If an erosion and sedimentation control plan is not required for purposes other than LEED, use the referenced standard listed above as a guideline on how to compose the plan. Table 1 shows common strategies for controlling erosion and sedimentation on construction sites.

SS	
NC	Prerequisite 1
CS	Prerequisite 1

TABLE 1. STRATEGIES FOR CONTROLLING EROSION AND SEDIMENTATION

CONTROL TECHNOLOGY	DESCRIPTION
STABILIZATION	
Temporary Seeding	Plant fast-growing grasses to temporarily stabilize soils
Permanent Seeding	Plant grass, trees, and shrubs to permanently stabilize soil
Mulching	Place hay, grass, woodchips, straw, or gravel on the soil surface to cover and hold soils
STRUCTURAL CONTROL	
Earth Dike	Construct a mound of stabilized soil to divert surface runoff volumes from distributed areas or into sediment basins or sediment traps
Silt Fence	Construct posts with a filter fabric media to remove sediment from stormwater volumes flowing through the fence
Sediment Trap	Excavate a pond area or construct earthen embankments to allow for settling of sediment from stormwater volumes
Sediment Basin	Construct a pond with a controlled water release structure to allow for settling of sediment from stormwater volumes

5. TIMELINE AND TEAM

During the design phase, the civil engineer or landscape architect should compare local codes with the requirements of this prerequisite and create an erosion and sedimentation control plan. The general contractor should work with the project team's civil engineer or landscape architect to implement the plan during the construction phase and throughout project completion. The general contractor should photograph and maintain erosion and sedimentation control measures on-site during the various stages of construction. Once the site is stabilized, the general contractor should remove any temporary erosion and sedimentation control measures.

6. CALCULATIONS

There are no calculations required for this prerequisite.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Develop an erosion and sedimentation control drawing and/or a written erosion and sedimentation control plan with specifications that detail the erosion and control best management practices used on the project site and the responsible parties for implementation.
- Over the course of site work activities, document implementation of the erosion and sedimentation control plan through date-stamped photos, inspection logs or reports, descriptions of corrective action in response to problems, etc.

SS	
NC	Prerequisite 1
CS	Prerequisite 1

8. EXAMPLES

BACKGROUND

The project is major renovation of a 5,000 square metre residence hall on a large campus. As a part of the scope of work, the project team intends to remove soil, change contours, and alter the site drainage. To meet the credit requirements, the team will incorporate silt fencing, catch basin sediment traps, and silt sack sediment traps. The following table outlines the controls in place during construction.

CONTROL STRATEGY	DESCRIPTION
Vehicle tracking	Approximately 800 square metres of lawn and topsoil will be removed and replaced by a free-draining gravel material to allow truck access with minimal soil displacement.
Silt fencing	Silt fencing with straw bale barrier will be installed along the north, east, and west elevations. The south elevation will have a silt fence barrier without straw bales.
Sediment basin	The site has 2 existing catch basins, 1 on the west and 1 on the north, plus 9 smaller catch basins on the south elevation. Each catch basin will have sediment traps. One existing catch basin, located within the site perimeter fence, will have a sediment trap with a straw bale barrier.
Inspections	Silt fencing and sediment traps will be inspected and maintained on a weekly basis by the general contractor. In the event of significant rainfall, controls will be inspected at the end of the workday or the following morning.
Permanent seeding and planting	Undisturbed site areas containing existing landscaping and trees will be protected from truck and vehicle traffic. Upon completion, disturbed areas of the site will be immediately seeded and planted with permanent vegetation.

9. EXEMPLARY PERFORMANCE

This prerequisite is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Project teams should adhere to either local erosion and sedimentation control standards and codes, or the requirements of the 2003 U.S. EPA construction general permit, whichever is more stringent.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

The project team and groundskeeper should create an ongoing maintenance plan for permanent erosion control measures to prevent future or recurring erosion of site areas caused by damaging storms and traffic. At a minimum, the maintenance plan should include periodic visual inspections to identify any areas that are either eroding or susceptible to erosion and include recommendations for typical corrective actions. For example, identifying and promptly replacing dead or dying vegetation can prevent potential washouts during high-intensity storms. Additionally, it is helpful to

SS	
NC	Prerequisite 1
CS	Prerequisite 1

construct direct paths for foot and vehicle traffic to avoid degrading the site.

12. RESOURCES

In addition to the resources below, check with state and local organizations for information on erosion and sedimentation control in your project region.

WEBSITES

CBD-156: Drainage Around Buildings
http://www.nrc-cnrc.gc.ca/eng/ibp/irc/cbd/building-digest-156.html

NRC's Institute for Research in Construction publishes Canadian Building Digest, a collection of articles covering various aspects of design and construction in Canada. "Drainage Around Buildings" provides basic principles for good drainage around buildings, which can prevent flooding and erosion and improve the general attractiveness of a site.

CBD-183: Drainage and Erosion at Construction Sites
http://www.nrc-cnrc.gc.ca/eng/ibp/irc/cbd/building-digest-183.html

NRC's Institute for Research in Construction publishes Canadian Building Digest, a collection of articles covering various aspects of design and construction in Canada. "Drainage and Erosion at Construction Sites" provides basic principles and guidelines for drainage and erosion control at construction sites.

CPESC, Inc.
http://www.cpesc.net

The searchable directory on this website identifies certified erosion and sedimentation control professionals by state.

Environment Canada, Freshwater, Sediment
http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=32121A74-1

This site includes information on the environmental effects of sedimentation.

Erosion Control Technology Council
http://www.ectc.org

This nonprofit organization develops performance standards, testing procedures, and guidance on the application and installation of rolled erosion control products.

International Erosion Control Association
http://www.ieca.org

This organization's mission is to connect, educate, and develop the worldwide erosion and sediment control community.

Soil Erosion and Sedimentation in the Great Lakes Region
http://www.great-lakes.net/envt/pollution/erosion.html

This resource from the Great Lakes Information Network provides links to education and training opportunities, materials, manuals, maps, and other resources related to soil erosion, sedimentation, and watershed management.

SS	
NC	Prerequisite 1
CS	Prerequisite 1

U.S. EPA, Erosion and Sediment Control Model Ordinances
http://www.epa.gov/owow/nps/ordinance/erosion.htm

This resource is geared to helping municipalities draft ordinances for erosion and sedimentation control and could help companies develop policies to meet this prerequisite.

13. DEFINITIONS

Erosion is a combination of processes or events by which materials of the earth's surface are loosened, dissolved, or worn away and transported by natural agents (e.g., water, wind, or gravity).

Eutrophication is the slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. During the later stages of eutrophication the water body is choked by abundant plant life due to higher levels of nutritive compounds such as nitrogen and phosphorus. Human activities can accelerate the process.[3]

The **National Pollutant Discharge Elimination System (NPDES)** is a permit program that controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

Sedimentation is the addition of soil particles to water bodies by natural and human-related activities. Sedimentation often decreases water quality and can accelerate the aging process of lakes, rivers, and streams.

A **stormwater pollution prevention plan** describes all measures to prevent stormwater contamination, control sedimentation and erosion during construction, and comply with the requirements of the Clean Water Act.

Stormwater runoff consists of water from precipitation that flows over surfaces into sewer systems or receiving water bodies. All precipitation that leaves project site boundaries on the surface is considered stormwater runoff.

SS	
NC	Credit 1
CS	Credit 1

SITE SELECTION

	NC	CS
Credit	SS Credit 1	SS Credit 1
Points	1 point	1 point

INTENT

To avoid the development of inappropriate sites and reduce the environmental impact from the location of a building on a site.

REQUIREMENTS: NC & CS

Do not develop buildings, hardscape, roads or parking areas on portions of sites that meet any of the following criteria:

- Prime farmland (farm buildings are exempt from this requirement).
- Previously undeveloped or graded land whose elevation is EITHER:
  - lower than 1.5 metres (5 feet) above the elevation of the 100-year flood plain,

  OR

  - lower than 0.9 metres (3 feet) above the elevation of the 200-year flood plain.
- Ecologically sensitive land.
- Land specifically identified as habitat for any species on federal, provincial, or territorial threatened or endangered lists.
- Land within 30.5 metres (100 feet) of any wetlands or areas of special concern identified by federal, provincial, or local authorities, OR within setback distances from wetlands prescribed in federal, provincial, or local regulations and requirements, whichever are more stringent.
- Previously undeveloped or graded land that is within 15.2 metres (50 feet) of a water body, defined as seas, lakes, rivers, streams and tributaries which support or could support fish, recreation or industrial use, consistent with federal, provincial, or local regulations and requirements.
- Land that prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner (park authority projects are exempt).

SS	
NC	Credit 1
CS	Credit 1

INTERPRETATIONS

CAMPUS

This credit is allowed to be achieved on a campus-wide basis by demonstrating that the requirements are met at the campus level.

SS	
NC	Credit 1
CS	Credit 1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

As nonurban development increases, the importance of prudent site selection increases as well. Prevention of habitat encroachment is an essential element of sustainable site selection. The best strategy for selecting a building site is to choose a previously developed site. Because these sites have already been disturbed, further damage to the environment is limited and sensitive land areas can be preserved. This prevents the need for expanded transportation and utility infrastructure and likely affords building occupants more access to alternative transportation, further limiting the overall environmental impact of the development project.

The site surrounding a building defines its character and provides the first impression for its occupants and visitors. Creative and careful site designs can integrate natural surroundings with a building, providing a strong connection between the built and natural environments and minimizing adverse impacts on the undisturbed portions of a site. For school projects, this connection with the natural world can help students see how a school building and its occupants exist within a larger ecosystem.

Habitat preservation is the most effective means to minimize developmental impacts on indigenous wildlife. Not building on inappropriate sites preserves these areas for wildlife, recreation, and ecological balance.

ECONOMIC ISSUES

Site selection can play an important role in the way that the public responds to and gets involved with a proposed development. Channelling development away from sensitive ecological areas in favour of previously disturbed sites can encourage public support for a project and speed public review periods, thus minimizing or preventing obstacles traditionally encountered during project scoping. Economically, this can also save on mitigation costs that a developer would incur if the proposed development were approved within a sensitive area.

Appropriate site selection can reduce the risk of property damage due to natural events such as landslides, floods, sinkholes, and soil erosion. Although site survey and selection activities may entail initial costs, increased property values can offset these costs in the future.

2. RELATED CREDITS

Previously developed sites are more likely to have access to established public transportation systems and community services and may also present an opportunity to remediate a contaminated site. Protecting sensitive areas of the site by limiting development to a smaller footprint can increase open space and protect habitat. For these reasons, this credit is related to the following:

- SS Credit 2: Development Density and Community Connectivity
- SS Credit 3: Brownfield Redevelopment
- SS Credit 4.1: Alternative Transportation—Public Transportation Access
- SS Credit 5.1: Site Development—Protect or Restore Habitat
- SS Credit 5.2: Site Development—Maximize Open Space
- SS Credit 6.1: Stormwater Design—Quantity Control
- SS Credit 6.2: Stormwater Design—Quality Control

SS	
NC	Credit 1
CS	Credit 1

3. SUMMARY OF REFERENCED STANDARDS

Prime Farmland

Prime Farmland is land that is being used for viable agriculture. This land would include Class 1, 2 and 3 as defined by the Canada Land Inventory for rural Canada and any other land which prior to acquisition for development was actively farmed. Previously developed land is not considered prime farmland.

Canada Land Inventory
http://sis.agr.gc.ca/cansis/nsdb/cli/classdesc.html
http://geogratis.cgdi.gc.ca/

The Canada Land Inventory is a comprehensive multi-disciplinary land inventory of rural Canada, covering over 2.5 million square kilometres of land and water. Land capability for agriculture, forestry, wildlife, recreation, wildlife (ungulates and waterfowl) was mapped.Prime farmland is land that has been designated as Agricultural Class 1, 2, or 3.

Land Capability Classes for Mineral Soils (as per the above standard)

CLASS 1 Land in this class either has no or only very slight limitations that restrict its use for the production of common agricultural crops.

Land in Class 1 is level or nearly level. The soils are deep, well to imperfectly drained under natural conditions, or have good artificial water table control, and hold moisture well. They can be managed and cropped without difficulty. Productivity is easily maintained for a wide range of field crops.

CLASS 2 Land in this class has minor limitations that require good ongoing management practises or slightly restrict the range of crops, or both.

Land in class 2 has limitations which constitute a continuous minor management problem or may cause lower crop yields compared to Class 1 land but which does not pose a threat of crop loss under good management. The soils in Class 2 are deep, hold moisture well and can be managed and cropped with little difficulty.

CLASS 3 Land in this class has limitations that require moderately intensive management practises or moderately restrict the range of crops, or both.

The limitations are more severe than for Class 2 land and management practises are more difficult to apply and maintain. The limitations may restrict the choice of suitable crops or affect one or more of the following practises: timing and ease of tillage, planting and harvesting, and methods of soil conservation.

Endangered Species List - Canadian Wildlife Service

http://www.ec.gc.ca/nature/default.asp?lang=En&n=FB5A4CA8-1

This reference standard provides regional listings of endangered species and a link to the Species at Risk Public Registry.

SS	
NC	Credit 1
CS	Credit 1

4. IMPLEMENTATION

Before selecting a site, evaluate the potential environmental disturbance that will occur as a result of construction, and avoid developing sites that exhibit any of the characteristics listed in the restricted criteria. After considering the proposed use of the building, compile a list of sites that have already been developed that fit the needs for the building's use. Inventorying the important environmental characteristics of a site will help the project team protect resources and ecological services.

Restricted areas include previously undeveloped land or graded that is within 15.2 metres (50 feet) of a water body. Small manmade ponds such as those used in stormwater retention, fire suppression, and recreation, are exempt from this requirement. Manmade wetlands and other water bodies created to restore natural habitats and ecological systems are not exempt and must meet the 15.2 metre (50-foot) setback criteria to comply with the requirements of this credit.

Once a site has been selected, consider taking measures to preserve the site's natural features, and use design features that complement these natural features. Building in dense blocks can minimize the development footprint and site disturbance and help preserve the site's ecologically significant areas. It may be appropriate to incorporate some of the site's existing natural features into the design, such as natural shelter from trees or terrain, natural areas for outdoor activities, and water features for thermal, acoustic, and aesthetic benefit. Building designers should also take into account wildlife that lives on the site. For example, glazing on buildings sited near open space, wetlands, and water bodies that naturally attract birds can increase the potential for bird collisions. Site buildings on the property to minimize the reflection of existing vegetation. Buildings facing open space, wetlands, and water bodies may require measures to reduce the potential for bird collisions. (See bird-safe strategies and references under SS Credits 5.1 and 5.2.)

5. TIMELINE AND TEAM

During the site selection process, the project team should include landscape architects, ecologists, environmental engineers, and civil engineers, as well as local professionals who can provide site-specific expertise. A government official, ecologist, or other qualified professional should survey the site and inventory the important environmental characteristics, including wetlands, sloped areas, important habitat areas, and forested areas. Community coordination and consideration of public comments can help preempt negative community reaction.

6. CALCULATIONS

There are no calculations required for this credit.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Record any special circumstances regarding compliance with the site selection criteria.

SS	
NC	Credit 1
CS	Credit 1

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations associated with this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Environmentally sensitive portions of the site should be protected during both initial construction and later facility alterations and additions. For sites that contain environmentally sensitive areas, clearly demarcate on the site plans the sections that should be protected and remain undeveloped during future alterations and additions. Include labels that describe the nature of the sensitive area and ensure that these documents are transferred to the building owners and the facility manager and staff.

12. RESOURCES

WEBSITES

Atlas of Canada – Wetlands
http://atlas.nrcan.gc.ca/site/english/learningresources/theme_modules/wetlands/index.html

Natural Resources Canada website providing information on location of significant Canadian wetlands, fauna associated with them and the pressures wetlands are under.

ESRI
http://www.esri.com/

This software company creates tools for geographic information systems (GIS) mapping. Its website includes an option to make a map of all flood areas within a user-defined location.

Species at Risk Public Registry
http://www.sararegistry.gc.ca/default_e.cfm

National government source for news, information, and documents related to species at risk in Canada.

PRINT MEDIA

Constructed Wetlands in the Sustainable Landscape, by Craig Campbell and Michael Ogden (John Wiley & Sons, 1999).

Saved By Development: Preserving Environmental Areas, Farmland, by Rick Pruetz (Arje Press, 1997).

Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping, by Ralph W. Tiner (Lewis Publishers, 1999).

13. DEFINITIONS

SS	
NC	Credit 1
CS	Credit 1

The **development footprint** is the area affected by development or by project site activity. Hardscape, access roads, parking lots, nonbuilding facilities, and the building itself are all included in the development footprint.

Ecologically sensitive land is land that includes rare or fragile ecosystems, places of significant and recognized biodiversity of habitat for rare or endangered species.

An **ecosystem** is a basic unit of nature that includes a community of organisms and their nonliving environment linked by biological, chemical, and physical processes.

An **endangered species** is threatened with extinction because of harmful human activities or environmental factors.

Farm building is a building or part thereof which does not contain a residential occupancy and which is associated with, and located on, land devoted to the practice of farming and used essentially for the housing of equipment or livestock, or the production, storage or processing of agricultural and horticultural produce or feeds.

Graded site is any land or property that has been modified for human use as farmland or open space.

Previously developed is any land or property that contains (or recently contained) infrastructure or buildings.

Previously undeveloped land / Greenfield is property that has not been modified for human use through construction or manipulation of the land, or has returned to a natural state after an extended period during which no human influence was present.

Prime farmland is land that is being used for viable agriculture. This land would include Class 1, 2 and 3 as defined by the Canada Land Inventory for rural Canada and any other land which prior to acquisition for development was actively farmed. Previously developed land is not considered prime farmland.

Wetland is an area that is inundated or saturated by surface or ground water at a frequency and duration that under normal circumstances support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. A river or creek is not considered a wetland. Manmade wetlands are excluded from the requirements of SS credit 1 only if constructed as part of an overall storm system management approach.

SS	
NC	Credit 2
CS	Credit 2

DEVELOPMENT DENSITY AND COMMUNITY CONNECTIVITY

	NC	CS
Credit	SS Credit 2	SS Credit 2
Points	3, 5 points	3, 5 points

INTENT

To channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources.

REQUIREMENTS: NC & CS

OPTION 1. DEVELOPMENT DENSITY (5 Points)

Construct or renovate a building on a previously developed or graded site, that conforms with a minimum development density of 13,800 square metres per hectare requirement (60,000 square feet per acre), AND select a site in a community with a minimum density of 13,800 square metres per hectare (60,000 square feet per acre net). The density calculation is based on a typical two-storey downtown development and must include the area of the project being built.

OR

OPTION 2. COMMUNITY CONNECTIVITY (3 Points)

Construct or renovate a building on a site that meets the following criteria:

- Is located on a previously developed site
- Is within 800 metres (½ mile) of a residential area or neighbourhood with an average density of 25 units per hectare (10 units per acre net) (unless the project itself contains residential units meeting the density requirement)
- Is within 800 metres (½ mile) of at least 10 basic services
- Has pedestrian access between the building and the services.

SS	
NC	Credit 2
CS	Credit 2

If a service in a mixed use project is counted, it must be open to the public. No more than 2 of the 10 services required may be anticipated (i.e., at least 8 must be existing and operational). In addition, the anticipated services must demonstrate that they will be operational in the locations indicated within 1 year of occupation of the applicant's project. Examples of basic services include the following:

- Bank
- Place of Worship
- Convenience Grocery
- Day Care Centre
- Cleaners
- Fire Station
- Beauty Salon
- Hardware
- Laundry
- Library
- Medical or Dental Office
- Senior Care Facility
- Park
- Pharmacy
- Post Office
- Restaurant
- School
- Supermarket
- Theatre
- Community Centre
- Fitness Centre
- Museum

Proximity is determined by drawing an 800 metre (½ mile) radius around a main building entrance on a site map and counting the services within that radius.

OR

OPTION 3. COMMUNITY CONNECTIVITY WITH DENSITY (5 points)

Construct or renovate a building on a site that meets the following criteria:

- Is located on a previously developed site
- Meets the community connectivity requirements of Option 2
- Meets the minimum project site density requirement of 13,800 square metres per hectare (60,000 square feet per acre).

INTERPRETATIONS

CAMPUS

The surrounding planned development over which the applicant has control (e.g., master planned sites) can be included in the calculations for development density or community connectivity as long as the development is completed within 5 years. Where the applicant does not have control over the surrounding planned development, that development may not be included in the calculations with the exception of 2 anticipated services operational within a year of the applicant's project as noted in Option 2 above.

For master planned projects, compliance can be met if existing or planned master plan site density is a minimum of 13,800 m^2 per hectare within the boundary of the site master plan. The master plan site must be located in an urban infill area, previously developed site, and/or contaminated site; essentially where ecological damage has already occurred. Individual projects within the master plan can have a lower density

SS	
NC	Credit 2
CS	Credit 2

than 13,800 m^2 per hectare as long as the master plan being completed within 5 years, achieves an average density that is over this threshold.

Campus open space not used for roads or vehicle parking can be treated as park space and excluded from the development density calculation. For the purposes of this credit, campus open space is defined as general parkland that is for use by all campus users and land that is formally documented as being preserved as park space. Small green areas between buildings or along roadways are not considered campus open space but rather are associated with the adjacent building(s). Include supporting documentation detailing the function and status of the open space and public areas.

Primary roads providing central circulation to campus traffic are considered as 'public roads'. Public roads and right-of-ways are excluded from SS Credit 2 calculations.

For a project within a campus, it is acceptable to base the surrounding area on the Campus area (instead of using the defined radius) provided that the Campus area is equal to or greater than the area of the circle defined by the density radius for the project.

SS	
NC	Credit 2
CS	Credit 2

1. BENEFITS AND ISSUES TO CONSIDER

Urban sprawl affects quality of life because commuters spend increasing amounts of time in automobiles. In addition, families often require more vehicles to accommodate their needs, resulting in higher costs of living. The redevelopment of urban areas helps restore, invigorate, and sustain established urban living patterns, creating a more stable and interactive community.

ENVIRONMENTAL ISSUES

Consider proximity to transportation and community services. Developments located within walking distance of existing or planned basic services limit urban sprawl and reduce transportation impacts, such as air pollution and greenhouse gas emissions. Facilitating walkable access to basic services may improve productivity of building occupants by reducing the time spent driving and finding parking space. In addition, increased levels of physical activity can improve occupants' health.

Urban redevelopment affects all areas of site design, including site selection, transportation planning, building density, and stormwater management. Many cities have existing buildings that could be rehabilitated, an approach that reduces the demand for new materials. The potential trade-offs for sites in dense areas include limited open space and factors that could harm indoor environmental quality, such as contaminated soils, undesirable air quality, or limited daylighting opportunities.

ECONOMIC ISSUES

A significant economic benefit of infill development is that it may make new infrastructure, including roads, utility services, and other amenities, unnecessary. If public transportation serves an urban site, a project's parking capacity can be downsized, with significant cost reductions. Urban infill development sometimes requires significant additional costs compared with suburban development because of site constraints, contaminated soils, and other issues. However, municipal incentives for urban infill projects may be available.

2. RELATED CREDITS

Channelling development toward urban areas increases the likelihood of locating the project on a previously developed area and near public transportation, thus assisting project teams with earning the following credits:

- SS Credit 1: Site Selection
- SS Credit 4.1: Alternative Transportation—Public Transportation Access

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

SS	
NC	Credit 2
CS	Credit 2

4. IMPLEMENTATION

To achieve this credit, the best approach is to give preference to sites in an urban area. Work with local jurisdictions to follow the area's urban development plan, and meet or exceed density goals. Consider using community resources and sharing the project building's resources with neighbours. Choose sites based on infrastructure, transportation, and quality-of-life considerations. Consider renovating an existing building in an area where community revitalization is already underway and the required development density will be met by the time the project is completed.

OPTION 1. DEVELOPMENT DENSITY

To determine the development density, assess the density of the LEED project site, as well as the densities of surrounding developments. Determine the total area of the project site and the total size in square metres of the building. For projects that are part of a larger property (such as a campus), define the project area (outlined in the LEED project's scope). The project area must be defined consistently throughout LEED documentation.

Calculate the density of the project site and the density radius using the equations below. Overlay the density radius on a site map that includes the project site and surrounding areas, originating from the center of the LEED project site. This is the density boundary. For each property within the density boundary, including the LEED project site and any properties that intersect the density boundary, create a table with the building area (in square metres) and site area of each property. Include all properties except for undeveloped public areas, such as parks and water bodies. Do not include public roads and right-of-way areas. Information on neighbouring properties can be obtained from your local zoning department.

For the purposes of this option, physical education spaces that have been included as part of the project site—such as playing fields, buildings used during sporting events only (e.g., concession stands), and playgrounds with play equipment—are excluded from the development density calculations.

OPTION 2. COMMUNITY CONNECTIVITY

Consider both residential and commercial neighbours when determining the community connectivity of a project. Prepare a site map (Figure 1) and draw a 800 metre (1/2-mile) radius around the main building entrance. Radii may be drawn around multiple entrances for projects with multiple buildings or more than 1 main entrance. The combination of the area in these radii would then be considered the project radius.

SS	
NC	Credit 2
CS	Credit 2

FIGURE 1. SAMPLE MAP FOR COMMUNITY CONNECTIVITY

1) Headway National Bank, Bank
2) St. Peters Church, Place of Worship
3) Kids First Preschool, Day Care
4) Styles Unisex, Beauty
5) Topware Hardware, Hardware
6) Five Point Medical Clinic, Medical
7) Andrea D. Foster DDS, Dental
8) Ross Park, Park
9) Healthy Mart, Pharmacy
10) Pizza Best, Restaurant
11) Landmark Elementary, School
12) Fresh Grocery, Supermarket

\# Residential Area with 10 units per Acre or more

SS	
NC	Credit 2
CS	Credit 2

Mark all residential developments within the radius. For the project to earn this credit, a residential area with a minimum density of 25 units per hectare (10 units per acre) must be present within the radius.

Mark all commercial buildings within the radius. At least 10 basic services must be present within the radius for the project to earn this credit. Services other than those listed in the credit requirements will be considered on a project-by-project basis.

List each of the identified services, the business name, and the service type to confirm compliance. Table 1 illustrates an example.

TABLE 1. SAMPLE COMMUNITY CONNECTIVITY TABULATION

SERVICE IDENTIFICATION (CORRESPONDS TO VICINITY PLAN)	BUSINESS NAME	SERVICE TYPE
1	Restaurant 1	Restaurant
2	Grocery 1	Convenience Grocery
3	Urgent Care 1	Medical
4	Pharmacy 1	Pharmacy
5	Gym 1	Fitness
6	Hair Care 1	Beauty
7	Bank 1	Bank
8	Restaurant 2	Restaurant
9	Cleaners 1	Cleaners
10	Post Office 1	Post Office

With the exception of restaurants, no service may be counted more than once in the calculation. Up to 2 restaurants may be counted toward achievement of this credit. Count only those services that can be accessed by pedestrians from the project; that is, pedestrians must be able to walk to the services without being blocked by walls, highways, or other barriers.

The project building itself cannot be considered 1 of the 10 basic services; however, in a mixed-use building, each service within the building may be counted provided these services are open to the public.

Up to 2 services that are anticipated to be built in the near future can count toward this credit; at least 8 services must be existing and operational. Any anticipated services must be documented by lease agreements or other appropriate documentation (e.g., a letter from the owner or other appropriate party) to demonstrate that they will be operational in the locations indicated within a year of occupation of the project building.

OPTION 3. COMMUNITY CONNECTIVITY WITH DENSITY

Combine elements of Options 1 and 2: follow Option 2 while ensuring the project site meets the site density requirement of Option 1.

SS	
NC	Credit 2
CS	Credit 2

5. TIMELINE AND TEAM

During the site selection process, the building owner and developer, along with the entire team, should assess various options for locating the building based on density and proximity to existing infrastructure to meet the requirements of this credit.

6. CALCULATIONS

OPTION 1. DEVELOPMENT DENSITY

STEP 1

Calculate the development density for the project by dividing the building floor area in square metres by the total site area in hectares. The development density must be 13,800 square metres or more per hectare (Equation 1).

Equation 1

$$\text{Development Density } (m^2/ha) = \frac{\text{Building Floor Area } (m^2)}{\text{Site Area (ha)}}$$

STEP 2

Convert the total site area from hectares to square metres and calculate the square root of this number. Then multiply the square root by 3 to determine the appropriate density radius (Equation 2). The square root function normalizes the calculation by removing effects of site shape.

Equation 2

$$\text{Density Radius (m)} = 3 \times \sqrt{[\text{Site Area (ha)} \times 10{,}000\ (m^2/ha)]}$$

STEP 3

Calculate the average property density within the density boundary by adding up the square metre values and site areas of each property and dividing the total square metres by the total site area. The average property density of the properties within the density boundary must be 13,800 square metres or more per hectare. If this requirement is met, projects earn 5 points under this credit.

Equation 3

$$\text{Average Property Density within Density Boundary} = \frac{\sum \text{Square metres}}{\sum \text{Site Area}}$$

OPTION 2. COMMUNITY CONNECTIVITY

There are no calculations required for this option.

OPTION 3. COMMUNITY CONNECTIVITY WITH DENSITY

Site density calculations are as per Option 1, Equation 1.

SS	
NC	Credit 2
CS	Credit 2

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- For development density, keep records of the project site and building development area and prepare a project site vicinity plan that highlights the development density radius.
- For community connectivity projects, create a site vicinity plan that highlights the 800 metre radius, locations and types of qualifying services, and location of residential areas.

8. EXAMPLES

EXAMPLE 1. Development Density

A 2,800 square metre office building is located on a 0.18 hectare urban site. The building density, calculated by dividing the square footage of the building space by the site area, is 15,556 square metres per hectare (Table 2). The density thus exceeds the 13,800 minimum required by the credit.

Table 2. Building Density Calculation

PROJECT BUILDING	BUILDING SPACE (m^2)	SITE AREA (HECTARES)
Project	2,800	0.18
Density (m^2/ha)		15,556

Next, the density radius is calculated using the following equation.

Equation 2

$$\text{Density Radius (m)} = 3 \times \sqrt{[0.18\ (\text{ha}) \times 10{,}000\ (\text{m}^2/\text{ha})]} = 127\ (\text{m})$$

The density radius of 127 metres is applied to an area plan of the project site and surrounding area.

The plan identifies all properties that are within or are intersected by the density radius. The plan includes a scale and a north indicator (Figure 2).

SS	
NC	Credit 2
CS	Credit 2

FIGURE 2. SAMPLE AREA PLAN

For each property located within the density radius, the project team determined the building space and site area (Table 3). These values are summed and the average density is calculated by dividing the total building square footage by the total site area.

SS	
NC	Credit 2
CS	Credit 2

TABLE 3. SAMPLE AREA PROPERTIES

PROPERTIES WITHIN DENSITY RADIUS	BUILDING SPACE (m^2)	SITE AREA (HECTARES)
Project site	2,800	0.18
A	3,105	0.16
B	8,129	0.64
C	590	0.11
D	2,560	0.13
E	6,172	0.47
F	1,340	0.55
G	1,167	0.08
H	580	0.06
I	1,331	0.09
J	2,747	0.17
K	1,662	0.13
L	901	0.13
M	2,237	0.26
N	2,670	0.12
O	622	0.06
P	3,623	0.16
Q	32,405	1.03
R	8,477	0.75
S	2,083	0.11
T	3,126	0.21
U	3,939	0.21
V	--	0.31
W	1,784	0.26
X	569	0.11
Y	465	0.12
Z	399	0.10
Total Building Space	95,483m^2	
Total Site Area		6.71 ha
Average Density		14,230 m^2/ha

For this example, the average building density of the surrounding area is greater than 13,800 square metres per hectare; thus, the example qualifies for 5 points.

SS	
NC	Credit 2
CS	Credit 2

EXAMPLE 2. Community Connectivity

A project is located in a suburban neighbourhood. To determine the connectivity of the project, both residential and commercial adjacencies must be considered.

A site map is prepared (See Figure 1, above) and an 800 metre (1/2-mile) radius is drawn around the school building's main entrance. Residential developments within the radius are identified. A residential area with a minimum density of 25 units per hectare is identified within the radius and labelled on the site map.

Ten basic services are located within the 800 metre (1/2-mile) radius and within pedestrian access. Table 4 illustrates this example.

TABLE 4. SAMPLE COMMUNITY CONNECTIVITY TABULATION

SERVICE IDENTIFICATION (CORRESPONDS TO UPLOADED VICINITY PLAN)	BUSINESS NAME	SERVICE TYPE
1	Garden Eating	Restaurant
2	Natural Foods	Convenience Grocery
3	Boundary Medical Center	Medical
4	Hall's Drugs	Pharmacy
5	Bass United Methodist	Place of Worship
6	Avenue Hardware	Hardware
7	Total Savings Bank	Bank
8	Bistro Unique	Restaurant
9	College Cleaners	Cleaners
10	Thomas International	School

In this example, the project earns 3 points for demonstrating community connectivity, under Option 2.

SS	
NC	Credit 2
CS	Credit 2

9. EXEMPLARY PERFORMANCE

Based on evidence that higher-density locations can achieve substantially and quantifiably higher environmental benefits, the following threshold requirements can be used to qualify a *LEED Canada for New Construction* and a *LEED Canada for Core & Shell* project for exemplary performance under the Innovation in Design section. Projects must first meet the requirements of Option 1 under SS Credit 2, Development Density and Community Connectivity. Additionally, the project must meet 1 of the 2 following requirements:

- The project itself must have a density at least double that of the average density within the calculated area (see Equations 1 and 3).

OR

- The average density within an area twice as large as that for the base credit achievement must be at least 27,600 square metres per hectare (120,000 square feet per acre). To double the area, calculate a new density radius using Equation 2 but with twice the project site area.

10. REGIONAL VARIATIONS

There are no regional variations associated with this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Buildings in dense urban centres, particularly in zero lot-line situations, can present challenges for sustainable operations practices that require space. For example, designating adequate space for recycling storage is more difficult than for projects on expansive lots. During design, the project team should consider the critical aspects of sustainable operations and ensure that the building's layout supports these functions.

Densely developed communities may have air quality problems, making it difficult for building occupants and facility operators to address health and comfort issues. Consider optimizing the building's design for air quality protection by positioning air intakes away from pollutant sources, using superior filtration media, and selecting materials that do not contribute to indoor air quality issues. Encourage building operations staff to actively manage for high indoor air quality through the use of US EPA's Indoor Air Quality Building Education and Assessment Model, known as I-BEAM, or other strategies.

12. RESOURCES

SS	
NC	Credit 2
CS	Credit 2

WEBSITES

Canada Mortgage and Housing Corporation, Sustainable Community Planning
http://www.cmhc-schl.gc.ca/en/inpr/su/sucopl/index.cfm

Material provides examples of best practices in design and development, tools for planners and designers, and other research on sustainability.

Congress for New Urbanism
http://www.cnu.org

The Congress for New Urbanism promotes the efficient use of infrastructure and the preservation of habitats and farmland.

International Union for the Scientific Study of Population
http://www.iussp.org

IUSSP promotes scientific studies of demography and population-related issues.

Simon Fraser University Centre for Sustainable Community Development (CSCD)
http://www.sfu.ca/cscd/

The Centre's mission is to support the sustainable development of communities through research, education, and community mobilization; it provides research, training and advisory services throughout BC and Canada as well as internationally.

SmartGrowth BC
http://smartgrowth.bc.ca/

Smart Growth BC is a non-governmental organization devoted to fiscally, socially and environmentally responsible land use and development. They work throughout British Columbia with community groups, businesses, developers, planners, municipalities and the public to create more livable communities.

Infrastructure Canada, Sustainable Community Planning and Development
http://www.infc.gc.ca/links-liens/resources-ressources/resources-ressources-eng.html

Infrastructure Canada plays a role in the promotion of sustainable community development in Canada, both by virtue of its mandate and the programs that it delivers. This link provides information, tools and resources to help communities become more sustainable.

- Federal initiatives related to sustainability planning
- Canadian resources and templates
- International resources
- Examples of completed sustainable community plans

Urban Land Institute
ULI Washington
http://www.washington.uli.org

The Urban Land Institute is a nonprofit organization based in Washington, D.C., that promotes the responsible use of land to enhance the total environment.

SS	
NC	Credit 2
CS	Credit 2

PRINT MEDIA

Changing Places: Rebuilding Community in the Age of Sprawl, by Richard Moe and Carter Wilkie (Henry Holt & Company, 1999).

Density by Design: New Directions in Residential Development, by Steven Fader (Urban Land Institute, 2000).

Green Development: Integrating Ecology and Real Estate, by Alex Wilson, et al. (John Wiley & Sons, 1998).

Once There Were Greenfields: How Urban Sprawl Is Undermining America's Environment, Economy, and Social Fabric, by F. Kaid Benfield, et al. (Natural Resources Defense Council, 1999).

Suburban Nation: The Rise of Sprawl and the Decline of the American Dream, by Andres Duany, et al. (North Point Press, 2000).

13. DEFINITIONS

Building density is the floor area of the building divided by the total area of the site.

Graded Site is any land or property that has been modified for human use as farmland or open space.

A **mixed-use project** has at least 10% of the floor area for tenants whose space function is different from the majority of the building (e.g., MURB plus either retail or office or combo of both).

Neighbourhood is synonymous with residential area.

Pedestrian access allows people to walk to services without being blocked by walls, freeways, or other barriers.

Previously Developed is any land or property that contains (or recently contained) infrastructure or buildings.

Previously undeveloped land / Greenfield is property that has not been modified for human use through construction or manipulation of the land, or has returned to a natural state after an extended period during which no human influence was present.

Property area is the total area within the legal property boundaries of a site; it encompasses all areas of the site, including constructed and nonconstructed areas.

Public transportation consists of bus, rail, or other transit services for the general public that operate on a regular, continual basis.

A **residential area** is land zoned primarily for housing at a density of 25 units per hectare (10 units per acre) or greater. These areas may have single-family and multifamily housing and include building types such as townhomes, apartments, duplexes, condominiums, or mobile homes.

Site area is synonymous with property area.

SS	
NC	Credit 3
CS	Credit 3

BROWNFIELD REDEVELOPMENT

	NC	CS
Credit	SS Credit 3	SS Credit 3
Points	1 point	1 point

INTENT

To rehabilitate damaged sites where development is complicated by environmental contamination and to reduce pressure on undeveloped land.

REQUIREMENTS: NC & CS

Develop on a site defined as a brownfield or contaminated site by the appropriate local, provincial or federal government agency (or where allowed by your jurisdiction, documented as contaminated by an independent environmental assessment firm).

Provide remediation as defined and required by the relevant regulatory agency.

INTERPRETATIONS

The remediation of aboveground contaminates (e.g., asbestos, lead paint, etc.) is not an acceptable path to meet the requirements of this credit. This credit is set up to reward those projects that undergo the costly remediation of a contaminated site under the guidelines of the appropriate contaminated sites program.

The use of a Risk Management plan approved by the relevant regulatory authority is acceptable as part of the remediation for achieving this credit. The relevant regulatory authority is considered to be the expert and final authority on remediation measures that are considered acceptable.

CAMPUS

If over 25% of a campus is contaminated, all projects on the campus can achieve this credit, independent of whether the contamination is on the project site.

SS	
NC	Credit 3
CS	Credit 3

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Many potential building sites in urban locations have been abandoned because of actual or possible contamination from previous industrial or municipal activities. The National Round Table on the Environment and the Economy estimates that there are as many as 30,000 brownfield sites across Canada.[4] These sites can be remediated and redeveloped for reuse. Remediation efforts remove hazardous materials from a site's soil and groundwater, reducing the exposure of humans and wildlife to health risks as a result of environmental pollution. Redevelopment of brownfield sites provides an alternative to developing on greenfield sites, preserving undeveloped areas for future generations and decreasing the overall environmental impact of development. Brownfields often have existing infrastructure improvements that make the construction of new utilities and roads unnecessary, avoiding further environmental impacts. In some instances, rather than remediate the contamination, it may be more sensible to leave contaminants in place and instead stabilize and isolate the contaminants to prevent human exposure.

ECONOMIC ISSUES

Remediation of brownfield sites can be costly and time-intensive if extensive effort is required to characterize the contamination, evaluate cleanup options, and perform cleanup activities. However, substantially lower property costs can offset remediation costs and time delays. The cost of remediation strategies varies by site and region.

Weigh the value of a remediated property against cleanup costs to determine whether the site is economically viable for redevelopment. In the past, developers have been reluctant to redevelop brownfield sites because of potential liability associated with previous owners' contamination. In recent years, many provincial and local government agencies have begun to provide incentives for brownfield redevelopment by revising regulations to reduce the liability of developers who choose to remediate contaminated sites.

Perception of a building site by the building owner and future building occupants must also be weighed. Building owners may be wary of cleanup requirements and the potential for liability should contaminants migrate and affect neighbours. Building occupants may worry about health risks from breathing contaminated air or coming into contact with contaminated soil.

Brownfields can be in attractive locations and are often less expensive than similar uncontaminated properties. Additionally, remediation and reclamation of contaminated sites can increase local tax bases[5] and contribute to social and economic revitalization of depressed or disadvantaged neighbourhoods.

2. RELATED CREDITS

Projects that are developed on Brownfield sites will likely qualify for this credit as well:

- SS Credit 1: Site Selection

SS	
NC	Credit 3
CS	Credit 3

3. SUMMARY OF REFERENCED STANDARDS

Reference standards for this credit differ by province and territory and by the regulatory agency having jurisdiction over the site. Project teams must use standards appropriate for their site.

Project teams may also find the following Canadian Standards Association documentation useful for a description of Phase I and Phase II Environmental Site Assessments. Note that the jurisdiction having authority over the site may use alternate terms or equivalencies.

Canadian Standards Association (CSA) Z768-01, Phase I Environmental Site Assessment
http://www.csa.ca

A Phase I environmental site assessment is defined by the standard as the systematic process by which an Assessor seeks to determine whether a particular property is or may be subject to actual or potential contamination. The process is non-intrusive, i.e.: there is no soil sampling drilling of boreholes or sampling of building materials. A Phase I environmental site assessment is concerned with the environmental condition of the property itself, not compliance with environmental laws, but may assist in reducing uncertainty about potential environmental liabilities and may be a basis for further investigation of the property. The inspiration for the Canadian standard was ASTM E1527.

Canadian Standards Association (CSA) Z769-00, Phase II Environmental Site Assessment
http://www.csa.ca

A Phase II environmental site assessment is defined by the standard as the systematic, iterative process, as outlined in the Standard, by which an Assessor seeks to characterize and/or delineate the concentrations of quantities of substances of concern related to a site and compare those levels to criteria. A Phase II environmental site assessment involves sampling, analysing and measuring, and for that reason is generally considered an "intrusive" investigation. Such investigations can be carried out for a variety of reasons – in the acquisition of property or a business as part of due diligence or as a condition of financing, to identify a baseline for a new tenant occupying a site, or as a component of the environmental risk management and remediation strategy of an organization.

4. IMPLEMENTATION

If contamination is suspected, conduct a Phase II environmental site assessment (as documented by CSA Z769-00 or equivalent in your jurisdiction) to determine whether remediation of the site is necessary. The Phase II assessment requires that an environmental professional test the soil, air, and water to identify what kinds of contaminants exist and at what levels. The type of tests conducted varies, but typically the easiest and least expensive methods are used initially and involve taking samples, which are then sent to a laboratory for analysis. This initial sampling screens for broad categories of contaminants. If sufficient contamination is found or further investigation is needed, more sophisticated tests must be performed. Contaminant-specific testing involves more time and additional cost but is needed to identify specific contaminants and determine effective remediation strategies, if required.

Use remediation experts to develop a master plan for any site cleanup. Prioritize remediation activities according to available funds and specific site considerations, and establish time frames for completing each activity.

The site should be cleaned using proven technologies that will not damage aboveground or underground natural features. The appropriate technology for a specific site depends on the contaminants present, hydrogeologic conditions, and other factors. Traditional remediation efforts

SS	
NC	Credit 3
CS	Credit 3

for contaminated groundwater are termed "pump-and-treat"; they involve pumping contaminated groundwater to the surface and treating it with physical or chemical processes. Contaminated soils can be remediated in a variety of ways. Consider in situ remediation schemes that treat contaminants in place instead of off-site. Advanced technologies such as bioreactors and in situ applications are sometimes more cost-effective than hauling large quantities of contaminated soil to an approved disposal facility. Innovative remediation efforts (such as solar detoxification technologies) are currently being developed and are expected to reduce remediation costs in the future. Evaluate the environmental implications of each strategy to make sure that it will not cause problems elsewhere.

Finally, identify and implement the most cost-effective strategy, and once remediation is complete, continue to monitor the site for the identified contaminants to ensure that contamination problems do not return.

5. TIMELINE AND TEAM

During the site selection process, developers should contract with an environmental consultant to conduct site assessments, identify contaminants, and determine a schedule for cleanup based on the remediation methods selected. Contact government regulators to identify the rules governing the site and find financial assistance programs. General contractors need to incorporate remediation activities into the construction schedule.

6. CALCULATIONS

There are no calculations required for this credit.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- For New Construction and Core & Shell projects, prepare descriptions of site contamination and remediation efforts undertaken by the project.

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Preliminary screening levels or remediation criteria may differ by region.

SS	
NC	Credit 3
CS	Credit 3

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Some remediation efforts may require ongoing activities. The project team and owner should keep careful records of remediation activities and develop a plan for ongoing compliance with the monitoring and reporting requirements of the relevant federal, provincial , or local regulatory agency.

12. RESOURCES

WEBSITES

ASTM International
http://www.astm.org

ASTM produced two important standards on contaminated site assessments: ASTM E1527-05, Phase I Environmental Site Assessment and ASTM E1903-97, Phase II Environmental Site Assessment, effective 2002. These standards were used as the base for CSA Z768-01 and Z769-00.

Brownfield Redevelopment
http://www.nrtee-trnee.com/eng/publications/brownfield-redevelopment-strategy/NRTEE-Ch2-Case-for-Strategy-Brownfield-Strategy.php

National Round Table on the Environment and the Economy (NRTEE). This site describes the NRTEE program to identify barriers to brownfield redevelopment and to make recommendations for improvement.

Canadian Brownfields Network
http://www.canadianbrownfieldsnetwork.ca/

The CBN is a national advocacy network that represents the interests of brownfield practitioners and stakeholders who want to effect change and address the barriers associated with brownfield redevelopment in Canada.

Canadian Council of Ministers of the Environment
http://www.ccme.ca

This website has a catalogue of publications with numerous documents relevant to contaminated sites.

Contaminated Sites. Waste Management and Remediation Section. Environment Canada
http://atlenv.ns.ec.gc.ca/epb/wastemgmt/contamsite.html

Provides information on legislation/policies and technologies related to remediation of contaminated sites. Also provides an extensive list of related publications.

Federal Contaminated Sites. Government of Canada
http://www.federalcontaminatedsites.gc.ca/index-eng.aspx

This website provides information sources on or related to the Federal Contaminated Sites Action Plan for members of the public and stakeholders.

U.S. EPA, Office of Research and Development, Technical Approaches to Characterizing and Cleaning Up Brownfield Sites
http://www.epa.gov/ORD/NRMRL/pubs/625r00009/625r00009.htm

This document assists communities, decision makers, states, municipalities, researchers, and the private sector in addressing issues related to brownfield site redevelopment. The document helps

SS	
NC	Credit 3
CS	Credit 3

users understand the problems associated with the redevelopment of these sites, the sources of information that could help to assess the sites, and the regulatory groups that should be involved in the process. The guidance has appendices of relevant terms, references, and applicable technologies.

PRINT MEDIA

ASTM Standard Practice E1739-95: Risk-Based Corrective Action Applied at Petroleum Release Sites, ASTM International
http://www.astm.org

This document is a guide for risk-based corrective action (RBCA), a decision-making process that is specific to cleaning up petroleum releases at contaminated sites. It presents a tiered approach to site assessment and remedial actions. It also includes a comprehensive appendix with risk calculations and sample applications.

EPA OSWER Directive 9610.17: Use of Risk-Based Decision-Making in UST Correction Action Programs, U.S. Environmental Protection Agency, Office of Underground Storage Tanks
http://www.epa.gov/swerust1/directiv/od961017.htm

This document addresses the application of risk-based decision-making techniques to properties where leaking underground storage tanks (USTs) pose risks to human health and the environment. The guidelines included can assist in making decisions in a manner consistent with federal law, specifically CERCLA and RCRA programs. Risk-based decision making uses risk and exposure assessment methodology to determine the extent and urgency of cleanup actions. The goal is to protect human health and the environment. This standard includes several examples of state programs that use risk-based decision making in legislation regarding leaking USTs.

13. DEFINITIONS

A **Brownfield Site** or **Contaminated Site** is a site where below-grade "substances occur in concentrations that:

1. are above background levels and pose, or are likely to pose, an immediate or long-term hazard to human health or the environment; or
2. exceed the levels specified in policies and regulations."[6]

In situ remediation involves treating contaminants in place using injection wells, reactive trenches, or other technologies that take advantage of the natural hydraulic gradient of groundwater; they usually minimize disturbance of the site.

Remediation is the process of cleaning up a contaminated site by physical, chemical, or biological means. Remediation processes are typically applied to contaminated soil and groundwater.

A **site assessment** is an evaluation of a site's aboveground and subsurface characteristics, including its structures, geology, and hydrology. Site assessments are typically used to determine whether contamination has occurred, as well as the extent and concentration of any release of pollutants. Information generated during a site assessment is used to make remedial action decisions.

SS	
NC	Credit 4.1
CS	Credit 4.1

ALTERNATIVE TRANSPORTATION: PUBLIC TRANSPORTATION ACCESS

	NC	CS
Credit	SS Credit 4.1	SS Credit 4.1
Points	3, 6 points	3, 6 points

INTENT

To reduce pollution and land development impacts from automobile use.

REQUIREMENTS: NC & CS

OPTION 1. RAIL STATION PROXIMITY (6 points)

Locate the project within 800 metres (½ mile) walking distance (measured from a main building entrance) of an existing or planned and funded commuter rail, light rail or subway station with frequent service.

OR

OPTION 2. BUS STOP PROXIMITY (6 points)

Locate the project within 400 metres (¼ mile) walking distance (measured from a main building entrance) of 1 or more stops for 2 or more public, campus, or private bus lines with frequent service usable by building occupants.

OR

OPTION 3. TRANSPORTATION DEMAND MANAGEMENT PLAN (3 or 6 points)

Provide a Transportation Demand Management Plan (TDM) Strategy that results in a more efficient use of transportation resources, demonstrated through reduction of single occupant vehicle (SOV) trips by 25% (3 points) or 50% (6 points).

INTERPRETATIONS

For a school, a school bus system may count as 1 of the bus lines under Option 2.

SS	
NC	Credit 4.1
CS	Credit 4.1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

The extensive use of single-occupancy vehicles and their heavy reliance on petroleum contribute to environmental problems. Fortunately, alternatives to conventional transportation methods exist. Many people are willing to use other options, if they are convenient. The use of mass transit helps reduce energy demand for transportation and associated greenhouse gas emissions, as well as the space needed for parking lots that encroach on the green space of a building site. Minimizing parking lots reduces a building's footprint and sets aside more space for natural areas or greater development densities.

Reductions in single-occupancy vehicle use directly affect fuel consumption and air and water pollution from vehicle exhaust. On the basis of passenger miles traveled, public transportation is twice as fuel efficient as private vehicles.[7] Another benefit of public transportation is the associated reduction in the need for infrastructure. Parking facilities and roadways for automobiles affect the environment because impervious surfaces, such as asphalt, increase stormwater runoff while contributing to urban heat island effects.

ECONOMIC ISSUES

Many occupants, employers, employees, and students view proximity to mass transit as a benefit, and this can increase the value and marketability of a building. For building occupants, costs associated with traveling to and from the workplace can be significantly reduced by access to public transportation. Not only is this an economic benefit for building occupants, it helps business owners attract and retain employees.

Reducing the size of parking areas based on anticipated use of public transportation by building occupants may alter operating costs associated with parking lot maintenance. If local utilities charge for stormwater based on impervious surface area, minimizing these areas can result in lower stormwater fees.

2. RELATED CREDITS

Sites close to existing public transportation infrastructure tend to be in more densely developed areas, including previously developed areas. The following credits may be more likely achievable for projects in such locations:

- SS Credit 1: Site Selection
- SS Credit 2: Development Density and Community Connectivity

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

SS	
NC	Credit 4.1
CS	Credit 4.1

OPTION 1 & 2:

Select a site that has convenient access to existing transportation networks to minimize the need for new transportation lines. Local transit authorities can provide maps and directories that will help identify the available transportation options.

If a light rail or subway station is sited, planned, and funded at the time the project is completed, it satisfies the intent of this credit.

If private shuttle buses will be used to meet the requirements, they must connect to public transportation and operate during the most frequent commuting hours.

OPTION 3:

Develop a transportation management plan that evaluates anticipated transportation use patterns and offers alternatives aimed at reducing commuting by single-occupancy vehicles. This is particularly useful for large buildings, buildings that are part of a master plan implementation, and developments with multiple buildings.

If possible, survey future building occupants about whether the available public transportation options meet their needs. Look for functional sidewalks, paths, and walkways that lead directly to existing mass transit stops.

Strategies to consider for the Transportation Demand Management Plan:

INFRASTRUCTURE

- Provide reliable, secure bicycle storage and shower or changing facilities for bicycle commuters.
- For campuses or multi-building facilities, provide public bicycles for use on campus grounds.
- Offer a preferred parking program that reserves the most desirable parking spaces for carpool or fuel-efficient vehicles.
- Provide charging stations for electric, hybrid-electric, or compressed air vehicles.
- For buildings without access to public transportation, provide regular shuttles to and from transit hubs.
- Promote and support compressed workweeks and telecommuting programs for employees whose jobs allow a nontraditional schedule.
- Reduce available parking.
- Institute paid parking for occupants/visitors, excluding carpools.

INCENTIVE PROGRAMS

- Provide financial incentives for using alternative transportation.
- Provide nonfinancial incentives for using alternative transportation, such as employee recognition programs and intraorganizational competitions.
- Provide management-subsidized passes for public transit.
- Provide management subsidies or payback programs for the purchase of bicycles or environmentally friendly vehicles.

SS	
NC	Credit 4.1
CS	Credit 4.1

PROGRAMS

- Institute a "free ride home" program for alternative-mode commuters who need to work unexpected hours that result in missed carpools or unsafe commute conditions.
- Facilitate carpooling by creating a database that allows occupants to identify potential carpool opportunities based on their commuting routes and schedules.
- Promote the use of mass transit by providing information on transportation options, routes, services, and incentives.
- Participate in local or regional transportation planning to ensure that building occupants' needs are considered.

Alternative transportation infrastructure and programs should address the building's location and occupants and the local or regional circumstances. For example, the transportation challenges and opportunities for a building serving an undergraduate student population are very different from those for a building occupied by a financial services firm. In the same way, a building in an urban center with extensive public transit options will achieve this credit differently than a building in a suburban or rural area. Also account for weather patterns when planning an alternative transportation program; many forms of alternative transportation become more or less practical in different seasons. Well-crafted programs support the use of different alternative transportation modes over the course of the year. Property managers of multitenant buildings should develop programs in collaboration with their tenants and work with them to promote the programs to building occupants.

5. TIMELINE AND TEAM

Achieving this credit requires proximity to existing transit infrastructure. If the project is in the site selection phase, the architect, design team, and client should determine which options for the project site location will best meet the public transportation access requirements for this credit.

6. CALCULATIONS

OPTION 1 AND OPTION 2

Use an area drawing, aerial photograph, or map to calculate the walking distance to the transit stops. If the building has multiple main or public entrances, project teams can measure walking distances from multiple building entrances. Software tools like Google™ Maps Pedometer (http://www.gmap-pedometer.com) may be useful for determining walking distance.

OPTION 3

The Transportation Demand Management Plan must include calculations to justify the claimed reductions in SOV use. Where a range of effectiveness values are given in literature, the mid-value should be used.

SS	
NC	Credit 4.1
CS	Credit 4.1

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

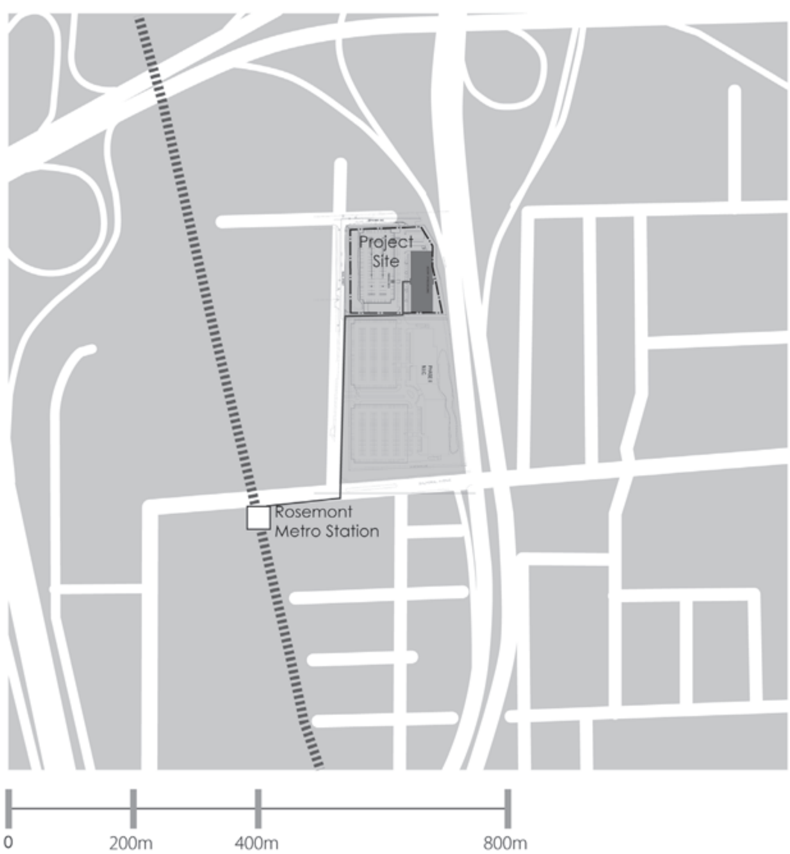
- Identify local rail stations or bus routes serving the project building.
- Develop a site vicinity plan, to scale, and label walking paths between the project building's main entrance and rail stations or bus stops.
- If the team anticipates rail development, obtain verification of funding for the rail project.
- Retain a copy of the Transportation Demand Management Plan or transportation analysis of facility including SOV reduction calculations.

8. EXAMPLES

EXAMPLE 1

A downtown office building is located within walking distance of public transportation. Figure 1 shows a rail station within 800 metres (1/2-mile) walking distance from the building's main entrance. The map includes a scale bar.

FIGURE 1. SAMPLE AREA DRAWING: DISTANCE TO RAIL

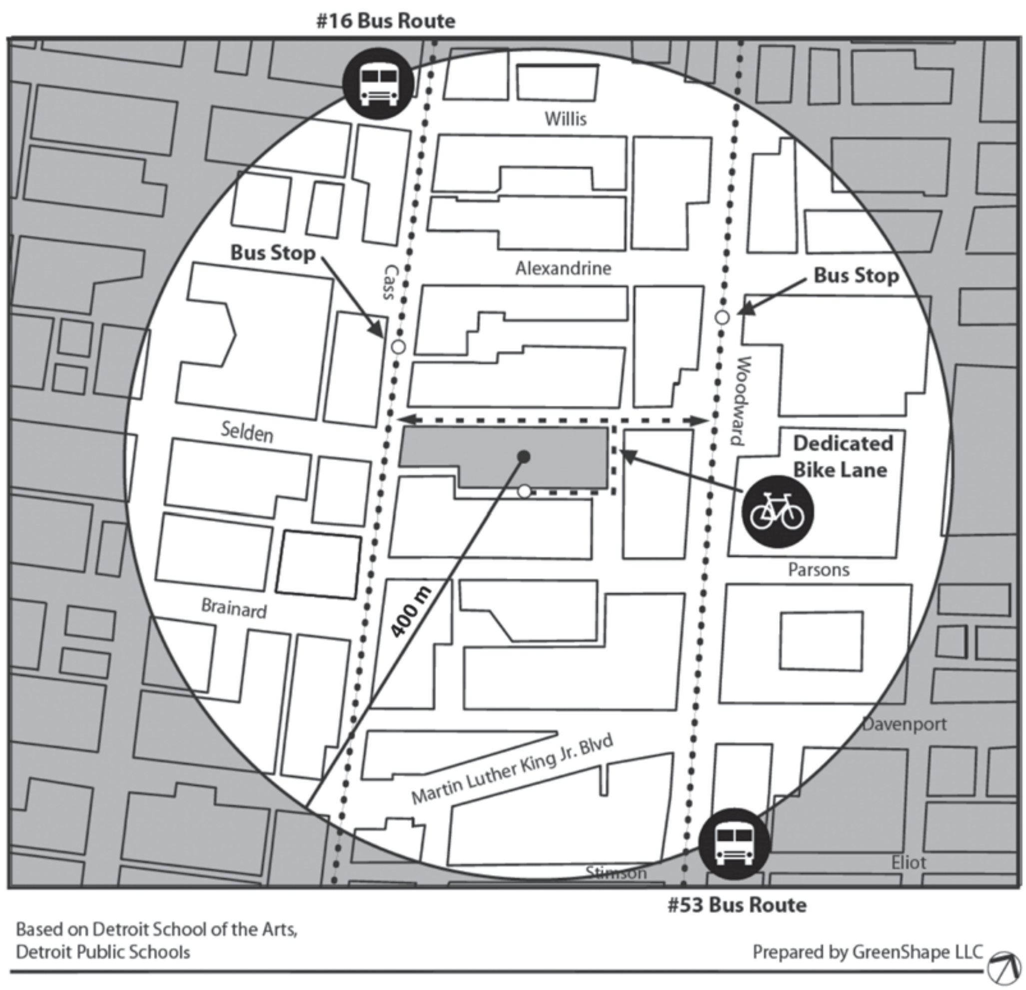


SS	
NC	Credit 4.1
CS	Credit 4.1

EXAMPLE 2

A school building is sited in a suburban commercial district. Figure 2 shows 2 bus lines within 400 metres (1/4-mile) walking distance of the building's main entrance. Normally walking distances should be clearly shown along the walking path, rather than simply using a radius circle, but where it is obvious that the distance is within the requirement, a radius circle can be used.

FIGURE 2. SAMPLE AREA DRAWING



9. EXEMPLARY PERFORMANCE

SS	
NC	Credit 4.1
CS	Credit 4.1

Project teams may earn an Innovation in Design credit for exemplary performance by complying with the requirements of 1 of the 2 options described below.

OPTION 1. COMPREHENSIVE TRANSPORTATION MANAGEMENT PLAN

Institute a comprehensive transportation management plan that demonstrates a 75% reduction in personal automobile use through any of multiple alternative options.

OPTION 2. DOUBLE TRANSIT RIDERSHIP

Because projects in locations with good mass transit can achieve substantially and quantifiably higher environmental benefits, meeting the following threshold qualifies a project for exemplary performance. The US Center for Clean Air Policy has found that average transit ridership increases by 0.5% for every 1.0% increase in growth of transit service levels, which leads to the conclusion that quadrupling transit service generally doubles transit ridership.

To achieve exemplary performance, meet the following minimum requirements:

- Locate the project within 800 metre (1/2 mile) of at least 2 existing commuter rail, light rail, or subway lines.

OR

- Locate the project within 400 metre (1/4 mile) of at least 2 or more stops for 4 or more public or campus bus lines usable by building occupants.

AND

- Frequency of service must be at least 200 transit rides per day, total, at these stops. A combination of rail and bus lines is allowable. This strategy is based on the assumption that the threshold of the base credit would provide, in most cases, at least 50 transit rides per day (half-hourly service 24 hours per day or more frequent service for less than 24 hours per day). If, on average, transit ridership increases by 0.5% for every 1.0% increase in transit service, then quadrupling the number of rides available would, on average, double the transit ridership: 4 x 50 rides = 200 rides. Include a transit schedule and map with the LEED certification submittal.

10. REGIONAL VARIATIONS

There are no regional variations associated with this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Transit infrastructure can be underutilized if building occupants are not informed about public transportation opportunities or encouraged to use these systems. Consider working with building owners and operators to develop ongoing programs to support transit use and infrastructure. Appropriate strategies will vary by building ownership and occupancy type. For example, a multi-tenant facility with third-party management is less likely to provide subsidized transit passes than an owner-occupied facility, but it could establish a program to inform occupants about transit opportunities.

SS	
NC	Credit 4.1
CS	Credit 4.1

Programming options to consider include the following examples:

- Providing financial incentives or subsidized passes for public transportation.
- Instituting a "free ride home" program for public transportation commuters who need to work unexpected hours.
- Promoting the use of mass transit by providing information on transportation options, routes, services, and incentives.
- Participating in local or regional transportation planning to ensure that building occupants' needs are considered.
- Establishing a method for tracking public transportation ridership.

12. RESOURCES

WEBSITES

ESRI
http://www.esri.com

This software company creates tools for geographic information systems (GIS) mapping.

Online TDM Encyclopaedia
www.vtpi.org/tdm/

This online encyclopedia from the Victoria Transport Policy Institute is a comprehensive source of information about innovative management solutions to transportation problems.

Escape the Rush
http://content.calgary.ca/CCA/City+Hall/Business+Units/Transportation+Planning/Transportation+Solutions/Sustainable+Transportation/Escape+the+Rush.htm

The website of this City of Calgary program contains valuable information on commuting options.

Mobili. T
http://www.mobili-t.com/index.html

Mobili. T promotes sustainable modes of travel in Québec, and has valuable information on commuting options on their website.

Resource Conservation Manitoba Green Commuting
http://www.resourceconservation.mb.ca/gci/gci.html

Resource Conservation Manitoba Green Commuting program's website offers valuable information on commuting options.

Smart Commute
www.smartcommute.ca

Smart Commute is a program of Metrolinx that has valuable information about telecommuting and carpool programs useful for any organization. Commuters within the Greater Toronto Area and Hamilton area can use the Carpool Zone on the website to connect with other commuters and arrange for carpooling.

SS	
NC	Credit 4.1
CS	Credit 4.1

Teletrips
www.teletrips.com

Teletrips helps create, implement, and manage public-private partnership programs to reduce commuter congestion, improve air quality, and reduce energy consumption.

TravelWise, Ottawa
http://ottawa.ca/residents/onthemove/travelwise/index_en.html

The City of Ottawa's TravelWise program offers a suite of services to reduce commuting and provides valuable information on commuting options.

Travelwise, Waterloo
http://www.region.waterloo.on.ca/web/region.nsf/vwSiteMap/22109C5E1CE95C5485257181004D11A0?OpenDocument

The Region of Waterloo's Travelwise program offers a suite of services to reduce commuting and provides valuable information on commuting options.

U.S. EPA, Office of Transportation and Air Quality
Environmental Protection Agency
http://www.epa.gov/otaq

This U.S. EPA website provides information on the types and effects of air pollution associated with automobile use and links to resources for organizations interested in promoting commuter choice programs.

13. DEFINITIONS

A **campus or private bus** is a bus or shuttle service that is privately operated and not available to the general public. In LEED, a campus or private bus line that falls within 1/4 mile of the project site and provides transportation service to the public can contribute to earning credits.

Frequent service is access to public transit with intervals of no more than 30 minutes during peak times for each line in each direction and available during hours of building operation.

OR

is at least 50 transit rides per day total, at all stops (half-hourly service 24 hours per day or more frequent service for less than 24 hours per day) and available during hours of building operation. For example, 1 bus line with 30 transit rides per day in one direction and a second line with 20 transit rides per day would meet the definition of frequent service. You may only count transit rides for one direction of a transit line.

Mass transit is designed to transport large groups of persons in a single vehicle, such as a bus or train.

Public transportation consists of bus, rail, or other transit services for the general public that operate on a regular, continual basis.

Walking distance is the length of the walkable pathway between the building and public transportation.

SS	
NC	Credit 4.2
CS	Credit 4.2

ALTERNATIVE TRANSPORTATION: BICYCLE STORAGE AND CHANGING ROOMS

	NC	CS
Credit	SS Credit 4.2	SS Credit 4.2
Points	1 point	2 points

INTENT

To reduce pollution and land development impacts from automobile use.

REQUIREMENTS: NC & CS

CASE 1. FOR NON-RESIDENTIAL PROJECTS

Provide secure and covered bicycle racks and/or storage within 183 metres (200 yards) of a building entrance for 5% or more of Full-Time Equivalent (FTE) occupants.

Provide secure bicycle racks and/or storage within 183 metres (200 yards) of a building entrance for 5% or more of peak Transient Users.

Provide shower and changing facilities in the building, or within 183 metres (200 yards) of a building entrance, for 0.5% of Full-Time Equivalent (FTE) occupants.

CASE 2. FOR MULTI-UNIT RESIDENTIAL PROJECTS

Provide covered storage facilities for securing bicycles for 15% or more of building occupants.

INTERPRETATIONS

The use of showers in a separate building is acceptable for providing the required showers provided that the showers are free and easily accessible to cyclists, within the required distance of the LEED Project, and satisfy the calculation requirements for all buildings that the facility is serving.

Non-ambulatory patients assigned to beds and incarcerated individuals can be excluded from the bike rack and shower calculations. This exclusion may be extended to building occupants who are physically unable to ride bicycles. Documentation justifying this exclusion must be presented.

For schools (K-12), showers provided must be dedicated to staff.

	SS
NC	Credit 4.2
CS	Credit 4.2

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

The environmental effects of automobile use include vehicle emissions that contribute to smog and air pollution, as well as environmental impacts from oil extraction and petroleum refining. Bicycling as an alternative to personal vehicle use offers a number of environmental benefits. Bicycle commuting produces no emissions, has zero demand for petroleum-based fuels, relieves traffic congestion, reduces noise pollution, and requires far less infrastructure for roadways and parking lots. Roadways and parking lots, on the other hand, produce stormwater runoff, contribute to the urban heat island effect, and encroach on green space.

Bicycles are more likely to be used for relatively short commuting trips. Displacing vehicle miles with bicycling, even for short trips, carries a large environmental benefit because a large portion of vehicle emissions occur in the first few minutes of driving. Following a cold start, emissions control equipment is less effective because of cool operating temperatures.

ECONOMIC ISSUES

The initial cost of building bike storage areas and changing facilities or showers is typically low relative to the overall project cost. When buildings accommodate bicycling infrastructure, occupants can realize health benefits through bicycle and walking commuting strategies. Bicycling and walking also expose people to the community, encouraging interaction among neighbours and allowing for enjoyment of the area in ways unavailable to automobile passengers.

2. RELATED CREDITS

The materials used for paving on-site bicycle lanes can affect the heat island and stormwater properties of the project. Refer to the following credits:

- SS Credit 6: Stormwater Design
- SS Credit 7.1: Heat Island Effect—Nonroof

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

Select a site that provides convenient access to safe bicycle pathways and secure bicycle storage areas for cyclists. Shower and changing areas for cyclists should be easily accessible from the bicycle storage areas.

Look for functional and direct paths that can be used by bicycle commuters, and size and locate bike racks and showering facilities appropriately.

Secure bike storage systems vary in design and cost. A common approach is to install racks where users can individually park and lock their bikes. Spaces should be easily accessible by building occupants throughout the year, free of charge. Where required, bike storage must be covered to protect bicycles from weather and theft. Commercial office buildings should consider regional commuting patterns and provide appropriate amenities. Retail developments should consider bicycle usage for both employees and retail customers. Showering facilities can be shared between buildings as long as the facilities are within 183 metres (200 yards) walking distance of the entrance to the project building. The facilities can be unit showers or group showers.

SS	
NC	Credit 4.2
CS	Credit 4.2

5. TIMELINE AND TEAM

Bicycle storage and shower facilities should be incorporated into design concepts during schematic design and design development. By considering bicycling early on, the project team can implement a successful alternative transportation program. For example, during the site selection phase, the project team can include proximity to existing bicycle commuting infrastructure as a criterion. Coordination among the architect, plumbing engineer, civil engineer, and/or landscape architect may be required for locating and designing bicycle storage and shower facilities. The project team should also consider future expansion opportunities.

6. CALCULATIONS

To determine the number of secure bicycle storage spaces and changing and showering facilities required for the building, follow the steps below.

STEP 1

Identify the total number of building occupants for each of the following occupancy types:

a. Full-time staff.
b. Part-time staff.
c. Peak transients (students, volunteers, visitors, customers, etc.).
d. Residents.

In buildings with multiple shifts, use only the highest-volume shift in the calculation but consider shift overlap when determining peak building use. For projects that include residential spaces, estimate the number of residents based on the number and size of units. Generally, assume 2 residents per 1-bedroom unit, 3 residents per 2-bedroom unit, etc. If occupancy is not known, see Appendix 1, Default Occupancy Counts, for occupancy count requirements and guidance.

STEP 2

For full-time and part-time staff, calculate the full-time equivalent (FTE) occupants based on a standard 8-hour occupancy period. An 8-hour occupant has an FTE value of 1.0; a part-time occupant has a FTE value based on work hours per day divided by 8 (see Equation 1). FTE calculations for each shift must be used consistently for all LEED credits.

Equation 1. FTE Occupants

$$\text{Total FTE Occupants} = \frac{\text{Total Occupant Hours}}{8}$$

SS	
NC	Credit 4.2
CS	Credit 4.2

STEP 3

Calculate the number of secure bicycle spaces required for each group of occupants, according to Equation 2.

Equation 2. Number of Secure Bike Spaces

FTE Occupant Spaces (covered) = FTE Occupants X 0.05

Transient Spaces = Peak Transients X 0.05

Resident Spaces = Residents X 0.15

Certain types of transient populations can be excluded from these calculations if they cannot reasonably be expected to arrive by bicycle and thus use on-site storage facilities. For example, air travelers arriving at an airport will not need bicycle storage. Project teams should be prepared to justify the exclusion of any transients from the calculations.

STEP 4

Calculate the number of showers required for FTE Occupants using Equation 3.

Equation 3. Staff Showering Facilities

Showering Facilities = FTE Occupants X 0.005

Transient occupants and residents are not counted in the showering facility calculation.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Determine the number of occupants of each type and calculate the number of bicycle storage and showering facilities required.
- Develop a plan showing the location and quantity of bicycle storage and shower facilities and determine the distance between facilities and the building entry.

SS	
NC	Credit 4.2
CS	Credit 4.2

8. EXAMPLES

EXAMPLE 1. New Construction: College Classroom Building

Many college buildings house faculty, staff, and students, complicating the calculation of FTEs. In Table 1, the building occupants are separated into full-time and part-time users to simplify the calculation. The number of persons is multiplied by the number of hours they spend in the building each day and then divided by 8 to calculate the FTE value.

TABLE 1. SAMPLE OCCUPANCY CALCULATION FOR COLLEGE BUILDING

FTE STAFF OCCUPANT CALCULATIONS, PARRISH HALL								
OCCUPANTS	**PERSONS**		**PERSON-HOURS PER DAY**		**TOTAL PERSON-HOURS PER DAY**		**HOURS PER DAY PER FTE**		**FTES**
Full-time staff									
Administrators	8	x	8	=	64	÷	8	=	8
Faculty	6	x	8	=	48	÷	8	=	6
Part-time staff									
Faculty	24	x	2	=	48	÷	8	=	6
Researchers	20	x	4	=	80	÷	8	=	10
Total FTE occupants									30
TRANSIENT OCCUPANT CALCULATION									
Occupants									Number at Peak Period
Students									310
Visitors									6
Total									316
SUMMARY									
Total FTE occupants									30
Transient occupants									316

In this example, the required number of secure and covered bicycle storage space for FTE occupants is 30 x 0.05 = 1.5, or 2 spaces. The required number of secure bicycle racks and/or storage space for peak transients is 316 x 0.05 = 15.8, or 16 spaces, in addition to those above. The required number of changing and showering facilities is 30 x 0.005= 0.15, or 1.

SS	
NC	Credit 4.2
CS	Credit 4.2

9. EXEMPLARY PERFORMANCE

There is no exemplary performance path for this credit.

10. REGIONAL VARIATIONS

This credit may have particular importance in areas that have good but unrealized potential for bicycle use or areas where bicycle use is not promoted by the municipality. Establishing bicycling facilities will help promote greater bicycle use.

Project teams in areas with poor air quality may also want to encourage bicycling as a way of reducing single-occupancy vehicle usage, a major contributor to air quality problems.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Consider working with building owners and operators to develop ongoing programs to support bicycle use. Appropriate strategies will vary by building ownership and occupancy type.

Program options include the following:

- Providing financial incentives for commuting via bicycle.
- Instituting a "free ride home" program for bicycle riders who need to work unexpected hours.
- Promoting bicycling to the community by providing information on safe bike routes, locations of secure bicycle parking, lockers, showers, etc.
- Providing discounts on bicycle accessories and maintenance at local bike shops.
- Participating in local or regional transportation planning to ensure that building occupants' needs are considered. Bike lanes along corridors leading to the project site can significantly influence ridership levels.
- Establishing a method for tracking bicycle ridership.

12. RESOURCES

WEBSITES

Bicycle Coalition of Maine, Employer's Guide to Encouraging Bicycle Commuting
http://www.bikemaine.org/employers-guide

This website from the Bicycle Coalition of Maine suggests ways to encourage and facilitate bike commuting.

Information and links for bicycle parking issues can be found at
http://www.bicyclinginfo.org/engineering/parking.cfm

Bike to Work
www.biketowork.ca

This online resource for bicycle commuters provides a variety of links and information.

Commuting Guide for Employers
http://www.self-propelled-city.com/index.php

This website outlines strategies employers can use to encourage employees to commute by bicycle.

SS	
NC	Credit 4.2
CS	Credit 4.2

Pedestrian and Bicycle Information Center
http://www.bicyclinginfo.org

The Pedestrian and Bicycle Information Center provides information and resources for issues related to bicycle commuting, including health and safety, engineering, advocacy, education and facilities.

U.S. EPA, Transportation and Air Quality
http://www.epa.gov/otaq/

This website provides information on the types and effects of air pollution associated with automobile use and links to resources for organizations interested in promoting commuter choice programs.

13. DEFINITIONS

Bicycle racks, in LEED, include outdoor bicycle racks, bicycle lockers, and indoor bicycle storage rooms.

Covered bicycle storage is secure bicycle racks, which are protected from the elements. Examples include enclosed lockers, storage provided within the building, or racks provided under shelter.

Full time equivalent (FTE) occupants are building users, such as staff, that occupy the building for extended periods of time. The total FTE occupancy of a building for LEED calculations is taken for the 8 hour (consecutive) period during which the highest occupancy occurs. Part-time users are prorated to an equivalent 8 hour period.

Secure bicycle storage is an internal or external space that keeps bicycles safe from theft. It may include lockers and storage rooms.

Transient users are occupants who do not use a facility on a consistent, regular, daily basis. Examples include students in higher education settings, customers in retail settings, and visitors in institutional settings. For the purposes of this credit, transients also include K-12 students.

14. CASE STUDY

SS	
NC	Credit 4.2
CS	Credit 4.2

VANCOUVER ISLAND TECHNOLOGY PARK
LEED-NC 2.0 Gold, 3 February 2002

Location: Victoria, BC
Building Type: Office building/laboratory
Building Size: 17,700m^2
Owner Name: University of Victoria
LEED Consultant: BC Buildings Corporation
Responsible Firm (for this credit): JVB Development Corporation
Photo Credit: Alex Zimmerman

The first LEED certified building in Canada, University of Victoria's Vancouver Island Technology Park (VITP) is a LEED Gold project located near Victoria, British Columbia. VITP's design team set out to improve the 14 hectare site with renovated, high tech office buildings in what was an abandoned hospital.

The project team undertook a sustainable transportation study to determine strategies for the reduction of car traffic and pollution by encouraging alternative forms of transport. This resulted in negotiations with BC Transit to establish a bus service to the technology park directly from primary locations within Victoria. Two bus stops, a bus layby, and a transit loop are provided on site along with a transit shelter and well-lit walkways. Bicycling is also facilitated by the extension of the popular Galloping Goose trail which provides a more direct and safe route for bicyclists. Interior and exterior secured bike storage consists of 180 stalls, while showers are available for bicycle users at VITP's fitness centre, located within the building. In addition, carpool vehicles and Smart cars are given preferential parking spaces and provisions have been made to accommodate electric vehicles.

SS	
NC	Credit 4.3
CS	Credit 4.3

ALTERNATIVE TRANSPORTATION: LOW-EMITTING & FUEL-EFFICIENT VEHICLES

	NC	CS
Credit	SS Credit 4.3	SS Credit 4.3
Points	3 points	3 points

INTENT

To reduce pollution and land development impacts from automobile use.

REQUIREMENTS

OPTION 1. NC & CS

Install alternative-fuel refuelling stations for 3% of the total vehicle parking capacity of the site. Liquid or gaseous fuelling facilities must be separately ventilated or located outdoors.

OR

OPTION 2. NC

Provide low-emitting and fuel-efficient vehicles for 3% of full-time equivalent (FTE) occupants.

Provide preferred parking for these vehicles.

Note: Employee owned vehicles contribute towards this credit if supported by an organization-wide incentive program.

OR

OPTION 3. NC

Provide building occupants access to a low-emitting and fuel-efficient vehicle-sharing program. The following requirements must be met:

- One low-emitting or fuel-efficient vehicle must be provided per 3% of FTE occupants, assuming that 1 shared vehicle can carry 8 people (i.e., 1 vehicle per 267 FTE occupants). For buildings with fewer than 267 FTE occupants, at least one fuel-efficient vehicle must be provided.
- The vehicle sharing contract must demonstrate an agreement of at least 2 years.

SS	
NC	Credit 4.3
CS	Credit 4.3

- The estimated number of customers served per vehicle must be supported by documentation.
- A narrative explaining the vehicle-sharing program and its administration must be submitted.
- Parking for low-emitting and fuel-efficient vehicles must be located in the nearest available spaces in the nearest available parking area. Provide a site plan or area map clearly highlighting the walking path from the parking area to the project site and noting the distance.

ALL OPTIONS

For the purposes of this credit, low-emitting and fuel-efficient vehicles are defined as vehicles having a Combined Fuel Consumption Rating (CFCR) of 6.5L/100km or less, as defined by Natural Resources Canada's Office of Energy Efficiency.

INTERPRETATIONS

Providing power outlets to charge Electric Vehicles (EVs), Plug-in Hybrid Electric Vehicles (PHEVs), and/or Neighbourhood Electric Vehicles (NEVs) also known as Low Speed Vehicles (LSVs), can be used to achieve this Credit. NEVs are defined as *any four wheeled electric vehicle with an attainable speed of more than 32 km/h (20 mph) and not more than 40 km/h (25 mph)*. NEVs/LSVs should not be confused with golf carts, which commonly have a lower maximum speed, all terrain vehicles that are primarily intended for off-road use.

To achieve this Credit by providing power outlets, the outlets must be only used for charging EVs, PHEVs, and/or NEVs; therefore outlets that may or can be used for block heaters are not acceptable for this Credit. Access to the power must be "secured" to ensure intended use (such as through signage indicating EV parking only as well as either metering and charging for the power used and/or securing access to the power through a lock-box or device of similar functionality).

This credit may be achieved through a combination of Options 1, 2, & 3 provided the total number of compliant vehicles/refuelling stations is met.

CAMPUS

In projects where the occupants of more than one building use the low-emitting or fuel-efficient vehicle fleet, the number of these vehicles must serve at least 3% of the FTEs of all LEED buildings. Preferred parking in shared parking structures within 500 metres of the LEED project(s) is acceptable.

SS	
NC	Credit 4.3
CS	Credit 4.3

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Vehicle operation significantly contributes to global climate change and air quality problems through the emission of greenhouse gases (GHGs) and pollutants generated from combustion engines and fuel evaporation. In Canada, the transportation sector has generated more carbon dioxide emissions than any other end-use sector since 2003, and in 2007 was responsible for nearly 36% of total GHG emissions.[8] The Personal vehicles also generate large portions of the air pollutants responsible for smog and ground-level ozone, both of which have negative effects on human health.

Alternative-fuel and fuel-efficient vehicles offer the possibility of reducing air pollutants from vehicular travel as well as the negative environmental effects of producing gasoline. However, the extent to which alternative vehicles produce environmental benefits depends on the complete life-cycle of their fuels and the vehicle technology. For example, electric vehicles generate zero GHGs during operation, but the amount of GHGs emitted during the production of the electricity that these vehicles require varies greatly depending on the electricity source. Furthermore, the combustion of some alternative fuels releases less of certain pollutants but more of others. Because the environmental benefits of alternative fuels and alternative vehicles depend on complete fuel-cycle energy use and emissions, project teams should carefully consider available technologies and fuel sources before committing to purchasing vehicles or installing fuel stations.

ECONOMIC ISSUES

Initial costs for vehicles and buses using alternative fuel are higher than for conventional vehicles, and this may delay their purchase. Federal, provincial, and local government may offer tax incentives for purchasing alternative vehicles, which can help offset their higher initial costs. Different alternative-fuel vehicles need different fuelling stations, and the costs vary. Hybrid vehicles are gaining traction in the marketplace, which should help drive down their cost. Providing preferred parking generally involves minimal extra cost. For fuel-efficient vehicles, reduced operating costs can offset higher initial purchase prices or higher fuel costs.

2. RELATED CREDITS

Ideally, overall parking capacity would not increase as a result of incorporating designated spaces for low-emitting or fuel-efficient vehicles. Projects that provide preferred parking without increasing overall capacity may be eligible for the following credit:

- SS Credit 4.4: Alternative Transportation—Parking Capacity

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

SS	
NC	Credit 4.3
CS	Credit 4.3

If occupants of a project building use fleet vehicles (or if certain occupants are permitted to use a company vehicle), consider providing low-emitting and fuel-efficient vehicles. Assess the qualifying makes and models to determine the best way to meet the fleet needs for a project building.

Establishing alternative-fuel vehicle fuelling stations requires the consideration of legal, technical, and safety issues that vary by fuel type. Project teams may want to start with the following actions:

- Poll future building occupants to determine which alternative fuel type is in highest demand.
- Compare the environmental and economic costs and benefits of alternative fuels to determine which type would be most beneficial.
- Research local codes and standards for fuelling stations in the area.
- Compare fuelling station equipment options and fuel availability. Price and complexity of installation vary with the type of fuel. Lack of availability may limit the feasibility of providing fuelling stations for some types of fuels.
- Learn about the safety and maintenance issues associated with alternative fuels. Building personnel will need to be trained to operate and maintain the fuelling stations.

Consider the building's use when establishing preferred parking for low-emitting and fuel-efficient vehicles. For commercial office buildings, the location of these designated spaces should be closest to the main entrance of the project or the most desirable spaces. For example, covered parking spaces or parking spaces closest to the employee entrance may be deemed more desirable. Offering discounted parking rates for low-emitting and fuel-efficient vehicles is another way to comply with this credit's requirements. Mixed-use projects should consider the traffic patterns related to each use. Because retail developments often require that employees not park near the main entrance, consider other kinds of incentives.

5. TIMELINE AND TEAM

The architect and design team, with the project owner, should choose the appropriate approach for the building's future users. Any fuelling stations for alternative-fuel vehicles should be incorporated into design concepts during schematic design and design development. If such vehicles are purchased as part of the strategy, communicate requirements to procurement officials well in advance of the deadline for ordering the vehicles. Designating parking spaces is generally not as time sensitive as other strategies, but a plan should be developed early.

SS	
NC	Credit 4.3
CS	Credit 4.3

6. CALCULATIONS

NC & CS

OPTION 1

To determine the number of alternative-fuel vehicle fuelling stations required, multiply the total number of parking spaces in the project by 3%.

NC

OPTION 2

To determine the number of low-emitting and fuel-efficient vehicles required, follow the steps below.

STEP 1

Identify the total number of full-time and part-time building occupants. In buildings with multiple shifts, use only the highest-volume shift in the FTE calculation but consider shift overlap when determining peak building use.

STEP 2

Calculate the number of FTE occupants based on a standard 8-hour occupancy period. An 8-hour occupant has an FTE value of 1.0; a part-time occupant has a FTE value based on work hours per day divided by 8 (see Equation 1). FTE calculations for each shift of the project must be used consistently for all LEED credits.

If occupancy is not known, see Appendix 1, Default Occupancy Counts, for occupancy count requirements and guidance.

Equation 1

$$\text{Total FTE Occupants} = \frac{\text{Total Occupant Hours}}{8}$$

STEP 3

Multiply the number of FTE occupants by 3% to determine the number of vehicles and preferred parking spaces to provide.

SS	
NC	Credit 4.3
CS	Credit 4.3

NC

OPTION 3

To determine the number of low-emitting and fuel-efficient vehicles to be provided by a vehicle-sharing program, divide the project's FTE occupancy (see Equation 1) by 267 (1 vehicle must be provided for every 267 occupants; see Equation 2). If fewer than 267 FTEs occupy the building, provide a least 1 vehicle.

Equation 2

$$\text{Number of Low-Emitting and Fuel-Efficient Vehicles} = \frac{\text{FTE Occupancy}}{267}$$

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

NC & CS

OPTION 1

- Prepare information about the number of fuelling stations provided, the alternative fuel station type, manufacturer, model number, and the fuelling capacity per station.

NC

OPTION 2

- Determine the number of FTE occupants and calculate the number of qualifying vehicles that must be provided.
- Record information about purchased vehicles, including make, model, and fuel type.
- Prepare a site plan showing the location of preferred parking spaces, or collect photos showing parking spaces building proximity and signage.

SS	
NC	Credit 4.3
CS	Credit 4.3

NC

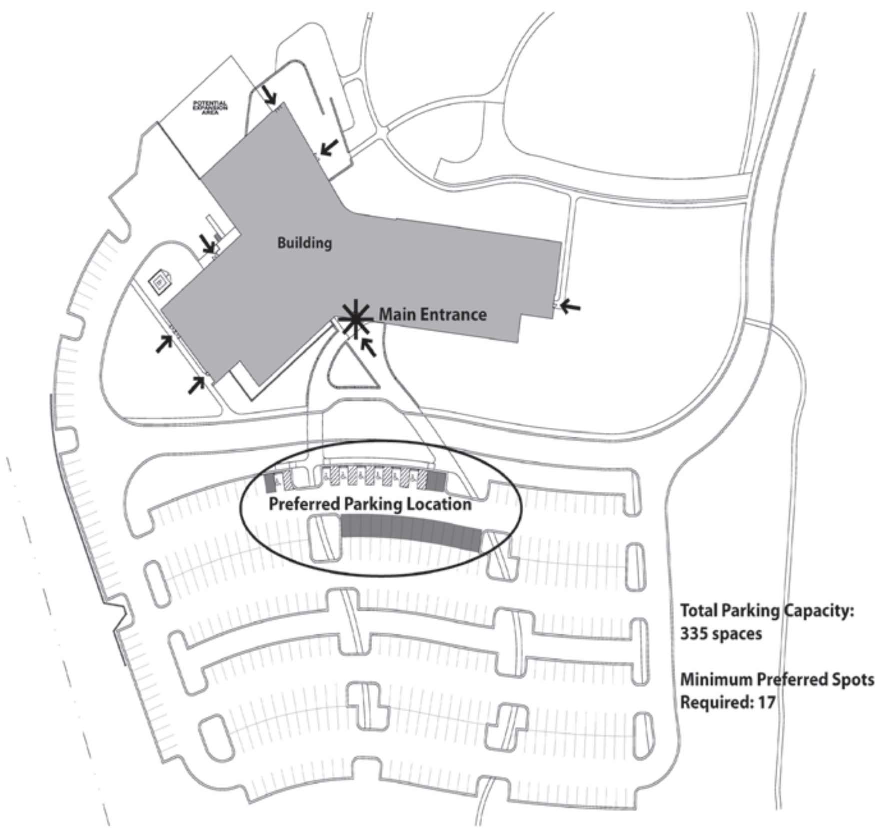
OPTION 3

- Prepare information about low-emitting and fuel-efficient shared vehicles, including quantity, make, model, and fuel type.
- Retain a copy of the contractual agreement with the vehicle sharing program.
- Assemble information about the vehicle sharing program, including estimates of the number of customers served per vehicle and descriptions of its administration.
- Develop a site plan or area map that highlights a pedestrian walkway from the parking area to the project site or collect photos demonstrating this sufficiently.

8. EXAMPLES

A *LEED Canada for New Construction* project building provides low-emitting or fuel-efficient vehicles and designated parking for these vehicles. The project's total FTE occupancy is 565. Three percent of 565 is 16.95, so at least 17 qualifying vehicles and preferred parking spaces near the building entrance must be provided. Figure 1 illustrates the location of preferred parking spaces.

FIGURE 1. LOCATION OF PREFERRED PARKING



SS	
NC	Credit 4.3
CS	Credit 4.3

9. EXEMPLARY PERFORMANCE

Only 1 exemplary performance credit is available under SS Credit 4, Alternative Transportation. See SS Credit 4.1, Alternative Transportation—Public Transportation Access.

10. REGIONAL VARIATIONS

Certain regions have better-developed infrastructure for some types of alternative fuels than others. Consider the existing infrastructure when making decisions about which alternative fuel to offer at the project building.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Establish procedures for the use of preferred parking, communicate them to building occupants, and assign operations staff for their administration. The procedures might include providing a list of qualifying vehicles (make, model, year) based on a Combined Fuel Consumption Rating (CFCR) of 6.5L/100km or less, as defined by Natural Resources Canada's Office of Energy Efficiency, establishing a system for enforcing use of designated spaces (e.g., a permitting system), discounting paid parking, and tracking the use of preferred parking.

For project buildings with alternative-fuel fuelling stations, special maintenance and safety procedures may be necessary. Ensure that building operators are given complete information about manufacture recommended maintenance and any applicable regulations and safety considerations for management of fuels.

12. RESOURCES

WEBSITES

Canadian Renewable Fuels Association
http://www.greenfuels.org

CRFA is a non-profit organization mandated to promote renewable biofuels (ethanol, biodiesel) for automotive transportation through consumer awareness and government liaison activities. CRFA's efforts focus on promoting public awareness of the merits of renewable fuels — via workshops for automotive sales/service personnel and fuel retailers, media awareness activities, newsletters/ publications, annual convention, expanding the CRFA internet information site, etc. They maintain a list of alternative fuel stations across Canada.

California Air Resources Board, Cleaner Car Guide
http://www.driveclean.ca.gov/

CARB has developed a comprehensive, searchable buyer's guide to finding the cleanest cars on the market. The guide also lists advantages clean vehicles offer.

Center for Renewable Energy and Sustainable Technology
http://www.repp.org/hydrogen/index.html

This is the CREST's online page about fuel cells and hydrogen.

SS	
NC	Credit 4.3
CS	Credit 4.3

Electric Auto Association
http://www.eaaev.org

This nonprofit education organization promotes the advancement and widespread adoption of electric vehicles.

Electric Vehicle Council of Ottawa
http://www.evco.ca/site

This nonprofit incorporated organization promotes the advancement and widespread adoption of electric vehicles.

Natural Resources Canada's Alternative Fuels
http://oee.nrcan.gc.ca/transportation/vehicle-fuels.cfm

Provides Canadians with information on alternative fuels and their benefits, and a database of natural gas, methanol or ethanol refuelling stations across Canada.

Natural Resources Canada's Fuel Consumption Ratings
http://oee.nrcan.gc.ca/transportation/tools/fuelratings/ratings-search.cfm

Provides Canadians with information on the fuel consumption of various makes and models of vehicles.

Union of Concerned Scientists, Clean Vehicle Program
http://www.ucsusa.org/clean_vehicles

This site provides information about the latest developments in alternative vehicles, the environmental impact of conventional vehicles, and documents such as the guide Buying a Greener Vehicle: Electric, Hybrids, and Fuel Cells.

U.S. Department of Energy, Fuel Economy
http://www.fueleconomy.gov/feg

This website offers comparisons of new and used cars and trucks based on gas mileage (mpg), greenhouse gas emissions, air pollution ratings, and safety information.

U.S. Department of Energy, Office of Transportation Technologies, Alternative Fuels Data Center
http://www.afdc.energy.gov

This center provides information on alternative fuels and alternatively fuelled vehicles, a locator for alternative fuelling stations, and more. Their Alternative Fuel Vehicles and Advanced Technology Vehicle Listing for 2010 can be found online at http://www.afdc.energy.gov/afdc/pdfs/my2010_afv_atv.pdf.

Vancouver Electric Vehicle Association
http://www.veva.bc.ca

This nonprofit society promotes the development of environmentally sustainable electric vehicles.

13. DEFINITIONS

SS	
NC	Credit 4.3
CS	Credit 4.3

Alternative Fuel Refuelling Station is a refuelling station which serves fully functioning alternative fuel vehicles (as might be used by commuters to travel to and from the project site).

Alternative-fuel vehicles are substantially non-petroleum and yield energy security and environmental benefits. These are: Methanol and denatured ethanol as alcohol fuels (alcohol mixtures that contain no less than 70% of the alcohol fuel), Bio-diesel, Natural gas (compressed or liquefied), Liquefied petroleum gas, Hydrogen, Fuels derived from biological materials, and electricity (including solar energy), Efficient gas-electric hybrid vehicles that can drive using only electric power are included in this designation.

Fuel-efficient vehicles are vehicles having a Combined Fuel Consumption Rating (CFCR) of 6.5L/100km or less, as defined by Natural Resources Canada's Office of Energy Efficiency.

Vehicle Sharing Program is a membership based service that operates with a distributed fleet of motor vehicles parked at varying reserved locations that are made available to members primarily for hourly or other short term use through a self-service, fully automated system not requiring a separate contract for each use. (Washington Metro Transit Authority)

Full Time Equivalent (FTE) Occupants are building users that occupy the building for extended periods of time, such as staff. The total FTE occupancy of a building for LEED calculations is taken for the 8 hour (consecutive) period during which the highest occupancy occurs. Part-time users are prorated to an equivalent 8 hour period.

Greenhouse gases are relatively transparent to the higher-energy sunlight but trap lower-energy infrared radiation (e.g., carbon dioxide, methane, and CFCs).

Hybrid vehicles use a gasoline engine to drive an electric generator and use the electric generator and/or storage batteries to power electric motors that drive the vehicle's wheels.

Low-emitting and **fuel-efficient vehicles**, for the purpose of this credit, are defined as vehicles having a Combined Fuel Consumption Rating (CFCR) of 6.5L/100km or less, as defined by Natural Resources Canada's Office of Energy Efficiency.

Preferred Parking are the parking spaces that are closest to a main entrance of the project (exclusive of spaces designated for handicapped persons), the most desirable or parking passes provided at a discounted price.

SS	
NC	Credit 4.4
CS	Credit 4.4

ALTERNATIVE TRANSPORTATION: PARKING CAPACITY

	NC	CS
Credit	SS Credit 4.4	SS Credit 4.4
Points	2 points	2 points

INTENT

To reduce pollution and land development impacts from automobile use.

REQUIREMENTS: NC & CS

CASE 1. NON-RESIDENTIAL PROJECTS

OPTION 1

Size parking capacity to meet but not exceed minimum local zoning requirements.

Do not exceed 3.5 spaces per 93 square metres (1000 square feet) of gross floor area.

Provide preferred parking for carpools or vanpools for 5% (for New Construction) or 3% (for Core and Shell) of the total provided parking spaces.

OR

OPTION 2

For projects that provide parking for less than 5% (for New Construction) or 3% (for Core and Shell) of full-time equivalent (FTE) building occupants:

Provide preferred parking for carpools or vanpools, marked as such, for 5% (for New Construction) or 3% (for Core and Shell) of total parking spaces. Providing a discounted parking rate is an acceptable substitute for preferred parking for carpool or vanpool vehicles. To establish a meaningful incentive in all potential markets, the parking rate must be discounted at least 20%. The discounted rate must be available to all customers (i.e. not limited to the number of customers equal to 5% of the vehicle parking capacity), publicly posted at the entrance of the parking area, and available for a minimum of 2 years.

SS	
NC	Credit 4.4
CS	Credit 4.4

OR

OPTION 3

Provide no new parking.

Do not exceed 3.5 spaces per 93 square metres (1000 square feet) of gross floor area.

For projects with existing parking, provide preferred parking for carpools or vanpools for 5% (for New Construction) or 3% (for Core and Shell) of the total provided parking spaces.

CASE 2. RESIDENTIAL PROJECTS

OPTION 1

Size parking capacity to meet but not exceed minimum local zoning requirements.

Provide infrastructure and support programs to facilitate shared vehicle usage such as carpool drop-off areas, designated parking for vanpools, or car-share services, ride boards, and shuttle services to mass transit.

OR

OPTION 2

Provide 20% less parking than required by the standard local zoning by-law requirements for residential projects in the general area of the development.

OR

OPTION 3

Provide no new parking.

Do not exceed 3.5 spaces per 93 square metres (1000 square feet) of gross floor area.

CASE 3. MIXED USE (RESIDENTIAL WITH COMMERCIAL/RETAIL) PROJECTS

Mixed-use buildings with less than 10% commercial area must be considered residential and adhere to the residential requirements in Case 2. For mixed-use buildings with more than 10% commercial area, the commercial space must adhere to non-residential requirements in Case 1 and the residential component must adhere to residential requirements in Case 2.

SS	
NC	Credit 4.4
CS	Credit 4.4

INTERPRETATIONS

For NC projects, where carpooling or vanpool parking spaces are provided, a carpool management plan must be developed.

Short term parking (i.e., coin operated metering) may be excluded for the calculation of carpool spaces.

Parking spaces reserved for vehicles used as part of the operation of a building (not used by staff to commute) may be excluded from all parking capacity calculations.

CAMPUS

Where all required parking is within the LEED project site area and no parking is used or allocated elsewhere, then the project can show compliance using one of the 3 cases. Alternatively for projects with shared parking, demonstrate that the total parking capacity for the Campus (including current and master planned projects to be developed within 5 years) meets one of the 3 cases.

The preferred parking and designated parking for carpools, vanpools or car co-ops required under Cases 1 to 3 need only be provided for the LEED building(s) but must be within 500 metres (550 yards) of the project.

It is acceptable to achieve a Campus Shared Infrastructure compliance path through a campus wide strategy if the campus can demonstrate that the preferred parking spots for carpools/vanpools/car co-ops are located at the discretion of the permit holders within the campus, though this may mean the selected spaces are not within 500m of each individual project(s).

Where local zoning requirements defining parking space to occupant ratios do not exist, apply the requirement for the central business district of the nearest municipality.

Street parking on municipal roads and primary roads providing central circulation to Campus traffic is excluded from this credit.

SS	
NC	Credit 4.4
CS	Credit 4.4

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Reducing private automobile use saves energy and avoids associated environmental problems, such as vehicle emissions that contribute to smog, air pollution, and greenhouse gas emissions, as well as environmental impacts associated with oil extraction and petroleum refining. The environmental benefits of carpooling are significant. For example, if 100 people carpooled (2 people per car) 16 km (10 miles) to work and 16 km (10 miles) home instead of driving separately, they would prevent about 440 kg (970 pounds) of carbon dioxide equivalent emissions per day and would forgo 190 L (50 gallons) of gas per day.[9]

Parking facilities also have negative impacts on the environment because asphalt surfaces increase stormwater runoff and contribute to urban heat island effects. By restricting the size of parking lots and promoting carpooling, project teams can reduce these effects and provide such benefits as more green space.

ECONOMIC ISSUES

Carpooling reduces the size of parking areas needed to support building occupants, allowing a building to accommodate more occupants without enlarging the parking area. Carpooling also helps reduce building costs, since less land is needed for parking and less infrastructure is needed to support vehicles. Smaller parking areas can decrease the amount of impervious surfaces on a site. This may result in reduced stormwater costs if the local utility bases its fees on impervious surface area. Moreover, because fewer cars on the road means less pollution, traffic congestion, and wear and tear to roadways, many municipalities and state governments offer tax incentives for carpooling programs.

2. RELATED CREDITS

Minimizing parking, particularly surface parking, by meeting but not exceeding zoning requirements can provide opportunities for enhancing open space, minimizing heat island effect, and minimizes stormwater runoff. See the following credits:

- SS Credit 5.1: Site Development—Protect and Restore Habitat
- SS Credit 5.2: Site Development—Maximize Open Space
- SS Credit 6: Stormwater Management
- SS Credit 7.1: Heat Island Effect—Non-roof

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

Limit the availability of parking to encourage the use of alternative forms of transportation to and from the site. Choose a project site that is easily accessible from residential areas by bicycle or public transportation. Once the site is selected, determine how many cars are likely to drive to the site and compare this number with local zoning requirements. If parking demand is expected to be less than that required by local codes, consider seeking a variance with the appropriate authorities to provide less parking. However, any on-site parking reductions should be carefully balanced with community needs to avoid needlessly burdening surrounding neighbourhoods with excessive street parking.

SS	
NC	Credit 4.4
CS	Credit 4.4

Where possible, develop transportation demand management strategies to reduce the number of parking spaces required to meet the needs of occupants. Transportation demand strategies may include publishing rosters with addresses to assist occupants, employees, and students in finding carpool partners, creating incentive programs for carpooling, providing a rideshare board, or setting parking fees at a level sufficient to encourage carpooling. When designing for schools, establish policies that will discourage or prohibit unnecessary student driving.

5. TIMELINE AND TEAM

Discussions regarding reduction of parking capacity are most productive at the project concept phase. This may entail discussions with zoning and civic officials and could include community and neighbourhood organizations. A traffic study can be a valuable tool for evaluating traffic patterns and expected commuting in single-occupancy vehicles. An additional team member may be engaged as part of the project team to develop this traffic study.

Because of their size or location or because of regulatory requirements, many projects may entail zoning negotiations over the parking requirements. Planned developments may have unique parking requirements that are valuable to consider and discuss as part of the overall alternative transportation strategies.

Design solutions to reduce parking capacity for the project site should be incorporated during schematic design and design development. The architect and design team, with the project owner, should choose the most appropriate approach for future occupants.

6. CALCULATIONS

Calculations are required for the options listed below; other approaches require no calculations.

CASE 1, OPTION 1 AND 3

Determine the number of parking spaces and multiply by 5% for New Construction projects or 3% for Core & Shell projects to determine the number of designated carpool or vanpool spaces required.

CASE 1, OPTION 2

Determine the number of FTE occupants (see below) and calculate the percentage for whom parking is provided. If parking is provided for less than 5% of FTEs, multiply the total number of parking spaces by 5% for New Construction projects or 3% for Core & Shell projects) to determine the number of designated carpool or vanpool spaces required.

FULL-TIME EQUIVALENT OCCUPANTS

To determine the number of full-time equivalent occupants, follow the steps below.

STEP 1

Identify the total number of full-time and part-time building occupants. In buildings with multiple shifts, use only the highest-volume shift in the FTE calculation but consider shift overlap when determining peak building use.

SS	
NC	Credit 4.4
CS	Credit 4.4

STEP 2

Calculate the full-time equivalent (FTE) number of occupants based on a standard 8-hour occupancy period. An 8-hour occupant has an FTE value of 1.0; a part-time occupant has a FTE value based on work hours per day divided by 8 (see Equation 1). FTE calculations for each shift of the project must be used consistently for all LEED credits.

If occupancy is not known, see Appendix 1, Default Occupancy Counts, for occupancy count requirements and guidance.

Equation 1: FTE Occupants

$$\text{Total FTE Staff Occupants} = \frac{\text{Total Staff Occupant Hours}}{8}$$

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measure. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Prepare information about the amount and type of parking provided, and how carpooling or vanpooling is supported by infrastructure and/or programming. Depending on the option pursued, this might include information about parking capacity, number of preferred parking spaces, number of FTEs, zoning requirements, or copies of brochures that communicate carpooling and vanpooling support structures to occupants.
- Prepare a site plan showing the location of preferred parking spaces, or collect photos showing parking spaces building proximity and signage.

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

Only 1 exemplary performance credit is available under SS Credit 4, Alternative Transportation. See SS Credit 4.1, Alternative Transportation—Public Transportation Access.

10. REGIONAL VARIATIONS

There are no regional variations associated with this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

For project buildings that include preferred parking, establish procedures for the use of this amenity, communicate them to building occupants, and assign operations staff for their administration. The procedures might include establishing a system for enforcing use of designated spaces (e.g., a permitting system), discounting paid parking, and tracking use of preferred parking.

SS	
NC	Credit 4.4
CS	Credit 4.4

12. RESOURCES

WEBSITES

Carpool.ca
https://www.carpool.ca/

National carpool site to promote development of rideshare programs.

Carpool Zone (Smart Commute)
http://www.carpoolzone.smartcommute.ca

To connect commuters in Ontario to share rides.

Jack Bell Ride-Share for BC
https://online.ride-share.com

Operates large-scale public vanpooling service and provide online ride-matching for BC.

Pathway Intelligence Inc.
http://www.carpooltool.com/

Provides turnkey solution to enable and track carpooling and vanpooling both public, and across organizations

The Carpooling Network
http://www.carpoolingnetwork.com/

Provide affiliated partners with the tools and support required to manage carpooling programs.

U.S. EPA, Transportation and Air Quality
http://www.epa.gov/otaq/

This site provides information on the types and effects of air pollution associated with automobile use and links to resources for organizations interested in promoting commuter choice programs.

13. DEFINITIONS

A **carpool** is an arrangement by which 2 or more people share a vehicle for transportation.

A **mixed-use project** has at least 10% of the floor area for tenants whose space function is different from the majority of the building (e.g., MURB plus either retail or office or combo of both).

Preferred Parking are the parking spaces that are closest to the main entrance of the project (exclusive of spaces designated for handicapped persons), the most desirable or parking passes provided at a discounted price.

SS	
NC	Credit 5.1
CS	Credit 5.1

SITE DEVELOPMENT: PROTECT OR RESTORE HABITAT

	NC	CS
Credit	SS Credit 5.1	SS Credit 5.1
Points	1 point	1 point

INTENT

To conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

REQUIREMENTS: NC & CS

CASE 1. GREENFIELD SITES

Limit all site disturbance to the following parameters:

- 12 metres (40 feet) beyond the building perimeter;
- 3 metres (10 feet) beyond surface walkways, patios, surface parking and utilities less than 300 mm (12 inches) in diameter;
- 4.5 metres (15 feet) beyond primary roadway curbs and main utility branch trenches;
- 7.5 metres (25 feet) beyond constructed areas with permeable surfaces (such as pervious paving areas, stormwater detention facilities and playing fields) that require additional staging areas to limit compaction in the constructed area.

CASE 2. PREVIOUSLY DEVELOPED AREAS OR GRADED SITES

Restore or protect a minimum 50% of the site area (excluding the building footprint) or 20% of the total site area (including building footprint), whichever is greater, with native or adapted vegetation. Projects earning 5 points under SS Credit 2: Development Density and Community Connectivity may include vegetated roof surface in this calculation if the plants are native or adapted, provide habitat, and promote biodiversity.

SS	
NC	Credit 5.1
CS	Credit 5.1

INTERPRETATIONS

The open space that counts toward earning this credit is intended to stay open for the life of the building.

A vertical living wall planted with native or adaptive plants may be included as part of the calculation for achievement of SS Credit 5.1 under the following conditions:

1. The site was previously developed;
2. The project also earns 5 points under Sustainable Sites Credit 2 (Development Density and Community Connectivity);
3. Plants used on the living wall meet the requirement for native /adaptive, providing habitat and promoting biodiversity (as above);
4. The living wall incorporates growing media to preclude the need for ongoing and frequent maintenance, and chemical solutions.

While it is recognized that a living wall does not provide the same benefit as a grade level restoration, in a dense urban location a living wall can provide some habitat that would be otherwise unavailable.

CAMPUS

This credit can be achieved on a campus-wide basis by demonstrating the entire campus meets the requirements of the credit. The campus site plan must clearly indicate all buildings (and future buildings), all parking areas, all shared amenities, and most importantly, the restored site area. If a master planning approach is used on the Campus, all future projects and their open space allocation must be included.

Municipal roads and primary roads providing central circulation to the Campus are excluded from calculations for this credit.

In phased projects this credit may be captured for the entire build-out based on a finalized development master plan. Include a copy of the finalized development master plan.

SS	
NC	Credit 5.1
CS	Credit 5.1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Development on building sites often damages site ecology, indigenous plants, and regional animal populations. Natural areas provide important ecological services, including effective and natural management of stormwater volumes. Ecological site damage can be mitigated by restoring native and adapted vegetation and other ecologically appropriate features to a site, which in turn provide habitat for fauna. Other ecologically appropriate features are natural site elements beyond vegetation that maintain or restore the ecological integrity of a site. These may include water bodies, exposed rock, bare ground or other features that are part of the natural landscape within a region and provide habitat value. Establishing strict site boundaries and staging areas during construction reduces damage to the site and helps preserve wildlife habitats and migration corridors.

For school project teams, connecting a school building to its historical natural landscape can provide meaningful opportunities for student learning outside the classroom.

ECONOMIC ISSUES

Native or adapted plantings require less maintenance than non-native plants and reduce costs over the building life cycle by minimizing the need for fertilizers, pesticides, and irrigation. In many cases, trees and other vegetation grown off-site are expensive and may not survive transplanting. Additionally, trees and other landscaping, as well as soil remediation and water features, will add to initial costs. To distribute costs over time, it may be advantageous to implement site restoration in phases. Strategic plantings can shade a building's and site's impervious areas, which can decrease cooling loads during warm months and reduce energy expenditures. If vegetated roofs are used to satisfy credit requirements, energy costs are generally lessened because of their insulating properties.

2. RELATED CREDITS

Protecting or restoring habitat provides open space, which minimizes the stormwater runoff and heat island problems that stem from impervious surfaces. Use of native vegetation on-site or as part of a vegetated roof may contribute to achieving the following credits:

- SS Credit 5.2: Site Development—Maximize Open Space
- SS Credit 6.1: Stormwater Design—Quantity Control
- SS Credit 6.2: Stormwater Design—Quality Control
- SS Credit 7.1: Heat Island Effect—Non-roof
- SS Credit 7.2: Heat Island Effect—Roof
- WE Credit 1: Water-Efficient Landscaping

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

SS	
NC	Credit 5.1
CS	Credit 5.1

4. IMPLEMENTATION

Preserve and enhance natural site elements, including existing water bodies, soil conditions, ecosystems, trees, and other vegetation. Identify opportunities for site improvements that would increase the area of native and adapted vegetation or other ecologically appropriate features. The landscape plan must include a wide variety of native/adaptive species and not be dominated by a few species. Any grasses or plantings intended to require ongoing and frequent maintenance such as mowing or chemical inputs (fertilizers, pesticides, herbicides), in monoculture or polyculture, cannot be considered to achieve this credit's requirements. Restoration and maintenance activities might include removing unnecessary paved areas and replacing them with landscaped areas, or replacing large lawns with native or adapted plantings to promote biodiversity and provide habitat to native animals. If possible, connect protected or restored areas to habitat corridors adjacent to the project site. The open space that counts toward earning this credit is intended to stay open for the life of the building.

For sites that contain both greenfield and previously developed areas, the project must comply with those site conditions' specific criteria. For example, if a 4 hectare (10-acre) site contains 2 hectares (5 acres) of greenfield and 2 hectares (5 acres) of previously developed land, site disturbance must be limited in the greenfield area, and native and adapted vegetation must be protected or restored for at least 50% (excluding the building footprint) of the previously developed site area. For projects that can demonstrate the majority of development is on the previously developed site area, the total site area can be used to demonstrate that at least 50% has been protected or restored with native and adapted vegetation. In these situations, minimizing the development of the greenfield portion of the site is an environmentally sound choice.

During the construction process, establish clearly marked construction and disturbance boundaries and note the site protection requirements in construction documents. The contractor should delineate lay-down, recycling, and disposal areas and use paved areas for staging activities. Erecting construction fencing around the dripline of existing trees will protect them from damage and soil compaction by construction vehicles. Consider the costs and benefits of contractual penalties if protected areas outside the construction boundaries are destroyed. The contractor should coordinate infrastructure construction to minimize the disruption of the site and work with existing topography to limit cut-and-fill efforts for the project.

For urban projects with few landscape opportunities, consider installing a vegetated roof to help meet the credit requirements. A landscape architect can help select native, adapted, and non-invasive species; a structural engineer should confirm that the roof structure is designed to support the added weight of plant beds. Research the bird and insect species that are likely to use the roof and select plants that will provide food, forage, or nesting areas. Vegetated roofs that lack a diversity of habitat-providing species types do not meet the intent of the credit.

Assess the impact of building and site development on resident and migratory wildlife and determine the necessary measures to reduce the threat that building windows pose to birds. Building façades that reflect trees, vegetated open space, wetlands, and water bodies may require measures to reduce the potential for collisions (see guidance in SS Credit 5.2, Maximize Open Space). Teams should avoid planting trees and shrubs that attract wildlife in locations likely to be reflected in building glazing unless they also take measures to reduce bird collisions. Such plants should be placed either very close - 0.9 metres or less (3 feet or less) to windows or far enough away that the reflection will not be mistaken for actual vegetation.

SS	
NC	Credit 5.1
CS	Credit 5.1

5. TIMELINE AND TEAM

Consult landscape architects, ecologists, environmental engineers, civil engineers, and local professionals who can provide site-specific expertise during the site design process and can help in identifying opportunities to minimize the building footprint and impervious areas. Have an ecologist, a government official, or other qualified professional identify the site's important environmental characteristics, including wetlands, sloped areas, special habitat areas, and forested areas to be protected. In the construction documents, clearly identify construction entrances and site disturbance setbacks; verify their locations on the site before construction proceeds. During construction, the site superintendent or other responsible party should routinely inspect fences and boundaries to ensure that construction activities are not encroaching on the protected areas. If a vegetated roof is part of the strategy for achieving this credit, the roof designers should work with a structural engineer to address load issues.

6. CALCULATIONS

CASE 1. GREENFIELD SITES

There are no calculations required for this case.

CASE 2. PREVIOUSLY DEVELOPED AREAS OR GRADED SITES

Compliance with the credit requirements is based on the project building's site area, the building footprint, and the size of site areas covered with native or adapted vegetation or other ecologically important site features. First subtract the building footprint from the total site area and multiply this area by 0.5 (Equation 1). Then multiply the total site area by 0.2. The larger of these 2 area calculations is equal to the area of restored or protected habitat required. Using scaled site drawings, determine the size of qualifying natural areas. These areas must contain polycultures of native or adapted plant species or otherwise meet the definition of an ecologically appropriate site feature.

Equation 1

50% of Site (excluding building footprint) = (Total Site Area – Building Footprint Area) X 0.5

Equation 2

20% of Total Site = Total Site Area X 0.2

The building footprint and site boundary used for SS Credit 5.1 must be applied consistently across other credits.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- For greenfield sites, develop site plans that clearly demarcate disturbance boundaries. Collect photos of the disturbed areas.
- For previously developed or graded sites, prepare site plans that highlight the protected or restored site area and list native and adapted plant species. Also, prepare a short narrative describing species selection and maintenance.

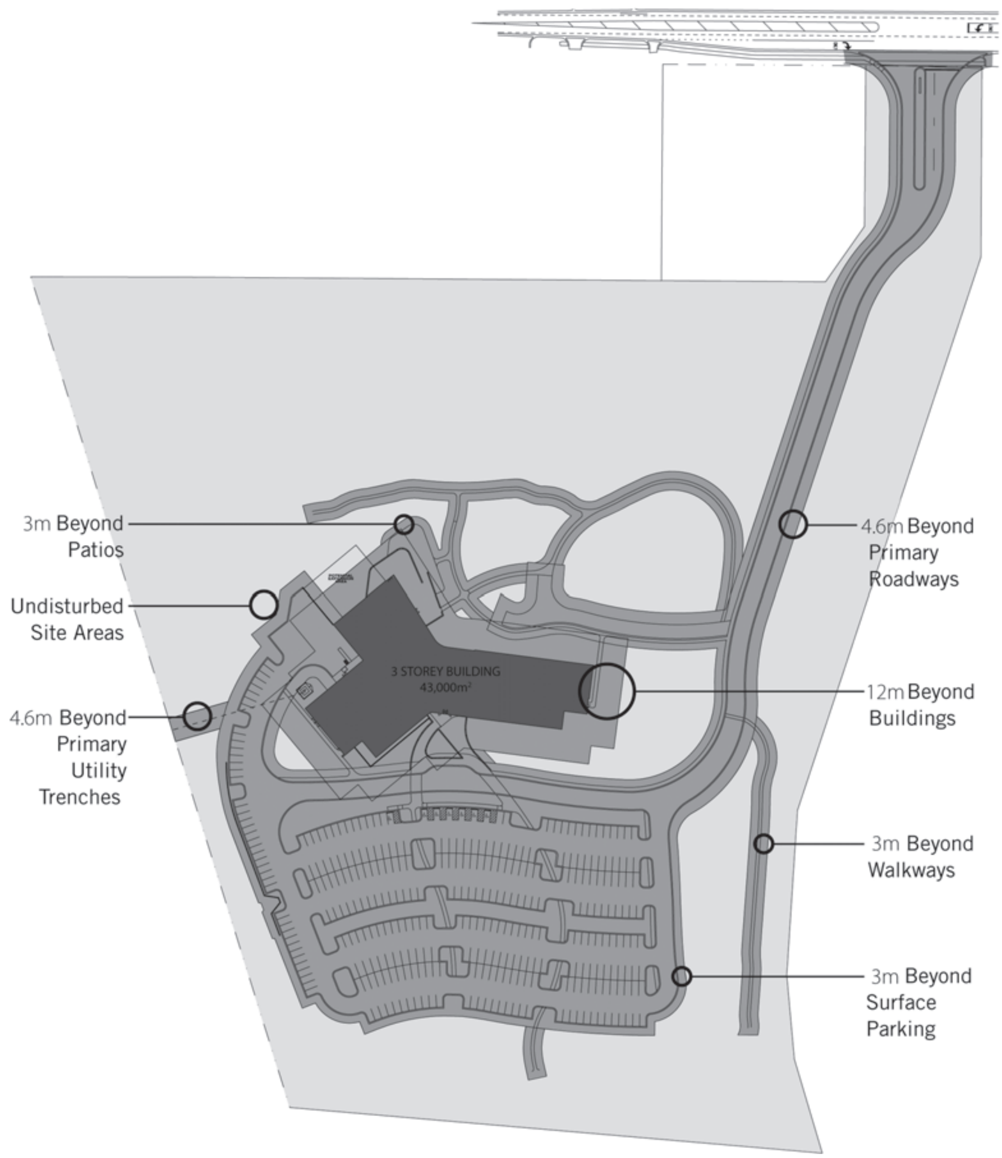
SS	
NC	Credit 5.1
CS	Credit 5.1

8. EXAMPLES

CASE 1. GREENFIELD SITES

Figure 1 shows disturbance boundaries around the development footprint that protect the site's natural areas.

FIGURE 1. EXAMPLE OF DISTURBANCE BOUNDARIES

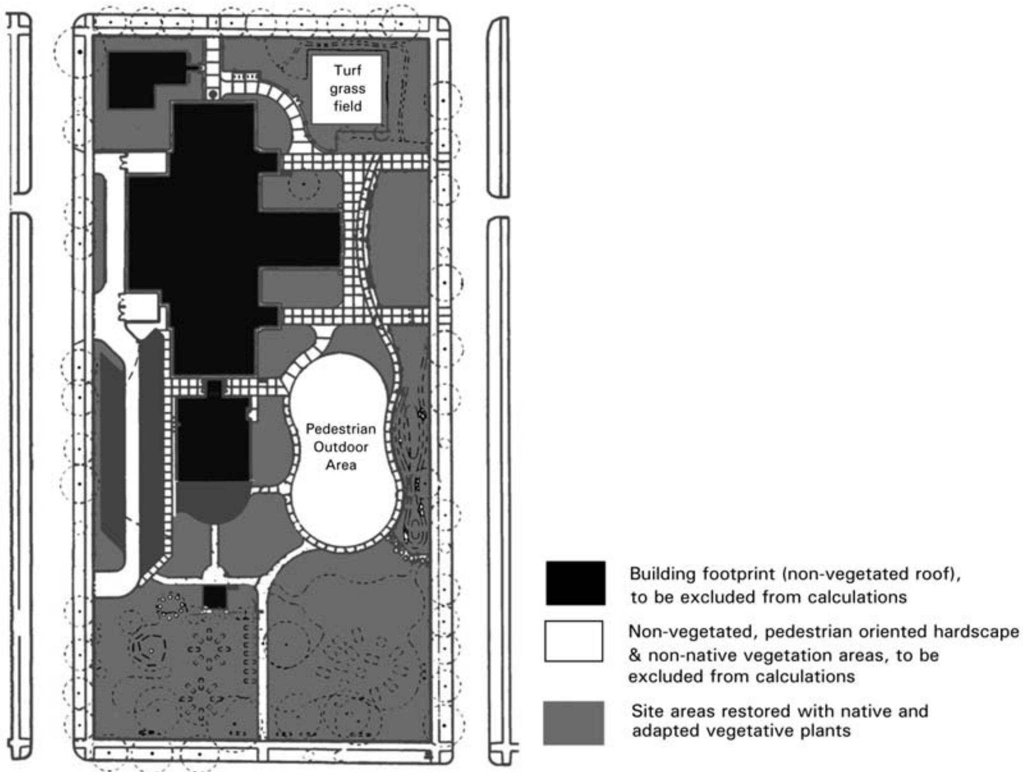


SS	
NC	Credit 5.1
CS	Credit 5.1

CASE 2. PREVIOUSLY DEVELOPED AREAS OR GRADED SITES

Figure 2 shows the areas of a site used for calculating the percentage of site area qualifying as protected or restored.

FIGURE 2. EXAMPLE OF SITE DRAWING SHOWING NATURAL AREAS



9. EXEMPLARY PERFORMANCE

Projects may earn an Innovation in Design credit for exemplary performance by restoring or protecting a minimum of 75% of the site (excluding the building footprint) or 30% of the total site (including building footprint), whichever is greater, with native or adapted vegetation.

10. REGIONAL VARIATIONS

By definition, native and adapted plants vary with climate and region. Focus on protecting and restoring vegetation and ecological features that are appropriate to the local area.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Landscape design affects the type of maintenance needed to support the health of the plant species on site, as well as the frequency and methods for hardscape maintenance. Landscaping can also be a source of contaminants entering the building.

In vegetated areas near walkways, consider using plant species that will drop few leaves, petals, or berries to minimize hardscape maintenance requirements. Be aware that certain types of

SS	
NC	Credit 5.1
CS	Credit 5.1

vegetation produce allergens that will affect building occupants. Avoid plantings that will harbour pest populations near the building shell.

Consider coordinating with building operators and landscape maintenance contractors or groundskeepers to establish a sustainable landscape management plan; the plan should include the following:

- A list of all plant species used in the site landscaping plan, with notations about which species meet the LEED definition of native or adapted species.
- Information about invasive species and pests that plantings may harbour.
- Best maintenance practices for the chosen plantings.
- Site maps that show boundaries around protected or restored habitat that should not be disturbed or developed during future projects.

For the first 2 to 3 years, watering and weeding may be necessary to establish new plantings. Once established, native and adapted plantings generally require minimal maintenance, so water and fertilizing applications should be reduced or eliminated. Certain species may require occasional pruning or mowing to maintain. Fall mowing should not occur until after seeds have matured to ensure that annuals will return the next spring and to help perennials spread.[10]

12. RESOURCES

WEBSITES

Canadian Society of Landscape Architects
http://www.csla.org

CSLA is the national professional association representing landscape architects. Its website provides information about products, services, publications, and events.

American Bird Conservancy
http://www.abcbirds.org

ABC is a national leader in reducing human effects on birds and wildlife. ABC's bird collision program supports national efforts to reduce bird mortality through education and advocacy.

Birds and Buildings Forum
http://www.birdsandbuildings.org

This Chicago-based non-profit organization supports bird-friendly design through education and advocacy. Its website maintains lists of organizations and resources.

Ecological Restoration
http://www.ecologicalrestoration.info

This quarterly print and online publication from the University of Wisconsin-Madison Arboretum provides a forum for people interested in all aspects of ecological restoration.

Evergreen Foundation
http://www.evergreen.ca/en

A registered national charity founded in 1991 working to create healthy cities through innovative community naturalisation projects across Canada - on school grounds, on public lands, and on the home landscape.

SS	
NC	Credit 5.1
CS	Credit 5.1

Fatal Light Awareness Program
http://www.flap.org

Initiated the Bird-Friendly Building Development Program for the City of Toronto, FLAP monitors and promotes bird-friendly design.

Native Plant Crossroads
http://nature.ca/plnt/res/res_org_e.cfm

From the Canadian Museum of Nature, this site lists native plant resources and organizations by province.

North American Native Plant Society
http://www.nanps.org

NANPS is a non-profit association dedicated to the study, conservation, cultivation, and restoration of native plants. Its website contains links to state and local associations.

Society for Ecological Restoration International
http://www.ser.org

The mission of this non-profit consortium of scientists, planners, administrators, ecological consultants, landscape architects, engineers, and others is to promote ecological restoration as a means of sustaining the diversity of life and to re-establish an ecologically healthy relationship between nature and culture.

Soil and Water Conservation Society
http://www.swcs.org

This organization focuses on fostering the science and art of sustainable soil, water, and related natural resource management.

The Nature Conservancy
http://www.nature.org

The Nature Conservancy is a conservation organization that works to protect ecologically important lands and water.

PRINT MEDIA

Design for Human Ecosystems: Landscape, Land Use, and Natural Resources, by John Tillman Lyle (Island Press, 1999). This text explores types of landscape design that function like natural ecosystems.

Landscape Restoration Handbook, by Donald Harker, Marc Evans, Gary Libby, Kay Harker, and Sherrie Evans (Lewis Publishers, 1999). This resource is a comprehensive guide to natural landscaping and ecological restoration and provides information on 21 types of ecological restoration.

Bird-Safe Building Guidelines (New York City Audubon Society, Inc., May 2007). This publication provides useful information on minimizing bird collisions with buildings and offers case studies and design strategies for constructing new buildings and retrofitting existing buildings. The 38MB publication can be downloaded from http://www.nycaudubon.org/home/BirdSafeBuildingGuidelines.pdf

SS	
NC	Credit 5.1
CS	Credit 5.1

13. DEFINITIONS

Adapted (or introduced) plants reliably grow well in a given habitat with no winter protection, pest control, fertilization, or irrigation once their root systems are established. Adapted plants are considered low maintenance and not invasive.

Biodiversity is the variety of life in all forms, levels, and combinations, including ecosystem diversity, species diversity, and genetic diversity.

Building footprint is the area on a project site used by the building structure, defined by the perimeter of the building plan. Parking lots, landscapes, and other non-building facilities are not included in the building footprint.

The **development footprint** is the area affected by development or by project site activity. Hardscape, access roads, parking lots, nonbuilding facilities, and the building itself are all included in the development footprint.

Graded Site is any land or property that has been modified for human use as farmland or open space.

Invasive plants are non-native to the ecosystem and likely to cause harm once introduced. These species are characteristically adaptable and aggressive, have a high reproductive capacity, and tend to overrun the ecosystems they enter. Collectively, they are among the greatest threats to biodiversity and ecosystem stability.

Local zoning requirements are local government regulations imposed to promote orderly development of private lands and prevent land-use conflicts.

Native (or indigenous) plants are adapted to a given area during a defined time period and are not invasive. In North America, the term often refers to plants growing in a region prior to the time of settlement by people of European descent.

Open space area is usually defined by local zoning requirements, but for the purposes of LEED calculations, it is defined as the property area minus the development footprint; it must be vegetated and pervious, with exceptions only as noted in the credit requirements section. Only ground areas are calculated as open space. For projects located in urban areas that earn 5 points under SS Credit 2, Development Density and Community Connectivity, open space also includes non-vehicular, pedestrian-oriented hardscape spaces.

Previously Developed is any land or property that contains (or recently contained) infrastructure or buildings.

Previously undeveloped land / Greenfield is property that has not been modified for human use through construction or manipulation of the land, or has returned to a natural state after an extended period during which no human influence was present.

SITE DEVELOPMENT: MAXIMIZE OPEN SPACE

	NC	CS
Credit	SS Credit 5.2	SS Credit 5.2
Points	1 point	1 point

INTENT

To promote biodiversity by providing a high ratio of open space to development footprint.

REQUIREMENTS: NC & CS

CASE 1. SITES WITH LOCAL ZONING OPEN SPACE REQUIREMENTS

Reduce the development footprint and/or provide vegetated open space within the project boundary such that the amount of open space exceeds local zoning requirements by 25%.

CASE 2. SITES WITH NO LOCAL ZONING REQUIREMENTS (e.g., some university campuses, military bases)

Provide vegetated open space area adjacent to the building that is equal in area to the building footprint.

CASE 3. SITES WITH LOCAL ZONING BUT NO OPEN SPACE REQUIREMENTS

Provide vegetated open space equal to 20% of the project's site area.

ALL CASES

For projects in urban areas that earn 5 points under SS Credit 2: Development Density and Community Connectivity, accessible vegetated roof areas can contribute to credit compliance.

For projects in urban areas that earn 5 points under SS Credit 2: Development Density and Community Connectivity, pedestrian oriented hardscape areas can contribute to credit compliance. For such projects, a minimum of 25% of the open space counted must be vegetated.

Wetlands or naturally designed ponds may count as open space if the side slope gradients average 1:4 (vertical: horizontal) or less and are vegetated.

SS	
NC	Credit 5.2
CS	Credit 5.2

INTERPRETATIONS

CAMPUS

Campus projects wishing to achieve this credit under campus-wide compliance must use the "no zoning requirement" case. The campus site plan must clearly indicate all buildings (and future buildings), all parking areas, all shared amenities, and most importantly, the open space area. If a master planning approach is used on the Campus, all future projects and their open space allocation must be included.

Municipal roads and primary roads providing central circulation to the Campus are excluded from calculations for this credit.

In phased projects this credit may be captured for the entire build-out based on a finalized development master plan. Include a copy of the finalized development master plan.

SS	
NC	Credit 5.2
CS	Credit 5.2

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Open space provides habitat for vegetation and wildlife. Even small open spaces in urban areas can provide refuges for wildlife populations that have become increasingly marginalized. Plants that support insects and other pollinators can help sustain populations higher up the food chain. Open space also reduces the urban heat island effect, increases stormwater infiltration, and provides human populations with a connection to the outdoors.

ECONOMIC ISSUES

Preserving topsoil, plants, and trees on a site can reduce landscaping costs. Even where rents are high and the incentive to build out to the property line is strong, well-designed open space can significantly increase property values. Reducing the footprint of a structure on a given site can have varying economic impacts. Building a vertical structure with the same square footage as a horizontal structure may add a small percentage to initial costs, depending on building size and use. However, a structure with a smaller footprint is generally more resource efficient, resulting in reduced material and energy costs. A more compact building with coordinated infrastructure can reduce initial project costs as well as operations and maintenance costs. Reduced earthwork, shorter utility lines, and reduced surface parking and paved areas all can decrease initial project costs. If vegetated roofs are used to satisfy credit requirements, energy costs are generally lessened because of their insulating properties.

2. RELATED CREDITS

Providing vegetated open space on the project site may contribute to stormwater mitigation goals and reduce the urban heat island effect, in turn helping project teams earn the following credits:

- SS Credit 5.1: Site Development: Protect or Restore Habitat
- SS Credit 6.1: Stormwater Design—Quantity Control
- SS Credit 6.2: Stormwater Design—Quality Control
- SS Credit 7.1: Heat Island Effect—Non-roof
- SS Credit 7.2 : Heat Island Effect—Roof

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

Choose a development footprint and location that minimize disturbance of the existing ecosystem, taking into consideration building orientation, daylighting, heat island effect, stormwater generation, significant vegetation, existing green corridors, and other sustainable sites issues. Once the site and building location have been determined, work with a civil engineer to design and construct a compact parking, road, and building footprint layout to preserve open land and provide connections to adjacent ecosystems. The design team and the owner can reduce footprints by tightening program needs and stacking floor plans.

In a campus setting with no local zoning requirements, open space that is equal to the building footprint can be considered separate from the project site, as long as the open space is preserved for the life of the building.

SS	
NC	Credit 5.2
CS	Credit 5.2

When designing vegetated roofs, pay attention to support, waterproofing, and drainage issues. Vegetated roofs typically include a waterproof and root-repellent membrane, drainage system, filter cloth, lightweight growing medium, and plants. Modular systems are available, with all layers designed as movable interlocking grids, or individual layers can be installed separately.

Urban open space that includes hardscape surfaces should be accessible to pedestrians and provide recreation opportunities. Consider use of pervious paving for these surfaces to aid stormwater management. Examples of urban open space include pocket parks, accessible roof decks, plazas, and courtyards.

Naturally designed ponds provide ecosystem services, such as aquatic habitat, stormwater quality control, and nutrient recycling.

Assess the impact of building and site development on resident and migratory wildlife, and determine the necessary measures to alleviate the threat that building windows pose to birds. Site strategies to maximize vegetated open space may increase the number of bird collisions. Assess the problem and use bird-safe landscaping and façade treatments as appropriate. Specifically, plants that attract birds should be placed either very close to glazed façades 0.9 metres (3 feet) or less or far enough away that they are not reflected in the windows. Bird-safe treatments for the building design and glazing include using exterior shading devices, introducing etched or frit patterns in the glass, and creating "visual markers" in sufficient locations. Visual markers are differentiated planes, materials, textures, colors, opacity, or other visually contrasting features that help fragment window reflections and reduce overall transparency and reflectivity.

5. TIMELINE AND TEAM

Consult landscape architects, ecologists, environmental engineers, and civil engineers, as well as local professionals who can provide site-specific expertise during the site selection and design process to maximize open space. Have a government official, ecologist or other qualified professional identify important environmental characteristics, including wetlands, sloped areas, special habitat areas, and forested areas, to be protected, and facilitate collaboration between these professionals and the design team. If a vegetated roof is part of the strategy for achieving this credit, the roof designers should work with a structural engineer to address load issues.

6. CALCULATIONS

CASE 1

Determine the amount of open space required by local zoning requirements and multiply by 125% to determine the amount of open space necessary to meet the credit requirement.

CASE 3

Multiply the site area by 20% to determine the amount of open space necessary to meet the credit requirement.

ALL CASES

For projects in urban areas that can count pedestrian-oriented hardscape as open space, multiply the total open space by 25% to determine the portion that must be vegetated.

The building footprint and site boundary used for SS Credit 5.2 must be applied consistently across other credits.

SS	
NC	Credit 5.2
CS	Credit 5.2

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Show that the qualifying open space meets or exceeds the amount required by the credit (see calculations).
- Prepare a site plan that highlights qualifying open space.
- Retain zoning documentation.

8. EXAMPLES

CASE 1. SITES WITH LOCAL ZONING OPEN SPACE REQUIREMENTS

Calculation for a high-rise commercial office building in an urban centre.

A 62,000 square metre commercial office building has an overall site area of 10,800 square metres. The zoning requirement calls for making a minimum of 20% of the net lot area (2160 square metres) public open space. The project is in an urban center, achieves 5 points under SS Credit 2, Development Density and Community Connectivity, and has provided the following open space:

Pedestrian-oriented hardscape	1,400 m^2
Vegetated open space on structure	1,600 m^2
Vegetated open space on grade	50 m^2
Total open space	3,050 m^2
Percentage greater than zoning requirement	41.2%

The percentage of vegetated open space as a portion of the total open space provided is 54.1%. Because the project exceeds the zoning requirements by more than 25% and because more than 25% of the open space is vegetated, the credit requirements are met.

9. EXEMPLARY PERFORMANCE

Projects may earn an Innovation in Design credit for exemplary performance by demonstrating that they have doubled the amount of open space required for credit achievement. All designated open space must be within the LEED project boundary. For example, projects subject to local zoning requirements must increase the amount of open space provided by 50% instead of by 25%; projects not subject to local zoning requirements must provide open space equal to twice the building footprint; and urban projects where zero open space is required must provide open space equal to 40% of the site area.

10. REGIONAL VARIATIONS

There are no regional variations associated with this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

For open spaces with native and adapted vegetation, refer to SS Credit 5.1, Site Development—Protect or Restore Habitat.

SS	
NC	Credit 5.2
CS	Credit 5.2

If open space consists of monoculture and/or non-native plantings, optimize the landscape for sustainable operations by choosing species with relatively low water, fertilizer, and maintenance requirements.

Consider using plant species that will drop few leaves, petals, or berries, to minimize hardscape maintenance requirements. Be aware that certain types of vegetation produce allergens that will affect building occupants. Avoid plantings that will harbour pest populations near the building shell. Consider providing facilities within the landscape design for on-site composting of landscape waste.

Consider working with building operators and landscape maintenance contractors or groundskeepers to establish a sustainable landscape management plan. The plan should specify the following:

- Using organic fertilizers suited to installed species.
- Applying fertilizer only when nutrient deficiencies have been determined through soil testing, and selecting fertilizers based on the soil and plant characteristics.
- Using environmentally preferred maintenance equipment as defined in the *LEED Canada for Existing Buildings: Operations & Maintenance 2009 Reference Guide*, SS Credit 2, Building Exterior and Hardscape Management Plan.
- Using integrated pest management techniques.
- Developing site maps that show boundaries around open space that should not be disturbed or developed during future projects.

12. RESOURCES

WEBSITES

Evergreen Foundation
http://www.evergreen.ca/

A registered national charity founded in 1991 working to create healthy cities through innovative community naturalisation projects across Canada - on school grounds, on public lands, and on the home landscape.

Green Roofs for Healthy Cities
http://www.greenroofs.org

This non-profit industry association consists of individuals and public and private organizations committed to developing a market for green roof infrastructure products and services across North America.

Soil and Water Conservation Society
http://www.swcs.org

This organization focuses on fostering the science and art of sustainable soil, water, and related natural resource management.

The Nature Conservancy
http://www.nature.org

The Nature Conservancy is a conservation organization that works to protect ecologically important lands and water.

SS	
NC	Credit 5.2
CS	Credit 5.2

PRINT MEDIA

Beyond Preservation: Restoring and Inventing Landscapes, by Dwight A. Baldwin, et al. (University of Minnesota Press, 1994).

Design for Human Ecosystems: Landscape, Land Use, and Natural Resources, by John Tillman Lyle and Joan Woodward (Milldale Press, 1999).

Landscape Restoration Handbook, by Donald Harker (Lewis Publishers, 1999).

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SS	
NC	Credit 5.2
CS	Credit 5.2

14. CASE STUDY

DOCKSIDE GREEN PHASE 1 – SYNERGY

LEED Canada – NC 1.0 Platinum, 20 June 2008

Location: Victoria, BC
Building Type: Multi-Unit Residential Building
Building Size: 9,700m^2
Owner Name: Dockside Green Limited Partnership, a partnership between Vancity and Windmill West
LEED Consultant: Busby Perkins+Will
Responsible Firm (for this credit):
Busby Perkins + Will
PWL Partnership
Worley Parsons Komex
Aqua-Tex Scientific Consulting Ltd.
Photo Credit: Aqua-Tex Scientific Consulting Ltd.

Dockside Green, a multi-use development, is located on 15 acres of former industrial land near downtown Victoria. Dockside Green is a multi-phase project, with Phase 1 including four detached buildings constructed over a common underground parking structure. These buildings include a nine-storey residential tower with minor commercial units on the ground floor, a two-storey townhouse, a six-storey building residential tower with minor commercial units on the ground floor, and a four-storey residential building.

Every effort has been made through site selection, planning, landscaping, and design strategies to use land more effectively, minimize construction and operational impacts, and improve the site ecology. At the onset a decision was made by the owner to address a number of LEED issues from a site wide perspective and to take advantage of the various synergies that exist between credits and issues. This was the case for Site Development (previously called Reduced Site Disturbance) which had design synergies with Brownfield Redevelopment, Stormwater Design, Heat Island Effect, Water Efficient Landscaping, Innovative Wastewater Technologies, and Water Use Reduction. This credit was successfully applied for under the campus master plan approach, demonstrating over 53% of the site will be designated as open space with over 90% of the parking spaces underground.

	SS
NC	Credit 5.2
CS	Credit 5.2

The key feature of the open space is a winding internal north/south greenway lined with a pedestrian path connected to a series of plaza and play areas. This greenway, which provides a significant amenity and landscape feature, highlights rainwater harvesting, bio-swales, and indigenous plant life in a naturalized pond. This pond utilizes stormwater captured on the site, along with treated wastewater from the residential and commercial buildings on site, and is planted with native plants that clean the stormwater before it reaches the marine foreshore of Victoria Harbour. In addition, crayfish male and female were introduced into the greenway; an environmentally-friendly method of improving the quality of the water, as the crayfish will eat phytoplankton and algae.

The roofs of the buildings are also fundamental to stormwater management. A large percentage of the roofs are green roofs that capture and evapotranspire rainwater. The remaining roofs are used to capture rainwater, which is stored in cisterns and used for irrigation on-site.

The master plans for Dockside Green limits species selection to native and adaptive plants and over 100 trees are being planted to restore the site.

A final key element of maintaining the open space for Dockside Green was community engagement, applied to the rehabilitation of the onsite publicly-owned Point Ellice Park. This shoreline park was severely damaged. The park rehabilitation design was developed with input from a broad range of community members and other potential stakeholders, such as the Garry Oak Ecosystem Recovery team, The Urban Agriculture Group, Natural Resources Canada and the City Environment and Shoreline Committee. The project is also part of the Green Shore initiative and is being used as a case example by that group (www.greenshores.ca). Green Shore is an initiative of the Stewardship Centre of BC to develop tools for sustainable coastal design and development, including a rating system and certification system for coastal development projects. The plan included a new sand beach and tidal pools as well as native adaptive plant species. All invasive species were removed from the site.

SS	
NC	Credit 6.1
CS	Credit 6.1

STORMWATER DESIGN: QUANTITY CONTROL

	NC	CS
Credit	SS Credit 6.1	SS Credit 6.1
Points	1 point	1 point

INTENT

To limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff and eliminating contaminants.

REQUIREMENTS: NC & CS

CASE 1. SITES WITH EXISTING IMPERVIOUSNESS 50% OR LESS

OPTION 1

Implement a stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the pre-development peak discharge rate and quantity for the 1 and 2-year 24-hour design storms.

OR

OPTION 2

Implement a stormwater management plan that protects receiving waterways from excessive erosion by implementing velocity and quantity control strategies.

CASE 2. SITES WITH EXISTING IMPERVIOUSNESS GREATER THAN 50%

Implement a stormwater management plan that results in a 25% decrease in the rate and volume of stormwater runoff from the 2-year 24-hour design storms.

INTERPRETATIONS

Stormwater strategies that control the site discharge, such as cisterns, could meet the requirements of this credit even if the entire discharge eventually ends up in the municipal system. For instance, in the case of a cistern, it should be demonstrated that the cistern will be holding the stormwater long enough to reduce the 24-hour peak rate and total quantity. It should also demonstrate that the cistern has the effective

SS	
NC	Credit 6.1
CS	Credit 6.1

capacity to reduce the rate after accounting for rainfall stored in the cistern on the previous days (i.e., you cannot simply assume the cistern is empty on the day of the 2 year storm). A key intent of SS Credit 6.1 is to avoid overtaxing natural water flows by managing runoff appropriately.

CAMPUS

As per the Implementation Section, Master Site Development Considerations, this credit is eligible to be achieved on a campus-wide approach. To receive campus-wide approval, the application must demonstrate that the stormwater system meets the LEED requirements for all drainage areas it currently serves and those it is intended to serve in the future.

SS	
NC	Credit 6.1
CS	Credit 6.1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Stormwater is a major source of pollution for all types of water bodies in the United States.[11] Soil compaction caused by site development and the expanse of impervious surfaces, such as roads and parking lots, produce stormwater runoff that contains sediment and other contaminants, including atmospheric deposition, pesticides, fertilizers, vehicle fluid leaks, and mechanical equipment waste. Increased stormwater runoff can overload pipes and sewers and damage water quality, affecting navigation and recreation. Furthermore, municipal systems that convey and treat runoff volumes require significant infrastructure and maintenance.

The health of streams is closely linked to stormwater runoff velocities and volumes. Increases in the frequency and magnitude of stormwater runoff due to development can increase bankfull events and erosion, widen channels, and cause downcutting in streams. Effective on-site management practices let stormwater infiltrate the ground, thereby reducing the volume and intensity of stormwater flows.[12] Additionally, reducing stormwater runoff helps maintain the natural aquifer recharge cycle and restore depleted stream base flows.

ECONOMIC ISSUES

If natural drainage systems are designed and implemented at the beginning of site planning, they can be integrated economically into the overall development. Water retention features require investments for design, installation, and maintenance; these features can also add significant value as site amenities, and costs can be minimized if systems are planned early in the design. The use of pervious pavement as part of an infiltration strategy may reduce the need for expensive and space-consuming retention options as well as the infrastructure needed to support conveyance. Using stormwater for non-potable purposes, such as flushing urinals and toilets, custodial applications, and building equipment uses, would lower costs for potable water. A water analysis can help determine the estimated volume of water available for reuse.

Even small stormwater collection and treatment systems lessen the burden on municipalities for maintenance and repair, resulting in a more affordable and stable tax base. Where public utilities provide stormwater collection and conveyance service, projects may be able to lower stormwater fees by implementing strategies for managing stormwater on-site. Check with the local stormwater utility for fee reduction programs.

2. RELATED CREDITS

Efforts to reduce the rate and quantity of stormwater runoff will result in increased on-site infiltration, reducing stormwater treatment needs. Such steps will help projects achieve the following credit:

- SS Credit 6.2: Stormwater Design—Quality Control

Efforts to decrease impervious surfaces on the project site through pervious pavements, vegetated roofing, and vegetated open space can help meet the requirements of the following credits:

- SS Credit 5.1: Site Development—Protect or Restore Habitat
- SS Credit 5.2: Site Development—Maximize Open Space
- SS Credit 7.1: Heat Island Reduction—Non-roof
- SS Credit 7.2: Heat Island Reduction—Roof

SS	
NC	Credit 6.1
CS	Credit 6.1

Harvested rainwater reduces stormwater runoff and can be reused inside the building in non-potable applications or as landscape irrigation, assisting projects with earning these credits:

- WE Credit 1: Water-Efficient Landscaping
- WE Credit 3: Water Use Reduction

However, projects in dense urban areas that earn credit for development density and community connectivity may have difficulty finding space for stormwater mitigation features. See the requirements for the following:

- SS Credit 2: Development Density and Community Connectivity

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

The best way to achieve this credit may depend on the condition of the site. For a largely undeveloped site, the goal is to preserve stormwater flows and design the project to preserve the natural soil conditions, habitat, and rainfall characteristics. For redevelopment of a previously developed site, the goal typically is to improve stormwater management to restore the natural functions of the site as much as possible and decrease the amount of stormwater runoff.

The best way to minimize stormwater runoff volume is to reduce the amount of impervious surface area. Reducing impervious area can minimize the need for stormwater infrastructure or even make it unnecessary. Stormwater runoff is also affected by site topography and site design. Strategies to minimize or mitigate stormwater runoff may include using pervious paving materials, harvesting stormwater for reuse in irrigation and indoor non-potable water applications, designing infiltration swales, detention basins or facilities, and retention basins or facilities, planting vegetated filter strips, installing vegetated roofs, and clustering development to reduce paved surfaces such as roads and sidewalks.

Ensure that site hardscape surfaces meet all loading and accessibility requirements.

HARVESTING STORMWATER

Stormwater harvested in cisterns or other kinds of tanks can be substituted for potable water in landscape irrigation, fire suppression, toilet and urinal flushing, and custodial uses.

Storage options range from small rain barrels to underground cisterns that hold large volumes of water. Designers of stormwater harvesting systems of any size should consider the following:

1. **Water budget.** How will the harvested water be used and when will it be needed? For example, if stormwater will be used to irrigate landscaping for 4 summer months, teams should estimate the amount of water needed and the amount and timing of precipitation expected.
2. **Drawdown.** The storage system design must provide for the use or release of water between storm events for the design storage volume to be available.
3. **Drainage area.** The size and permeability of the area draining to the storage system determines how much runoff will be available for harvesting. Vegetated roofs will reduce the volume of runoff collected from roof surfaces.
4. **Conveyance system.** Reused stormwater and greywater systems must not be connected to

SS	
NC	Credit 6.1
CS	Credit 6.1

other domestic or commercial potable water systems. Pipes and storage units should be clearly marked (e.g., "WARNING: NON-POTABLE WATER — DO NOT DRINK").

5. **Pretreatment.** Screens or filters may be used to remove debris and sediment from runoff and to minimize pollutants.
6. **Pressurization.** Uses for harvested rainwater may require pressurization. For example, most irrigation systems require water pressure of at least 103 kilopascals (15 psi) to function properly. Stored water has a pressure of 9.73 kPa per metre (0.43 psi per foot) of water elevation, and the water pressure at the bottom of a 3-metre vault would be 29.2 kPa (3 m x 9.73 kPa/m) (~10 ft x 0.43 psi = ~4.3 psi). Pressurization (pump, pressure tank, and filter) costs more but creates a more usable system.

Provincial and local governments have different design requirements for capturing and reusing stormwater runoff. Regulations may specify locations where stormwater may be captured and reused, length of time stormwater can be held in a cistern, and type of water treatment required before reuse. Check with local authorities to determine best management practices that will affect collection and use of harvested stormwater.

MASTER SITE DEVELOPMENT CONSIDERATIONS

In urban settings with regional or master stormwater management systems, it may be possible (and in some cases required) to discharge site runoff into the master system. An off-site stormwater management system designed to manage runoff from the project site can contribute to achieving this credit, provided that the system meets the LEED requirements for all drainage areas that it serves.

5. TIMELINE AND TEAM

The design of stormwater management systems will ideally take place during the earliest planning phases of the project. The most effective designs are integrated with the landscape and building plans to maximize pervious areas and take advantage of possible reuse opportunities.

During pre-design, analyze the conceptual site plan and look for opportunities to decrease impervious area and thereby decrease runoff volumes. During design development, the civil engineer and landscape architect, or qualified environmental professional should design the stormwater management system and perform preliminary calculations to confirm compliance with this credit. During construction, the project team should confirm proper installation and operation of the stormwater management system by reviewing the contractor's as-built drawings.

6. CALCULATIONS

Various methods and computer-based software programs are available to estimate stormwater runoff rates and volumes. The rational method is widely accepted and used to determine peak site runoff rates. Which methods are used will depend on the available data and the preference of the civil engineer (or qualified environmental professional); however, the chosen method should be widely accepted and recognized.

VOLUME CAPTURED VIA COLLECTION FACILITIES

The amount of runoff reduced by a stormwater harvesting system is based on its storage volume, the rate at which the system is emptied, and the interval between storm events. Use Equation 1 to

SS	
NC	Credit 6.1
CS	Credit 6.1

determine the amount of captured runoff and Equation 2 to assess the minimum drawdown rate necessary to empty the tank prior to the next rainfall event. If the actual drawdown rate is less than the minimum drawdown rate, the volume of runoff presumed to be captured by the system must be reduced accordingly.

Equation 1. Volume of Captured Runoff

$$V_r \text{ (cubic metres)} = \frac{(P)(R_v)(A)}{100 \text{ cm/m}}$$

Where V_r = volume of captured runoff

P = average rainfall event (cm)

$R_v = 0.05 + (0.009)(I)$ where I = percentage impervious of collection surface

A = area of collection surface (m^2)

Equation 2. Minimum Drawdown Rate

$$Q_r \text{ (cubic metres per second)} = \frac{\text{Tank Capacity (cubic metres)}}{\text{Rainfall Event Interval (seconds)}}$$

Where Q_r = minimum drawdown rate

CASE 1. EXISTING IMPERVIOUSNESS IS 50% OR LESS (LARGELY UNDEVELOPED SITES)

OPTION 1. DISCHARGE RATE AND QUANTITY

Determine the pre-development discharge rate and quantity for the project. These values are typically calculated by the civil engineer (or qualified environmental professional) using the surface characteristics of the site and data on storm event frequency, intensity, and duration. Calculate the rate and quantity for the 1-year and 2-year 24-hour design storms.

Determine the post-development discharge rate and quantity for the project consistent with the pre development calculations. The post-development rate and quantity must be equal to or less than the pre development values.

OPTION 2. WATERWAY PROTECTION

Describe the project site conditions, measures taken, and controls implemented as part of the project scope that prevent excessive velocities, volumes, and resulting erosion. Hard armouring of the channel or receiving waterway (e.g., rip-rap, concrete) to prevent erosion does not meet the intent of this credit. Include numerical values for pre development and post-development conditions to demonstrate that the rate and quantity of stormwater runoff in the post-development condition are below critical values for the relevant receiving waterways.

CASE 2. Existing Imperviousness is Greater Than 50% (Largely Developed Sites)

Determine the pre-development discharge rate and quantity for the project. These values are typically calculated by the civil engineer (or qualified environmental professional) using the surface characteristics of the site and data on storm event frequency, intensity, and duration. Calculate the rate and quantity for the 2-year 24-hour design storm.

Determine the post-development discharge rate and quantity for the project consistent with the pre-development calculations. The post-development rate and quantity must be at least 25% less than the pre-development values.

SS	
NC	Credit 6.1
CS	Credit 6.1

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

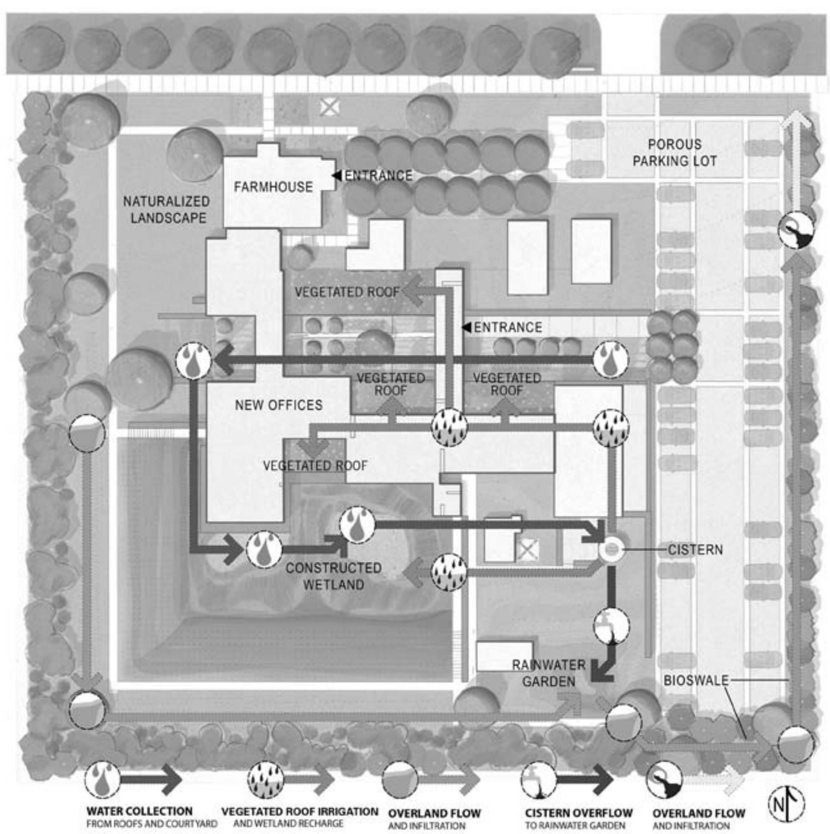
- Determine rates and quantities for pre- and post-development conditions for the required storm events.
- Prepare a stormwater plan assessment. The assessment can be completed by the team during the design phase, taking local regulations into account, or prepared by a qualified environmental professional, civil engineer or other professional.
- List stormwater management strategies and record the percentage of rainfall that each is designed to handle.

8. EXAMPLES

EXAMPLE 1. Strategies for Stormwater Quantity Control

A commercial office project uses multiple strategies for stormwater quantity control. Figure 1 shows the project site plan documenting the stormwater strategies: a cistern for reusing harvested rainwater as irrigation, a constructed wetland and vegetated roof for on-site retention, and rain gardens, bioswales, and pervious paving to increase infiltration.

FIGURE 1. SAMPLE SITE PLAN



SS	
NC	Credit 6.1
CS	Credit 6.1

EXAMPLE 2. Volume of Captured Runoff

Rainwater is harvested from non-vegetated roof surfaces (1,000 m^2 roof area, 100% impervious). The system is designed to capture the runoff from 2.5 cm of rainfall (90% of the average rainfall event for humid watersheds). The volume of the proposed storage system is the amount of runoff captured (V_r):

$$V_r = \frac{(P)(R_v)(A)}{100cm/m} = \frac{(3cm)(0.95)(1{,}000\ m^2)}{100cm/m} = 28.5\ m^3\ (28{,}500\ L)$$

Where:

$R_v = 0.05 + (0.009)\ (I) = 0.05 + (0.009)\ (100) = 0.95$

R_v = volumetric runoff coefficient

I = percentage imperviousness

The tank must be emptied after each storm. Using a tank that is 3-by-3-by-2.5 metres gives a total storage volume (V_s) of 22.5 cubic metres. Using a design storm interval of 3 days (72 hours), the drawdown rate (Q_r) is

$$Q_r = \frac{22.5\ (m^3)}{259{,}200\ (sec)} = 8.68\ x10^{-5}\ m^3/sec\ (5.2\ LPM)$$

In this example, the captured rain must be drained within 3 days, or at a minimum rate of 5.2 L per minute (LPM), for the tank to be emptied before the next storm. If the drainage rate is slower, full capacity cannot be assumed to be available during the 2-year 24-hour design storm.

Source: 2000 Maryland Stormwater Design Manual, Vols. i, ii (MDE, 2000)

9. EXEMPLARY PERFORMANCE

No standardized exemplary performance option has been established for this credit. However, project teams may apply for exemplary performance by documenting a comprehensive approach to capture and treat stormwater runoff and demonstrating performance above and beyond the credit requirements. Only 1 exemplary performance credit may be achieved for SS Credit 6.1, Stormwater Design—Quantity Control, and SS Credit 6.2, Stormwater Design—Quality Control.

10. REGIONAL VARIATIONS

The approach for achieving this credit varies dramatically across different regions and climate zones. The strategies employed in an urban environment where water is discharged to a municipal master system will be much different from the approach for a rural project that discharges to streams or lakes with high water quality standards. Regions that are generally dry and need to retain and reuse rain water but also have seasonally heavy rainfall can benefit greatly from collection and storage strategies.

SS	
NC	Credit 6.1
CS	Credit 6.1

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

The owner and site management team should adopt an ongoing inspection and maintenance plan to ensure the proper upkeep of the entire stormwater management system, including desired levels of vegetation and mulching, repair of washouts, and proper functioning of any controls. Preventing erosion will extend the life of installed stormwater management measures, since silting of infiltration trenches or dry retention wells may impair long-term performance. At a minimum, the maintenance plan should include periodic visual site inspections to identify unsatisfactory conditions and recommendations for typical corrective action. If stormwater harvesting systems are used, schedule periodic checks for leaks and blockages; occasional cleaning may be necessary to keep the system operating effectively.

12. RESOURCES

WEBSITES

Center for Watershed Protection
http://www.cwp.org

A non-profit dedicated to disseminating watershed protection information to community leaders and watershed managers; the center offers online resources, training seminars, and watershed protection techniques.

Ministry of Environment (Ontario) – Stormwater planning
http://www.ene.gov.on.ca/envision/gp/4329eindex.htm

This website features a thorough Stormwater Management Planning and Design Manual.

National Climate Data and Information Archive
http://www.climat.meteo.ec.gc.ca/climateData/canada_e.html

This federal website is useful for researching local climate information such as data for rainwater harvesting calculations.

Metro Vancouver: Stormwater Best Management Practices Guide
http://www.metrovancouver.org/services/wastewater/sources/Pages/StormwaterManagement.aspx

Provides municipalities with a toolbox consisting of a series of stormwater best management practice (BMP) options.

U.S. EPA, Low-Impact Development
http://www.epa.gov/owow/nps/lid

This website provides valuable information on low-impact development through fact sheets, design guides, and cost estimates for low-impact development strategies that reduce stormwater runoff.

U.S. EPA, National Pollutant Discharge Elimination System
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

This website offers help on managing stormwater, including fact sheets on the 6 minimum control measures for management best practices.

SS	
NC	Credit 6.1
CS	Credit 6.1

U.S. EPA, Office of Wetlands, Oceans, and Watersheds
http://www.epa.gov/owow

This website has information about watersheds, water resources, water conservation, landscaping practices, and water pollution.

Water Words Dictionary: A Compilation of Technical Water, Water Quality, Environmental and Water-Related Terms.
http://water.nv.gov/WaterPlanning/dict-1/ww-index.cfm

This dictionary from the Nevada Division of Water Resources. Department of Conservation and Natural Resources (author Gary A. Horton) contains many useful stormwater management terms, some of which were included in the definition section.

PRINT MEDIA

Low-Impact Development Technical Reference Manual for Puget Sound (Puget Sound Action Team and Washington State University Pierce County Extension, 2005). http://www.psp.wa.gov/downloads/LID/LID_manual2005.pdf.

This manual provides technical data, specifications, and performance data for low-impact development design strategies.

Stormwater Best Management Practice Design Guide (EPA/600/R-04/121A) (U.S. Environmental Protection Agency, September 2004).
http://www.epa.gov/nrmrl/pubs/600r04121/600r04121.htm.

Maryland Stormwater Design Manual (Maryland Department of the Environment, October 2000).
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp.

13. DEFINITIONS

An **aquifer** is an underground water-bearing rock formation or group of formations that supply groundwater, wells, or springs.

A **detention basin** is a small storage lagoon for slowing stormwater runoff. Water is only retained in it for a short period of time after a heavy rainfall.[13]

A **detention facility** is "a surface water runoff storage facility that is normally dry but is designed to hold (detain) surface water temporarily during and immediately after a runoff event. Examples of detentional facilities are: natural swales provided with crosswise earthen berms to serve as control structures, constructed or natural surface depressions, subsurface tanks or reservoirs, rooftop storage, and infiltration or filtration basins."[14]

Erosion is a combination of processes or events by which materials of the earth's surface are loosened, dissolved, or worn away and transported by natural agents (e.g., water, wind, or gravity).

Hydrology is the study of water occurrence, distribution, movement, and balances in an ecosystem.

Impervious surfaces have a perviousness of less than 50% and promote runoff of water instead of infiltration into the subsurface. Examples include parking lots, roads, sidewalks, and plazas.

Peak discharge rate is the maximum volume flow rate exiting a site during a storm event. Peak discharge has units of volume/time (e.g. m^3/sec).

SS	
NC	Credit 6.1
CS	Credit 6.1

Predevelopment refers to before the LEED project was initiated, but not necessarily before any development or disturbance took place. Predevelopment conditions describe conditions on the date the developer acquired rights to a majority of the buildable land on the project site through purchase or option to purchase.

Retention is "that part of the precipitation falling on a drainage area that does not escape as a surface streamflow, during a given period."[15]

A **retention basin** is "a permanent lake or pond used to slow stormwater runoff."[16]

A **retention facility** is "a stormwater storage facility that normally holds water at a controlled level to serve functions such as recreation, aesthetic, and water supply. Stormwater runoff is temporarily stored above the controlled stage. Examples of types of retention storage reservoirs are permanent ponds in residential and commercial areas and in open spaces."[17]

Stormwater consists of water created during precipitation events that flow over surfaces into sewer systems or receiving waters. All precipitation waters that leave project site boundaries on the surface are considered to be stormwater.

Stormwater Management Plan is a plan developed for an area with the objectives of maintaining ground water quantity, protecting water quality, protecting aquatic species and habitat, reducing erosion, and preventing any increase in flood risk. As part of the plan, Best Management Practices (BMPs) are employed to capture or treat stormwater runoff.

SS	
NC	Credit 6.2
CS	Credit 6.2

STORMWATER DESIGN: QUALITY CONTROL

	NC	CS
Credit	SS Credit 6.2	SS Credit 6.2
Points	1 point	1 point

INTENT

To limit disruption and pollution of natural water flows by managing stormwater runoff.

REQUIREMENTS: NC & CS

Implement a stormwater management plan that reduces impervious cover, promotes infiltration and captures and treats the stormwater runoff from 90% of the average annual rainfall using acceptable best management practices (BMPs). BMPs used to treat runoff must be capable of removing 80% of the average annual post-development total suspended solids (TSS) load. BMPs are considered to meet these criteria if they are designed in accordance with standards and specifications from a provincial, territorial, or local program that has adopted these performance standards.

Implement a management plan to minimize pollution and eutrophication of waterways from excess nutrient pollutants such as nitrogen and phosphorus, often found in cleaning agents and fertilizers.

INTERPRETATIONS

CAMPUS

As per SS Credit 6.1, this credit is eligible to be achieved on a campus-wide approach. To receive campus-wide approval, the application must demonstrate that the stormwater system meets the LEED requirements for all drainage areas it currently serves and those it is intended to serve in the future.

SS	
NC	Credit 6.2
CS	Credit 6.2

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

As areas are developed and urbanized, surface permeability is reduced, resulting in increased stormwater runoff that is transported via urban gutters, pipes, and sewers to receiving waters. This stormwater contains sediment and other contaminants that have negative effects on water quality, navigation, and recreation. Furthermore, conveyance and treatment of stormwater require significant municipal infrastructure and maintenance.

Primary sources of stormwater pollution include atmospheric deposition, vehicle fluid leaks, and mechanical equipment wastes. During storm events, these pollutants are washed away and discharged to downstream waters, degrading aquatic habitats and decreasing the biological diversity of aquatic species.

ECONOMIC ISSUES

Planning early for natural drainage systems can help offset associated increased design and construction costs by integrating stormwater treatment strategies into the overall site plan. Although structural and non-structural measures require upfront investments for design, installation, and maintenance, these features can also add significant value as site amenities such as vegetated infiltration swales that are part of the landscape design and reduce costs for landscape irrigation. Small-scale, on-site strategies also lessen the burden on municipal systems, resulting in a more affordable and stable tax base.

2. RELATED CREDITS

Using best management practices to capture and treat stormwater runoff assists project teams with reducing the overall volume of runoff. The following credit has related requirements:

- SS Credit 6.1: Stormwater Design—Quantity Control

Efforts to decrease impervious surfaces on the project site through pervious pavements, vegetated roofing, and vegetated open space can help meet the requirements of the following credits:

- SS Credit 5.1: Site Development—Protect or Restore Habitat
- SS Credit 5.2: Site Development—Maximize Open Space
- SS Credit 7.1: Heat Island Reduction—Non-roof
- SS Credit 7.2: Heat Island Reduction—Roof

Careful design of best management practices such as rain gardens, vegetated swales, and rainwater harvesting systems can reduce or eliminate the need for landscape irrigation, assisting project teams with earning the following credit:

- WE Credit 1: Water-Efficient Landscaping

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

SS	
NC	Credit 6.2
CS	Credit 6.2

4. IMPLEMENTATION

This credit can be achieved using either non-structural or structural stormwater management measures (or both) to minimize or mitigate impervious area.

NON-STRUCTURAL MEASURES

Non-structural strategies, such as rain gardens, vegetated swales, disconnection of impervious areas, and pervious pavement, can be used to promote infiltration and capture and treat runoff. In these cases, stormwater is allowed to filter naturally into the soil. Most pollutants are then broken down by microorganisms.

Non-structural measures are often preferred because they can be less expensive to construct and maintain and help recharge groundwater supplies.

STRUCTURAL MEASURES

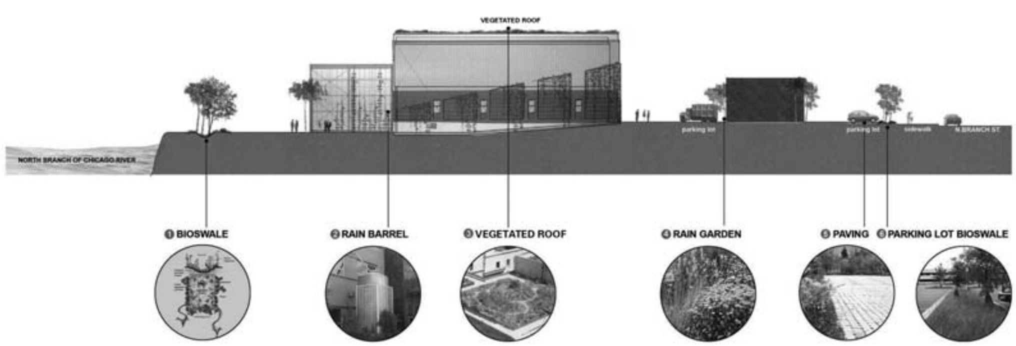
Structural measures, such as rainwater cisterns, manhole treatment devices, and ponds, can be used to remove the pollutants in runoff from impervious areas. In some cases, this water can be reused for irrigation or building flush fixtures.

On urban or constrained sites where space is limited, structural measures may be required to supplement non-structural measures and make it possible to effectively clean the runoff with minimal space allocation and land use. For existing sites with greater than 50% imperviousness, structural techniques may include restoring and repairing deteriorated storm sewers to prevent inflow and infiltration and reduce discharge volumes or separating combined sewers and ensuring that each flow is appropriately treated.

STORMWATER MANAGEMENT PLAN

The best way to minimize stormwater runoff volume and treatment requirements is to reduce the amount of impervious area and increase infiltration (Figure 1). Strategies to minimize or mitigate impervious surfaces and increase infiltration may include using pervious paving materials, harvesting stormwater for reuse in irrigation and indoor non-potable water applications, designing infiltration swales and retention ponds, planting vegetated filter strips, installing vegetated roofs, and clustering development to reduce paved surfaces such as roads and sidewalks.

FIGURE 1. STRATEGIES FOR CAPTURING AND TREATING STORMWATER RUNOFF



Drawing courtesy of City of Chicago, Department of General Services.

SS	
NC	Credit 6.2
CS	Credit 6.2

As part of the stormwater management plan process, describe the best management practices employed on the project site to capture and treat stormwater runoff. Describe how each measure contributes to reducing imperviousness and/or increasing infiltration. The plan must also document how BMPs are used to capture and treat stormwater runoff from 90% of the average annual rainfall. Annual rainfall is determined by the watershed where the project is located. Humid watersheds are defined as those that receive at least 100 cm (40 inches) of rainfall each year; semiarid watersheds receive between 50 and 100 cm (20 and 40 inches) of rainfall per year; and arid watersheds receive less than 50 cm (20 inches) of rainfall per year. For this credit, managing 90% of the average annual rainfall is equivalent to treating the runoff from the amounts listed in Table 1:

TABLE 1. RUNOFF TREATMENT EQUIVALENTS

WATERSHED	RAINFALL PER 24 HOURS (cm)	RAINFALL PER 24 HOURS (in)
Humid	2.5	1
Semiarid	1.9	0.75
Arid	1.3	0.5

To employ non-structural controls, work with a civil engineer, qualified environmental professional or landscape architect to determine the soil types and associated infiltration rates. Confirm that the soils can infiltrate water at a rate and quantity sufficient to absorb at least 90% of the annual rainfall volume.

If the project uses structural controls, confirm that the equipment can accommodate at least 90% of the annual rainfall volume.

If the project uses both structural and non-structural measures, each of which is designed to handle less than 90% of the annual rainfall volume, describe how the measures work together to satisfy the requirements of this credit.

In addition, the BMPs used on the project must be capable of removing 80% of the average annual post-development load of total suspended solids. BMPs that qualify for this credit can be designed in accordance with standards and specifications from a provincial or local program (if that program has adopted the 80% standard), or by providing field performance monitoring data from an accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology) demonstrating compliance with the criterion. Table 2 provides sample documentation of TSS removal effectiveness for various BMPs.

SS	
NC	Credit 6.2
CS	Credit 6.2

TABLE 2. MANAGEMENT PRACTICES FOR REMOVING TOTAL SUSPENDED SOLIDS FROM RUNOFF

	AVERAGE TSS REMOVAL	PROBABLE RANGE OF TSS REMOVAL	FACTORS TO CONSIDER
EFFECTIVENESS OF MANAGEMENT PRACTICES FOR TOTAL SUSPENDED SOLIDS REMOVAL FROM RUNOFF			
Infiltration Basin	75%	50 - 100%	soil percolation rates, trench surface area, storage volumes
Infiltration Trench	75%	50 - 100%	soil percolation rates, trench surface area, storage volumes
Vegetated Filter Strip	65%	40 - 90%	runoff volume, slope, soil infiltration rate
Grass Swale	60%	20 - 40%	runoff volume, slope, soil infiltration rates, vegetative cover, buffer length
Porous Pavement	90%	60 - 90%	percolation rates, storage volume
Open Grid Pavement	90%	60 - 90%	percolation rates
Sand filter Infiltration Basin	80%	60 - 90%	treatment volume, filtration media
Water Quality Inlet	35%	10 - 35%	maintenance, sedimentation storage volume
Water Quality Inlet with Sand Filter	80%	70 - 90%	sedimentation storage volume, depth of filter media
Oil/Grit Separator	15%	10 - 25%	sedimentation storage volume, outlet configuration
Extended Detention Dry Pond	45%	5 - 90%	storage volume, detention time, pond shape
Wet Pond	60%	50 - 90%	pool volume, pond shape
Extended Detention Wet Pond	80%	50 - 95%	pool volume, pond shape, detention time
Constructed Stormwater Wetlands	65%	50 - 90%	storage volume, detention time, pool shape, wetland's biota, seasonal variation

Source: Environmental Protection Agency's Guidance Specifying Management Measures for Sources of Non-Point Pollution in Coastal Waters. Table 4-7. January 1993.

MANAGEMENT PLAN TO MINIMIZE POLLUTION AND EUTROPHICATION OF WATERWAYS

The purpose of the nutrient management plan is to prevent pollutants from reaching water bodies. This is normally done through operational changes. The plan must guarantee that methods proposed will be followed for the life of the building and therefore must be included in any building operations manual, as well as in the specifications. The plan should address issues such as external cleaning agents (for building, grounds and vehicle maintenance) and landscape fertilizers. Alternatively pollutants may be prevented from reaching water bodies by dealing with pollutants onsite through swales, filter strips and detention ponds.

5. TIMELINE AND TEAM

During pre-design, setting goals related to water, including stormwater management and water reuse, involves the owner, architect, and engineers. This is the appropriate time to analyze the local climate, codes, and applicable water laws and determine the process for obtaining permits and approval.

During schematic design, civil and mechanical engineers and landscape architects can help establish a comprehensive water budget for stormwater, irrigation water, and the building's water consumption. This water budget will consider available supply sources, such as rainwater and stormwater, municipally supplied non-potable water, treated and untreated greywater, and treated blackwater, and provide the basis for making stormwater management decisions that complement the rest of the project. The civil engineer, qualified environmental professional, or landscape architect then identifies specific stormwater treatment measures appropriate for the project.

During design development, the civil engineer, qualified environmental professional, or landscape architect should design stormwater management systems, including water quality treatment, perform preliminary LEED calculations, and confirm or reassess stormwater management goals.

During construction documentation, the civil engineer, qualified environmental professional, or landscape architect, in coordination with the architect and owner, should finalize the design of stormwater management systems and complete the required calculations and documentation.

6. CALCULATIONS

The calculation methods used will depend on the available data and the preference of the qualified environmental professional; however, the chosen method should be widely accepted and recognized.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Develop a list of best management practices used to treat stormwater and a description of the contribution of each to stormwater filtration. Determine the percentage of annual rainfall treated by each practice.
- For structural controls, list and describe the pollutant removal performance of each measure; determine the percentage of annual rainfall treated by each.
- Develop a management plan outlining measures to minimize pollution and eutrophication of waterways.

SS	
NC	Credit 6.2
CS	Credit 6.2

8. EXAMPLES

A commercial office building is located on a 2,800 square metre urban site with a high percentage of impervious area. The city is in a humid watershed, requiring treatment of stormwater runoff for 2.5 cm (1 inch) of rainfall. The site has just 275 square metres of vegetated area on the ground level yet can meet the credit requirements through a combination of strategies including a vegetated roof, pervious pavers, and flow-through planters.

The vegetated roof captures stormwater, which then evapotranspires from the otherwise impervious roof area. These systems mimic the hydrology of the site prior to development, reducing peak runoff rates and volume. The parking lot has pervious pavers whose high rate of permeability allows stormwater to infiltrate to the subgrade. Finally, flow-through planters collect and filter stormwater runoff, allowing pollutants to settle and filter out as the water percolates through the soil.

The BMPs employed on this project remove more than 80% of the total suspended solids from the stormwater and provide all the irrigation needed for the vegetated roof and other landscaped areas.

9. EXEMPLARY PERFORMANCE

No standardized exemplary performance option has been established for this credit. However, project teams may apply for exemplary performance by documenting a comprehensive approach to capture and treat stormwater runoff and demonstrate performance above and beyond the credit requirements. Only 1 exemplary performance credit may be achieved for SS Credit 6.1, Stormwater Design—Quantity Control, and SS Credit 6.2, Stormwater Design—Quality Control.

10. REGIONAL VARIATIONS

The approach to this credit depends on the kind of watershed where the project is located and the annual rainfall on the project site. Humid watersheds are defined as those that receive at least 100 cm (40 inches) of rainfall each year; semiarid watersheds receive 50 to 100 cm (20 to 40 inches) of rainfall per year; arid watersheds receive less than 50 cm (20 inches) of rainfall per year.

Both structural and non-structural BMPs used on the project must be specific to the site and appropriate for the region's climate to effectively capture and treat stormwater runoff.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

The project should adopt an ongoing inspection and maintenance plan to ensure proper functioning of the installed stormwater controls. Silting of infiltration trenches or dry retention wells will reduce removal efficiency. At a minimum, the maintenance plan should include periodic visual site inspections to identify any areas of the site that are eroding or susceptible to erosion, as well as recommendations for typical corrective actions. Prevention of on-site erosion and entrainment of eroded materials into the stormwater runoff will extend the life of the BMPs.

Some pervious pavement systems require ongoing maintenance to remain effective. This might include quarterly vacuuming or washing. Limit application of de-icing agents (sand or chemicals) to prevent clogging. Maintenance contracts and practices should reflect the requirements of the installed system.

Structural stormwater measures are likely to require more ongoing maintenance than non-structural measures. Consider operating budgets when designing the stormwater management strategy.

SS	
NC	Credit 6.2
CS	Credit 6.2

12. RESOURCES

WEBSITES

Metro Vancouver: Stormwater Best Management Practices Guide
http://www.metrovancouver.org/services/wastewater/sources/Pages/StormwaterManagement.aspx

Provides municipalities with a toolbox consisting of a series of stormwater best management practice (BMP) options.

Ministry of Environment (Ontario) – Stormwater planning
http://www.ene.gov.on.ca/envision/gp/4329eindex.htm

This website features a thorough Stormwater Management Planning and Design Manual.

National Climate Data and Information Archive
http://www.climat.meteo.ec.gc.ca/climateData/canada_e.html

This federal website is useful for researching local climate information such as data for rainwater harvesting calculations.

Ontario Ministry of the Environment: Stormwater Management Planning and Design Manual 2003
http://www.ene.gov.on.ca/envision/gp/4329eindex.htm

Provides technical and procedural guidance for the planning, design, and review of stormwater management practices.

Pennsylvania Department of Environmental Protection, Technology Acceptance and Reciprocity Partnership
http://www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/

Stormwater Planning: A Guidebook for British Columbia
http://www.env.gov.bc.ca/epd/epdpa/mpp/stormwater/stormwater.html

Provides framework for effective stormwater management in BC.

U.S. EPA, Low-Impact Development
http://www.epa.gov/owow/nps/lid

This website provides valuable information on low-impact development through fact sheets, design guides, and cost estimates for low-impact development strategies that reduce stormwater runoff.

U.S. EPA, Office of Wetlands, Oceans, and Watersheds
http://www.epa.gov/owow

This website has information about watersheds, water resources, water conservation, landscaping practices, and water pollution.

SS	
NC	Credit 6.2
CS	Credit 6.2

PRINT MEDIA

Guidance Specifying Management Measures for Sources of Non-Point Pollution in Coastal Waters (Document No. EPA 840B92002), (U.S. Environmental Protection Agency, January 1993). http://www.epa.gov/owow/nps/MMGI

This document details a variety of management practices that can be incorporated to remove pollutants from stormwater volumes. Chapter 4, Part II, addresses urban runoff and suggests strategies for treating and infiltrating stormwater volumes after construction is completed.

Low-Impact Development Technical Reference Manual for Puget Sound (Puget Sound Action Team and Washington State University Pierce County Extension, 2005). http://www.psp.wa.gov/downloads/LID/LID_manual2005.pdf

This manual provides technical data, specifications, and performance data for low-impact development design strategies.

Maryland Stormwater Design Manual (Maryland Department of the Environment, October 2000) http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Stormwater Best Management Practice Design Guide (EPA/600/R-04/121A) (U.S. Environmental Protection Agency, September 2004) http://www.epa.gov/nrmrl/pubs/600r04121/600r04121.htm

13. DEFINITIONS

Eutrophication is the slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. During the later stages of eutrophication the water body is choked by abundant plant life due to higher levels of nutritive compounds such as nitrogen and phosphorus. Human activities can accelerate the process.[18]

Impervious surfaces have a perviousness of less than 50% and promote runoff of water instead of infiltration into the subsurface. Examples include parking lots, roads, sidewalks, and plazas.

Stormwater consists of water created during precipitation events that flow over surfaces into sewer systems or receiving waters. All precipitation waters that leave project site boundaries on the surface are considered to be stormwater.

Stormwater Management Plan is developed for an area with the objectives of maintaining ground water quantity, protecting water quality, protecting aquatic species and habitat, reducing erosion, and preventing any increase in flood risk. As part of the plan, Best Management Practices (BMPs) are employed to capture or treat stormwater runoff.

Total suspended solids (TSS) are those solids found in wastewater or in a stream which can be removed by filtration through a 0.45 micron filter. "The origin of suspended matter may be manmade wastes or natural sources such as silt."[19]

SS	
NC	Credit 6.2
CS	Credit 6.2

14. CASE STUDY

PINE CREEK WASTEWATER TREATMENT PLANT - OPERATIONS, MAINTENANCE AND ADMINISTRATION BUILDING

LEED Canada-NC 1.0 Gold, 9 February 2009

Location: Calgary, Alberta
Building Type: Mixed use (Office / Industrial)
Owner Type: Government - Local
Building Size: 3,200m^2
Owner Name: The City of Calgary
LEED Consultant: Designworks Architecture
Responsible Firm (for this credit): Stantec
Photo Credit: Building - GEC Architecture / Roy Ooms Photography
Berms - O2 Planning and Design

Stage 1 of the City of Calgary's Pine Creek Wastewater Treatment Plant comprises a 41 hectare site bounded on the south by the Bow River. A key project priority was minimizing the environmental impact of the development and ensuring protection of the Bow River. The Operations Maintenance and Administrative Building is the first building on the site to apply for LEED Certification. A campus approach was employed for the Sustainable Sites and site-related Water Efficiency credits.

A comprehensive, site-wide stormwater management plan provides for no post-development stormwater discharge from the site for any storm event up to and including a 1 in 100 year storm event thereby exceeding LEED SS Credit 6.1 Stormwater Design - Quantity Control requirements (pre-development condition <50% impervious). Both continuous simulation and single event modeling were used to predict performance. The strategies employed also met the TSS removal requirements under SS Credit 6.2 Stormwater Design - Quality Control and addressed TP.

SS	
NC	Credit 6.2
CS	Credit 6.2

Stormwater is directed to a series of conveyance swales near the site perimeter. The majority of stormwater either infiltrates in the conveyance swales or is discharged to an on-site infiltration pond, while a small amount dissipates by evaporation.

Other site features that aid stormwater management include:

- 5,500m^2 of green roofs across the site including 62% of the OM&A building (SS Credit 7 Heat Island Effect).
- A large and contiguous open space area restored with native and adaptive plant species enhances on-site stormwater infiltration capacity and ensured the project met SS Credit 5 Site Development.
- Grass pavers replace asphalt at road and parking areas required for periodic use by service and emergency vehicles.

This approach to stormwater management also had synergies with SS Prerequisite 1 Construction Activity Pollution Prevention. During construction the stormwater management conveyance system was used to mitigate erosion from the flow of rain, snow melt, and dewatering.

SS	
NC	Credit 7.1
CS	Credit 7.1

HEAT ISLAND EFFECT: NON–ROOF

	NC	CS
Credit	SS Credit 7.1	SS Credit 7.1
Points	1 point	1 point

INTENT

To reduce heat islands to minimize impact on microclimates and human and wildlife habitats.

REQUIREMENTS: NC & CS

CASE 1. ALL PROJECTS

OPTION 1

Use any combination of the following strategies for 50% of the site hardscape (including roads, sidewalks, courtyards and parking lots):

- Provide shade from existing tree canopy or within 5 years of landscape installation; landscaping (trees) must be in place at the time of occupancy.
- Provide shade from structures covered by solar panels that produce energy used to offset some non-renewable resource use.
- Provide shade from architectural devices or structures that have a solar reflectance index (SRI) of at least 29.
- Use hardscape materials with an SRI of at least 29.
- Use an open-grid pavement system (at least 50% pervious).

OR

OPTION 2

Place a minimum of 50% of parking spaces under cover. Any roof used to shade or cover parking must have an SRI of at least 29, be a vegetated green roof, or be covered by solar panels that produce energy used to offset some non-renewable resource use.

CASE 2 FOR NON-CAMPUS PROJECTS ONLY

For projects where the non-roof area constitutes less than 5% of the total site area: meet the requirements of SS Credit 7.2: Heat Island Effect: Roof and SS Credit 2: Development Density and Community Connectivity.

	SS
NC	Credit 7.1
CS	Credit 7.1

INTERPRETATIONS

Drop off and loading areas are not considered as parking and therefore do not contribute to the compliance option for placing 50% of parking undercover.

CAMPUS

Campuses can apply for this credit under campus-wide compliance. Applicants must provide the site plan and calculations for the whole campus, clearly indicating all buildings (and future buildings), all parking areas, and all hardscape, SRI values, shading, etc. to show compliance with the credit.

Municipal roads and primary roads providing central circulation to the Campus are excluded from calculations for this credit.

In phased projects this credit may be captured for the entire build-out based on a finalized development master plan. Include a copy of the finalized development master plan.

SS	
NC	Credit 7.1
CS	Credit 7.1

1. BENEFITS AND ISSUES TO CONSIDER

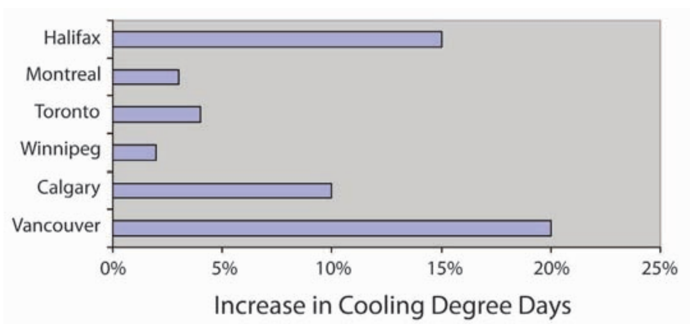
ENVIRONMENTAL ISSUES

The use of dark, non-reflective surfaces for parking, roofs, walkways, and other hardscapes contributes to the heat island effect by absorbing the sun's warmth, which then radiates into the surroundings. Because of heat island effect, ambient temperatures in urban areas are artificially elevated by 1-3ºC compared with surrounding suburban and undeveloped areas.[20] The result is increased cooling loads in the summer, requiring larger heating, ventilating, and air-conditioning (HVAC) equipment and greater electricity consumption, both of which generate greenhouse gases and pollution. Heat islands are detrimental to site habitat, wildlife, and animal migration corridors. Plants and animals are also sensitive to large fluctuations in daytime and nighttime temperatures and may not thrive in areas affected by heat islands.

ECONOMIC ISSUES

The energy used to cool a building represents a substantial portion of the operating budget over its lifetime. Reducing heat islands can significantly lower the cost of cooling and HVAC equipment needs. The figure below illustrates heat island effects in various cities throughout Canada. The greater amount of cooling degree-days in urban locations means that air-conditioning systems must work harder and use more energy to maintain thermal comfort in buildings.

FIGURE 1: HEAT ISLAND EFFECTS IN VARIOUS CITIES THROUGHOUT CANADA



Efforts to reduce heat islands may translate into higher initial costs for additional landscaping, open-grid paving, or architectural shading devices. However, these items have an acceptable payback when integrated into a systems approach to maximizing energy savings. Some high-reflectance pavements, such as concrete made with white cement, may cost up to twice as much as those made with grey cement, but some blended cements (for example, slag) are very light in colour and cost the same as or slightly less than Portland-only grey cement.[21] High-reflectance pavements also increase overall light levels and may enable a building to use fewer site lighting fixtures. Building owners should assess the cost of installing highly reflective pavements or coatings against possible energy savings from reduced site lighting.

SS	
NC	Credit 7.1
CS	Credit 7.1

2. RELATED CREDITS

Locating parking structures underground can help limit site disturbance and maximize open space, assisting with the following credit:

- SS Credit 5.2: Site Development—Maximize Open Space

Properly designed and installed open-grid pavements capture and treat stormwater runoff, helping project teams to earn points under the following credits:

- SS Credit 6.1: Stormwater Design—Quantity Control
- SS Credit 6.2: Stormwater Design—Quality Control

If vegetation is used to shade hardscapes, refer to the landscape irrigation requirements outlined in the following credit to reduce potable water use:

- WE Credit 1: Water-Efficient Landscaping

3. SUMMARY OF REFERENCED STANDARDS

ASTM Intl. Standards
http://www.astm.org

ASTM E408–71(1996)e1, Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques

This standard describes how to measure total normal emittance of surfaces using a portable inspection-meter instrument. The test methods are intended for large surfaces where non-destructive testing is required. See the standard for testing steps and a discussion of thermal emittance theory.

ASTM C1371–04a Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers

This test method covers a technique for determination of the emittance of typical materials using a portable differential thermopile emissometer. The purpose of the test method is to provide a comparative means of quantifying the emittance of opaque, highly thermally conductive materials near room temperature as a parameter in evaluating temperatures, heat flows, and derived thermal resistances of materials.

ASTM E903–96, Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres

Referenced in the ENERGY STAR® roofing standard, this test method uses spectrophotometers and need only be applied for initial reflectance measurement. It specifies methods of computing solar-weighted properties using the measured spectral values. This test method is applicable to materials having both specular and diffuse optical properties. Except for transmitting sheet materials that are heterogeneous, patterned, or corrugated, this test method is preferred over Test Method E1084. The ENERGY STAR roofing standard also allows the use of reflectometers to measure roofing materials' solar reflectance. See the roofing standard for more details.

ASTM E1918–97, Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field

This test method covers the solar reflectance measurements, using a pyranometer, of various horizontal and low-sloped surfaces and materials. The test method is intended for use when the angle from a surface to the sun is less than 45 degrees.

SS	
NC	Credit 7.1
CS	Credit 7.1

ASTM C1549–04, Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer

This test method covers a technique for determining the solar reflectance of flat, opaque materials in a laboratory or in the field using a commercial, portable solar reflectometer. The purpose of the test method is to provide the solar reflectance data required to evaluate temperature and heat flows across surfaces exposed to solar radiation.

4. IMPLEMENTATION

Strategies for mitigating heat island effect include using materials with higher solar reflectance properties in the site design, providing shaded areas, and reducing hardscape surfaces.

HIGHER SOLAR REFLECTANCE

Hardscape materials vary in their ability to reflect sunlight.

Table 1 provides the solar reflectance index (SRI) for standard paving materials. Dark paving materials generally have low reflectance and, consequently, low SRI values. Grey or white concrete has a higher reflectance and a higher SRI value. Both white and grey concrete will weather over time, and without proper maintenance their SRI value will decrease. Microsurfaces and coatings over asphalt pavement can be used to meet the required SRI value for this credit. Coatings and integral colorants can be used in cement or cast-in-place parking surfaces to improve solar reflectance. For projects with existing weathered grey concrete hardscapes, document that the weathered surfaces have been sufficiently cleaned and lightened to qualify for the default SRI values listed in Table 1.

TABLE 1. SOLAR REFLECTANCE INDEX (SRI) FOR STANDARD PAVING MATERIALS

MATERIAL	EMISSIVITY	REFLECTANCE	SRI
Typical new grey concrete	0.9	0.35	35
Typical weathered* grey concrete	0.9	0.20	19
Typical new white concrete	0.9	0.7	86
Typical weathered* white concrete	0.9	0.4	45
New asphalt	0.9	0.05	0
Weathered asphalt	0.9	0.10	6

** Reflectance of surfaces can be maintained with cleaning. Typical pressure washing of cementitious materials can restore reflectance close to original value. Weathered values are based on no cleaning.*

Project teams do not need to provide project-specific data measuring SRI values for new concrete. Documentation certifying that the concrete mix used for a project is equivalent to a previously used and tested mix is acceptable.

Because higher reflectance pavements increase overall light levels, lighting evaluations should include an assessment of the interreflected component and reflections off high-reflectance materials such as white concrete. High-reflectance materials can result in glare, which impairs vision and increases light pollution. Minimize the amount of light that is directed from site lighting fixtures directly onto reflective paving surfaces.

	SS
NC	Credit 7.1
CS	Credit 7.1

SHADING

Vegetation can reduce heat islands by shading buildings and pavements from solar radiation and cooling the air through evapotranspiration. Provide shade using landscape features such as native trees, large shrubs, and non-invasive vines. Newly installed landscape features should provide the desired level of shading within 5 years of being planted. These must be in place at the time of building occupancy. Give trees and other vegetation adequate root space for reaching their anticipated size and shade coverage within 5 years. Trellises and other exterior structures can support vegetation to shade parking lots, walkways, and plazas. Deciduous trees allow solar heat gain during the winter months. Where tree planting is not possible, consider using architectural shading devices and structures to block direct sunlight. Solar energy system installations, including photovoltaics, can contribute to shading non-roof hardscapes.

Avoid placing trees and vegetation in locations likely to be reflected in building glazing unless specific measures are taken to reduce bird collisions. Such measures include using exterior shading devices, introducing etched or frit patterns in the glass, and creating "visual markers" in sufficient locations. Visual markers are differentiated planes, materials, textures, colours, opacity, or other visually contrasting features that help fragment window reflections and reduce overall transparency and reflectivity.

REDUCE HARDSCAPE

Limit the amount of impervious hardscape areas on the site to reduce heat island effect. For features such as parking lots, roads, and walkways, use open-grid pavement systems that are at least 50% pervious and accommodate vegetation within the open cells. Another way to reduce hardscape surfaces is to place at least 50% of parking under shading structures or under cover. This can include using multi-story or underground parking structures. Any roof used to shade or cover surface parking must have an SRI of at least 29, be a vegetated roof, or be covered by solar panels. There is no SRI requirement for parking that is underground, under a deck, or under a building as long as any exposed parking surface area is 50% or less of the total parking surface area.

5. TIMELINE AND TEAM

Early in design, the project team should involve the landscape architect, architect, qualified environmental professional, and civil engineer in efforts to minimize hardscape surfaces on-site, assess whether open-grid paving can also assist with stormwater runoff mitigation, and evaluate the potential for locating parking underground or under cover. During the construction documents phase, designers should specify materials with a low emissivity that meet or exceed the SRI requirements on all non-roof surfaces. For projects that include cleaning of existing weathered grey concrete hardscapes, contractors must document that they have provided sufficient cleaning to achieve the required SRI values.

SS	
NC	Credit 7.1
CS	Credit 7.1

6. CALCULATIONS

CASE 1

Option 1

- Identify all non-roof hardscape surfaces on the project site and sum the total area (T), in square metres. Hardscapes must, at a minimum, include all roads, sidewalks, courtyards, and parking lots within the LEED project boundary.
- Identify all hardscape surfaces shaded by trees or other landscape features (at the time of building occupancy or within 5 years from the date of installation). Shade coverage must be calculated at 10 a.m., 12 noon, and 3 p.m. on the summer solstice. The arithmetic mean of these 3 values will be used as the effective shaded area (S).
- Identify all hardscape surfaces shaded by solar energy panels and sum the total area (E). The shaded area can be considered equivalent to the area covered by the panels on the site plan (from a direct overhead aerial perspective).
- Identify all hardscape surfaces shaded by architectural devices or structures that have an SRI of at least 29 and sum the total area (A). The shaded area can be considered equivalent to the area covered by the architectural devices or structures on the site plan (from a direct overhead aerial perspective).
- Identify all the hardscape surfaces that have an SRI of at least 29 and sum the total area (R). SRI can be calculated from emissivity and solar reflectance values. Emissivity is calculated according to ASTM E 408 or ASTM C 1371, and solar reflectance is calculated according to ASTM E 903, ASTM E 1918 or ASTM C 1549. Alternatively, use the SRI values for typical paving materials in Table 1 in lieu of obtaining specific emissivity and solar reflectance measurements for the listed materials.
- Identify all hardscape surfaces that have an open-grid paving system that is at least 50% pervious and sum the total area (O).
- Sum the area of all qualifying surfaces to determine the total qualifying area (Q), using Equation 1.

Each surface should be counted only once. For example, a 10-square-metre area that is 55% pervious, has an SRI of 30, and is shaded by a tree contributes 10 square metres to the total.

Equation 1

$$Q = (S + E + A + R + O)$$

- The total qualifying area must be 50% or more of the total hardscape area (T), as calculated in Equation 2.

Equation 2

$$Q > \frac{T}{2}$$

SS	
NC	Credit 7.1
CS	Credit 7.1

Option 2

- Determine the total number of parking spaces within the project boundary.
- Determine the number of parking spaces that are under acceptable cover (include underground, under deck, under roof, and under building). This number must be 50% or more of the total number of parking spaces.

The site and building footprint areas used in Option 1 calculations need to be consistent across all credits. Similarly, the number of parking spaces used to document compliance with Option 2 needs to be consistent with all credits.

CASE 2

For non-campus projects where the non-roof area constitutes less than 5% of the total site area, applicants must ensure that this minimal non-roof area requirement is met, as well as demonstrating that the project meets the requirements of SS Credit 7.2: Heat Island Effect: Roof and SS Credit 2: Development Density & Community Connectivity.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED letter templates for the complete descriptions of all required documentation.

- If surfaces are shaded, prepare a site plan that highlights all non-roof hardscape areas. Clearly label each portion of hardscape that counts toward credit achievement. List information about compliant surfaces (e.g., SRI values of reflective paving materials) and retain sources of that information (e.g., cutsheets, publications, etc.).
- If parking spaces are placed under cover, determine the total number of spaces and the portion covered. If applicable, assemble SRI values for the roofs that cover parking areas.

8. EXAMPLES

A building is located on a 2,500 square metre site, of which 1,500 square metres is occupied by the building footprint and vegetated areas. The project team employs strategies to reduce heat island effect for non-roof surfaces, installing deciduous trees to shade parking and driveway areas and using light-coloured concrete with an SRI of 35 for driving aisles and walkways (Figure 2). Areas that contain both light-coloured hardscapes and are shaded by trees are counted only once. Table 2 lists the areas of qualifying surfaces.

TABLE 2. SAMPLE QUALIFYING SURFACE AREAS

DESCRIPTION	AREA (m^2)
Total non-roof hardscapes	1,000
Shaded areas	300
Areas of hardscapes with minimum SRI-29	400
TOTAL QUALIFYING SURFACES	**700**

SS	
NC	Credit 7.1
CS	Credit 7.1

FIGURE 2. SHADING AND SRI FOR CREDIT COMPLIANCE

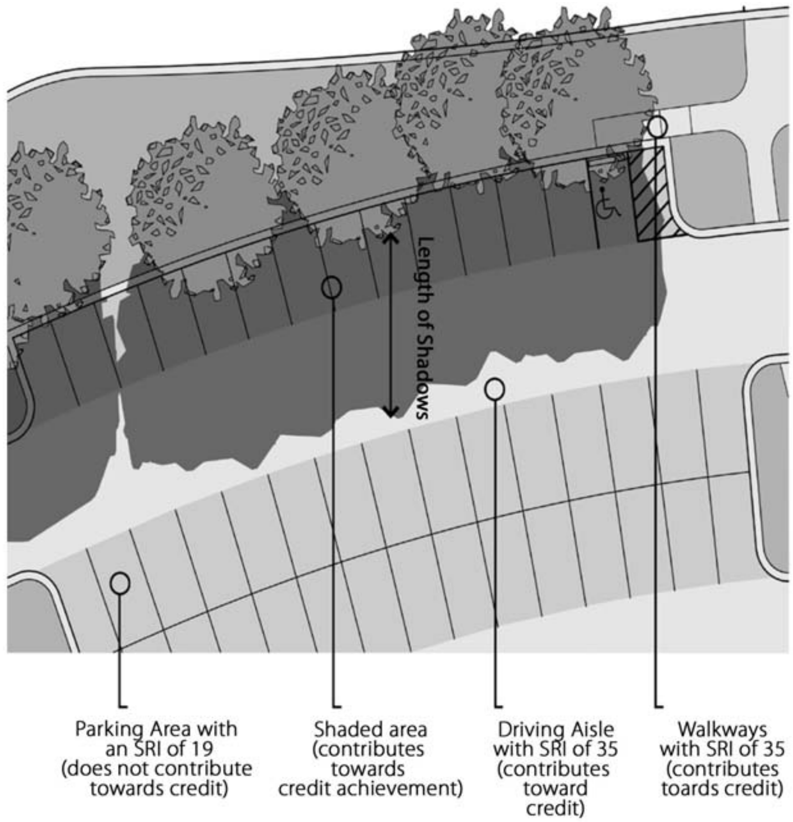


Diagram courtesy of OWP/P

9. EXEMPLARY PERFORMANCE

Projects may earn an Innovation in Design credit for exemplary performance by demonstrating that either (1) 100% of non-roof impervious surfaces have been constructed with high-albedo or open-grid paving, or will be shaded within 5 years; or (2) 100% of the on-site parking spaces have been located under cover (as defined by credit requirements and Definitions).

10. REGIONAL VARIATIONS

Heat island intensities depend on weather and climate, proximity to water bodies, and topography.[22] Buildings in very cold climates or at high latitudes may not experience the same rise of surface and ambient temperatures. In sunny climates, project teams should mitigate glare from reflective pavements into the building by providing shading devices. Consider hardscape surfaces and parking cover that is appropriate for the region's weather.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Surface materials with high reflectivity may need to be cleaned on a regular basis to maintain good reflectance. However, cleaning requires the use of energy, water and cleaning products, and applicants should consider choosing materials that have the overall lowest environmental impact (e.g., maintain highest SRI while minimizing other environmental impacts).

SS	
NC	Credit 7.1
CS	Credit 7.1

Some open-grid pavement systems require special maintenance to remain pervious. Request maintenance information from product manufacturers and/or installers and ensure that this information is given to the operations team.

Communicate proper care and maintenance of trees and other vegetation on the project site to landscaping and exterior maintenance crews to help ensure that the anticipated shading is achieved within 5 years.

12. RESOURCES

WEBSITES

American Bird Conservancy
http://www.abcbirds.org

ABC is a national leader in reducing human effects on birds and wildlife. ABC's bird collision program supports national efforts to reduce bird mortality through education and advocacy.

American Concrete Pavement Association
http://www.pavement.com

This national association represents concrete pavement contractors, cement companies, equipment and material manufacturers, and suppliers. See Albedo: A Measure of Pavement Surface Reflectance, R&T Update (3.05) (June 2002): http://www.pavement.com/Downloads/RT/RT3.05.pdf

Birds and Buildings Forum
http://www.birdsandbuildings.org

This Chicago-based non-profit supports bird-friendly design through education and advocacy. Their website maintains lists of organizations and resources.

Lawrence Berkeley National Laboratory, Heat Island Group
http://eetd.lbl.gov/HeatIsland/

Lawrence Berkeley National Laboratory conducts heat island research to find, analyze, and implement solutions to minimize heat island effect. Current research efforts focus on the study and development of more reflective surfaces for roadways and buildings.

New York City Audubon
http://www.nycaudubon.org

This Audubon chapter takes a leadership role in reducing bird collisions with buildings. The chapter publishes Bird-Safe Building Guidelines, conducts monitoring, and through its Project Safe Flight, promotes bird-friendly design.

U.S. EPA, Heat Island Effect
http://www.epa.gov/heatisland

This site offers basic information about heat island effect, its social and environmental costs, and strategies to minimize its prevalence.

SS	
NC	Credit 7.1
CS	Credit 7.1

13. DEFINITIONS

Emissivity is the ratio of the radiation emitted by a surface to the radiation emitted by a black body at the same temperature.

Greenhouse gases are relatively transparent to the higher-energy sunlight but trap lower-energy infrared radiation (e.g., carbon dioxide, methane, and CFCs).

Hardscape consists of the inanimate elements of the building landscaping. Examples include pavement, roadways, stone walls, concrete paths and sidewalks, and concrete, brick, and tile patios.

Heat islands are defined as thermal gradient differences between developed and undeveloped areas.

Heat island effect refers to the absorption of heat by hardscapes, such as dark, nonreflective pavement and buildings, and its radiation to surrounding areas. Particularly in urban areas, other sources may include vehicle exhaust, air-conditioners, and street equipment; reduced airflow from tall buildings and narrow streets exacerbates the effect.

Impervious surfaces have a perviousness of less than 50% and promote runoff of water instead of infiltration into the subsurface. Examples include parking lots, roads, sidewalks, and plazas.

Infrared (or thermal) emittance is a parameter between 0 and 1 (or 0% and 100%) that indicates the ability of a material to shed infrared radiation (heat). The wavelength range for this radiant energy is roughly 5 to 40 micrometers. Most building materials (including glass) are opaque in this part of the spectrum and have an emittance of roughly 0.9. Materials such as clean, bare metals are the most important exceptions to the 0.9 rule. Thus clean, untarnished galvanized steel has low emittance, and aluminum roof coatings have intermediate emittance levels.

Open-grid pavement is less than 50% impervious and accommodates vegetation in the open cells.

Perviousness is the percentage of the surface area of a paving system that is open and allows moisture to soak into the ground below.

Solar reflectance, or **albedo**, is a measure of the ability of a surface material to reflect sunlight—visible, infrared, and ultraviolet wavelengths—on a scale of 0 to 1. Black paint has a solar reflectance of 0; white paint (titanium dioxide) has a solar reflectance of 1.

The **solar reflectance index (SRI)** is a measure of a material's ability to reject solar heat, as shown by a small temperature rise. Standard black (reflectance 0.05, emittance 0.90) is 0 and standard white (reflectance 0.80, emittance 0.90) is 100. For example, a standard black surface has a temperature rise of 90˚F (50˚C) in full sun, and a standard white surface has a temperature rise of 14.6˚F (8.1˚C). Once the maximum temperature rise of a given material has been computed, the SRI can be calculated by interpolating between the values for white and black. Materials with the highest SRI values are the coolest choices for paving. Because of the way SRI is defined, particularly hot materials can even take slightly negative values, and particularly cool materials can even exceed 100. (Lawrence Berkeley National Laboratory Cool Roofing Materials Database) SRI is calculated according to ASTM E 1980. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C 1371.

Undercover parking is underground or under a deck, roof, or building; its hardscape surfaces are shaded.

SS	
NC	Credit 7.2
CS	Credit 7.2

HEAT ISLAND EFFECT: ROOF

	NC	CS
Credit	SS Credit 7.2	SS Credit 7.2
Points	1 point	1 point

INTENT

To reduce heat islands to minimize impact on microclimates and human and wildlife habitats.

REQUIREMENTS: NC & CS

OPTION 1

Use roofing materials with a solar reflectance index (SRI) equal to or greater than the values in the table below for a minimum of 75% of the roof surface.

Roofing materials having a lower SRI value than those listed below may be used if the weighted rooftop SRI average meets the following criteria:

$$\frac{\text{Projected area of SRI roof}}{\text{Total projected roof area}} \times \frac{\text{SRI of installed roof}}{\text{Required SRI}} \geq 75\%$$

ROOF TYPE	SLOPE	SRI
Low-Sloped Roof	≤ 2:12	78
Steep-Sloped Roof	> 2:12	29

OR

OPTION 2

Install a vegetated roof for at least 50% of the roof area.

OR

OPTION 3

Install high-albedo and vegetated roof surfaces that, in combination, meet the following criteria:

$$\frac{\text{Projected area roof meeting minimum SRI}}{0.75} + \frac{\text{Area of vegetated roof}}{0.5} \geq \text{Total projected roof area}$$

SS	
NC	Credit 7.2
CS	Credit 7.2

ROOF TYPE	SLOPE	SRI
Low-Sloped Roof	≤ 2:12	78
Steep-Sloped Roof	> 2:12	29

INTERPRETATIONS

At-grade surfaces covering underground parking are not considered roof area and are treated as non-roof area.

SS	
NC	Credit 7.2
CS	Credit 7.2

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

The use of dark, non-reflective roofing surfaces contributes to the heat island effect by absorbing the sun's warmth, which then radiates into the surroundings. As a result, ambient temperatures in urban areas are artificially elevated, increasing cooling loads, electricity consumption, and emissions of greenhouse gases and pollution. Heat island effect is also detrimental to site habitat, wildlife, and animal migration corridors. Plants and animals are sensitive to large fluctuations in daytime and nighttime temperatures and may not thrive in areas affected by heat islands. Projects that earn SS Credit 7.2 by providing vegetated roofs contribute to increased habitat areas for birds, insects, and other wildlife.

ECONOMIC ISSUES

The energy used to cool a building represents a substantial portion of the operating budget over its lifetime. Vegetated roofs and roof surfaces with high SRIs can reduce costs associated with HVAC equipment. Vegetated roofs typically require additional investment; cool roofs that effectively reflect the sun's energy could cost the same as more conventional roofing systems. However, any upfront investment is likely to result in energy cost savings throughout the life cycle of the project. A study conducted in Toronto indicates that rate payers in the Greater Toronto Area could potentially save over $11 million in energy cost savings from the effects of heat island reduction strategies.[23] An increasing number of jurisdictions are beginning to require the use of cool roofs on new building projects.

2. RELATED CREDITS

Vegetated roofs help capture and treat stormwater while also providing habitat and open space, providing synergies with the following credits:

- SS Credit 5.1: Site Development—Protect or Restore Habitat
- SS Credit 5.2: Site Development—Maximize Open Space
- SS Credit 6.1: Stormwater Design—Quantity Control
- SS Credit 6.2: Stormwater Design—Quality Control

Vegetated roofs also reduce the availability of rainwater that may be harvested for non-potable purposes, making it more challenging to achieve this water-efficiency credit:

- WE Credit 3: Water Use Reduction

Using highly reflective roofing materials and/or vegetated roofs can decrease cooling loads and help projects with earning this credit:

- EA Credit 1: Optimize Energy Performance

SS	
NC	Credit 7.2
CS	Credit 7.2

3. SUMMARY OF REFERENCED STANDARDS

ASTM Standards
http://www.astm.org

ASTM E1980–01, Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces

This standard describes how surface reflectivity and emissivity are combined to calculate a solar reflectance index (SRI) for a roofing material or other surface. The standard also describes a laboratory and field testing protocol that can be used to determine SRI.

ASTM E408–71(1996)e1, Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques

This standard describes how to measure total normal emittance of surfaces using a portable inspection-meter instrument. The test methods are intended for large surfaces where non-destructive testing is required. See the standard for testing steps and a discussion of thermal emittance theory.

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ASTM C1549–04, Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer

This test method covers a technique for determining the solar reflectance of flat, opaque materials in a laboratory or in the field using a commercial, portable solar reflectometer. The purpose of the test method is to provide the solar reflectance data required to evaluate temperature and heat flows across surfaces exposed to solar radiation.

SS	
NC	Credit 7.2
CS	Credit 7.2

4. IMPLEMENTATION

The choice of roofing can maximize energy savings and minimize the heat island effect. This credit can be achieved through high-reflectance surfaces, vegetated roofing, or a combination.

HIGH-REFLECTANCE MATERIALS

The solar reflectance index (SRI) of a roofing material is calculated from emissivity and solar reflectance values. Multiple testing methods are available for measuring emissivity and solar reflectance; check the manufacturer's literature carefully to ensure the use of appropriate data. For example, some manufacturers measure visible reflectance, which differs from the solar reflectance measurement used in this credit. Visible reflectance correlates to solar reflectance, but the 2 quantities are not equal because solar gain covers a wider range of wavelengths than visible light. A material that exhibits a high visible reflectance usually has a lower solar reflectance. Typically, white roof products exhibit higher performance characteristics than non-white products. Performance varies by roofing materials, as well as brand. Check with roofing manufacturers and the Lawrence Berkeley National Laboratory's Cool Roofing Materials Database (see the Resources section) for specific information, including the SRI value of a material. Table 1 provides examples of SRI values for typical roof surfaces. These values are for reference only, not for use as substitutes for actual manufacturer's data. Reflectance and emittance data for manufacturers are available from the Cool Roof Rating Council website (see the Resources section). Note that the infrared emittance of aggregates and cementitious materials is always 0.9.

TABLE 1. SOLAR REFLECTANCE INDEX (SRI) FOR TYPICAL ROOFING MATERIALS

SRI VALUES FOR SOLAR INFRARED TEMPERATURES	SOLAR REFLECTANCE	INFRARED EMITTANCE	TEMPERATURE RISE °F	SRI
Grey EPDM	0.23	0.87	68 (38°C)	21
Grey asphalt shingle	0.22	0.91	67 (37°C)	22
Unpainted cement tile	0.25	0.9	65 (36°C)	25
White granular surface bitumen	0.26	0.92	63 (35°C)	28
Red clay tile	0.33	0.9	58 (32°C)	36
Light gravel on built-up roof	0.34	0.9	57 (32°C)	37
Aluminum coating	0.61	0.25	48 (27°)	50
White-coated gravel on built-up roof	0.65	0.9	28 (16°C)	79
White coating on metal roof	0.67	0.85	28 (16°C)	82
White EPDM	0.69	0.87	25 (14°C)	84
White cement tile	0.73	0.9	21 (12°C)	90
White coating, 1 coat, 8 mils	0.8	0.91	14 (8°C)	100
PVC white	0.83	0.92	11 (6°C)	104
White coating, 2 coats, 20 mils	0.85	0.91	9 (5°C)	107
Source: Lawrence Berkeley National Laboratory Cool Roofing Materials Database. These values are for reference only and are not for use as substitutes for actual manufacturer data.				

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VEGETATED ROOFS

A vegetated roof is a layered system that consists of vegetation, growing medium, filter fabric, drainage, and a waterproof membrane atop a conventional roof (Figure 1). A vegetated roof can be installed as a complete system or as a modular system consisting of interlocking trays. Potted plants do not usually count as a vegetated roof because they do not offer the same magnitude of environmental benefits, and so do not contribute to meeting the credit requirements.

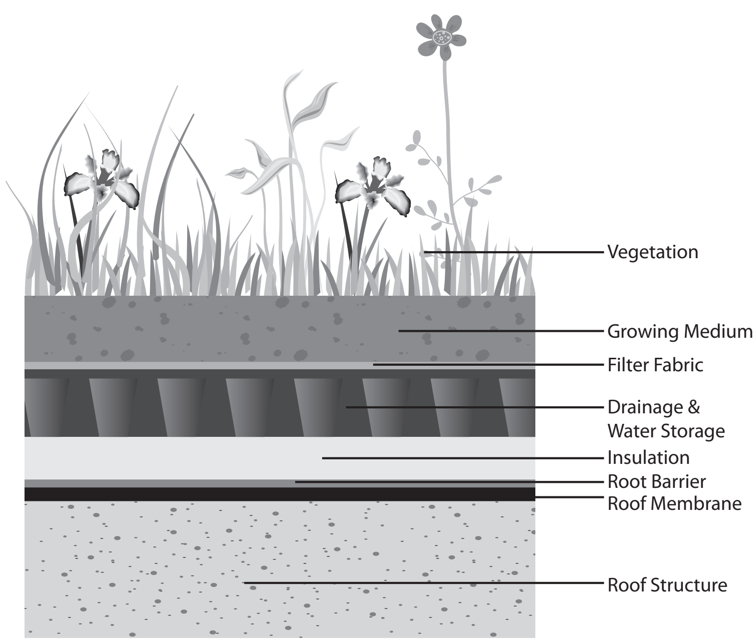
Vegetated roofs can be very beneficial. They can reduce the heat island effect by replacing heat-absorbing surfaces with herbaceous plants, shrubs, and small trees to cool the air through evapotranspiration. They also retain stormwater, provide insulating benefits, are aesthetically appealing, have longer lifetimes than conventional roofs, and often require less maintenance than conventional roofs. Some vegetated roofs are actual gardens and require significant plant care; others have grasses and other plants that require no maintenance or irrigation. All types of vegetated roofs require semi-annual inspection.

Occupants' use of roof gardens may be incompatible with high-reflectivity roofing materials. An area-weighted SRI equivalent may help allow for low-glare pavers where people congregate. The planted portions and unoccupied areas of the roof will offset a lower SRI.

Vegetated roofs may unwittingly cause bird collisions with adjacent structures, such as glazed buildings or penthouses. Measures to prevent or reduce bird collision include using exterior shading devices, introducing etched or frit patterns in the glass, and creating "visual markers" in sufficient locations. Visual markers are differentiated planes, materials, textures, colours, opacity, or other visually contrasting features that help fragment window reflections and reduce overall transparency and reflectivity. See strategies and references under SS Credits 5.1 and 5.2.

When designing green roofs, select native or adapted plant species to reduce or eliminate the need for irrigation. Where irrigation is required, consider using greywater or harvested stormwater to reduce potable water use.

FIGURE 1. TYPICAL VEGETATED ROOF



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5. TIMELINE AND TEAM

Early in the design process, the project team should engage the architect, landscape architect, civil and mechanical engineers, and an ecologist in evaluating cool roof systems. Architects should specify roofing materials with a high SRI value in the construction documents, and the general contractor should work with vendors to procure manufacturers' data with compliant SRI values. When designing vegetated roofs, involve landscape architects and civil engineers (or qualified environmental professionals) to determine appropriate soil types, average rainfall, and regional plant species that provide wildlife habitat.

6. CALCULATIONS

Obtain the roofing material's SRI value from the manufacturer and complete the following steps.

STEP 1

Determine the total roof surface area of the project building (square metres).

STEP 2

Determine the area of the roof covered by mechanical equipment, solar energy panels, skylights, and parapets, and deduct these areas from the total roof surface area.

STEP 3

Determine whether the areas of qualifying reflective and vegetated roofing are adequate to meet the credit requirements, using Equation 1. If more than 1 type of low-slope or steep-slope material is used, determine the weighted rooftop SRI average and verify that 75% or more of the roof area complies with the credit requirements.

Equation 1

$$\left(\frac{\text{Area of Low-Slope SRI Material}}{78 \times \frac{0.75}{\text{SRI Value}}} + \frac{\text{Area of Steep-Slope SRI Material}}{29 \times \frac{0.75}{\text{SRI Value}}} + \frac{\text{Vegetated Roof Area}}{0.5} \right) \geq \left(\text{Total Roof Area} - \text{Deducted Area} \right)$$

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Prepare roof drawings that show total roof area and the areas of reflective materials or vegetated roof systems.
- List the roofing products, and their emittance percentages, reflectance percentages, SRI values, and slopes. Retain product specifications that verify product characteristics.

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8. EXAMPLES

A new office building has a 1000 square metre low-slope roof and is designed to have both highly reflective roofing materials and a vegetated roof system. The vegetated roof makes up 35% of the roof area. White EPDM roofing with a SRI of 85 covers 60% of the roof area, and the remaining 5% is covered by rooftop mechanical equipment. Table 2 summarizes the roofing types.

TABLE 2. ROOFING AREA SUMMARY, BY TYPE

ROOFING TYPE	AREA (m^2)
Vegetated roof area	350
White EPDM roof area (SRI-85), low slope	600
Mechanical equipment	50
Total roof area	1,000

Using Equation 1,

$$\left(\frac{600}{78 \times \frac{0.75}{85}} + \frac{350}{0.5} \right) = 1{,}572\text{m}^2 \geq (1{,}000 - 50)$$

In this example, the white EPDM roofing plus the vegetated roofing meets the requirements of this credit, so the project earns 1 point.

9. EXEMPLARY PERFORMANCE

Projects may earn an Innovation in Design credit for exemplary performance by demonstrating that 100% of the project's roof area (excluding any mechanical equipment, photovoltaic panels, and skylights) consists of a vegetated roof system.

10. REGIONAL VARIATIONS

Heat island intensities depend on an area's weather and climate, proximity to water bodies, and topography. Buildings in very cold climates or at high latitudes may not experience the same rise of surface and ambient temperatures. Consider climate and rainfall at the site when determining the feasibility of a vegetated roof for the project building. In sunny climates, window shading devices will help mitigate glare from reflective roofing into the building.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Materials with high reflectivity must be periodically cleaned to maintain their heat island reduction properties. These surfaces should be cleaned at least every 2 years to maintain good reflectance.

Building operators should obtain the necessary information to maintain any vegetated roofing system. Extensive green roof systems with low-growing plants are generally easier to maintain than intensive systems with deeper soil and larger plants. The design team should select plantings that are easy to maintain and tolerant of extreme conditions, and avoid plants that produce airborne seeds that will litter the surroundings. The project team should establish an operations plan for inspecting the roof membrane and plantings, as well as maintaining drainage paths. Until plants are fully established, watering and fertilization might be necessary. Properly designed green roofs do not require mowing or cutting, but occasional weeding may be required.

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In the roof design, consider including habitat for the animal and insect populations needed to pollinate the installed plantings, such as beehives and wild bee shelters. The project team should request maintenance information from product manufacturers and installers, and then make sure this information is given to the operations team.

12. RESOURCES

WEBSITES

American Bird Conservancy
http://www.abcbirds.org

ABC is a national leader in reducing human effects on birds and wildlife. ABC's bird collision program supports national efforts to reduce bird mortality through education and advocacy.

Birds and Buildings Forum
http://www.birdsandbuildings.org

This Chicago-based non-profit supports bird-friendly design through education and advocacy. Their website maintains lists of organizations and resources.

City of Toronto – Green Roof Site
http://www.toronto.ca/greenroofs/index.htm

In mid-2009, the city of Toronto has adopted a bylaw to require and govern the construction of green roofs on new development. The site provides general resources and local studies on green roofs.

Cool Roof Rating Council
http://www.coolroofs.org

This non-profit organization is dedicated to implementing and communicating fair, accurate, and credible radiative energy performance rating systems for roof surfaces; supporting research into energy-related radiative properties of roofing surfaces, including durability; and providing education and objective support to parties interested in understanding and comparing roofing options.

Fatal Light Awareness Program
http://www.flap.org

Initiated the Bird-Friendly Building Development Program for the City of Toronto, FLAP monitors and promotes bird-friendly design.

Greenroofs.com
http://www.greenroofs.com

This site is an internet news media organization providing an information database and clearinghouse for the greenroof movement.

Green Roofs for Healthy Cities
http://www.greenroofs.org

This non-profit industry association consists of individuals and public and private organizations committed to developing a market for green roof infrastructure products and services across North America.

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Lawrence Berkeley National Laboratory, Heat Island Group, Cool Roofs
http://eetd.lbl.gov/HeatIsland/CoolRoofs/

This site offers a wealth of information about cool roof research and technology, including links to the cool roofing materials database.

New York City Audubon
http://www.nycaudubon.org

This Audubon chapter takes a leadership role in reducing bird collisions with buildings. The chapter publishes Bird-Safe Building Guidelines, conducts monitoring, and through its Project Safe Flight, promotes bird-friendly design.

U.S. EPA, ENERGY STAR Roofing Products
http://www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products

This site provides solar reflectance levels required to meet ENERGY STAR requirements for qualified roof products.

Whole Building Design Guide, Extensive Green Roofs
http://www.wbdg.org/resources/greenroofs.php

This article by Charlie Miller, PE, details the features and benefits of constructing green roofs.

PRINT MEDIA

Research on green rooftops and walls in Québec City (Canada Mortgage and Housing Corporation, 2007). Technical Series 07-112

13. DEFINITIONS

An **area-weighted SRI** is a weighted average calculation that may be performed for buildings with multiple roof surfaces to demonstrate that the total roof area has an average solar reflectance index equal to or greater than that of a theoretical roof 75% of whose surfaces have an SRI of 78 and 25% have an SRI of 30.

Emissivity is the ratio of the radiation emitted by a surface to the radiation emitted by a black body at the same temperature.

Greenhouse gases are relatively transparent to the higher-energy sunlight but trap lower-energy infrared radiation (e.g., carbon dioxide, methane, and CFCs).

Heat islands are defined as thermal gradient differences between developed and undeveloped areas.

Hardscape consists of the inanimate elements of the building landscaping. Examples include pavement, roadways, stone walls, concrete paths and sidewalks, and concrete, brick, and tile patios.

Infrared emittance, or thermal emittance, is a parameter between 0 and 1 (or 0% and 100%) that indicates the ability of a material to shed infrared radiation (heat). The wavelength range for this radiant energy is roughly 4 to 40 micrometers. Most building materials (including glass) are opaque in this part of the spectrum, and have an emittance of roughly 0.9. Materials such as clean, bare metals are the most important exceptions to the 0.9 rule. Thus clean, untarnished galvanized steel has low emittance, and aluminum roof coatings have intermediate emittance levels.

Solar reflectance, or **albedo**, is a measure of the ability of a surface material to reflect sunlight—visible, infrared, and ultraviolet wavelengths—on a scale of 0 to 1. Black paint has a solar reflectance of 0; white paint (titanium dioxide) has a solar reflectance of 1.

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The **solar reflectance index (SRI)** is a measure of a material's ability to reject solar heat, as shown by a small temperature rise. Standard black (reflectance 0.05, emittance 0.90) is 0 and standard white (reflectance 0.80, emittance 0.90) is 100. For example, a standard black surface has a temperature rise of 90˚F (50˚C) in full sun, and a standard white surface has a temperature rise of 14.6˚F (8.1˚C). Once the maximum temperature rise of a given material has been computed, the SRI can be calculated by interpolating between the values for white and black. Materials with the highest SRI values are the coolest choices for paving. Because of the way SRI is defined, particularly hot materials can even take slightly negative values, and particularly cool materials can even exceed 100. (Lawrence Berkeley National Laboratory Cool Roofing Materials Database) SRI is calculated according to ASTM E 1980. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C 1371.

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CS	Credit 8

LIGHT POLLUTION REDUCTION

	NC	CS
Credit	SS Credit 8	SS Credit 8
Points	1 point	1 point

INTENT

To minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction and reduce development impact from lighting on nocturnal environments.

REQUIREMENTS: NC & CS

Project teams must comply with 1 of the 2 options for interior lighting AND the requirement for exterior lighting.

FOR INTERIOR LIGHTING

OPTION 1

Reduce the input power (by automatic device) of all non-emergency interior luminaires with a direct line of sight to any openings in the envelope (translucent or transparent) by at least 50% between the hours of 11 p.m. and 5 a.m. After-hours override may be provided by a manual or occupant-sensing device provided the override lasts no more than 30 minutes.

OR

OPTION 2

All openings in the envelope (translucent or transparent) with a direct line of sight to any non-emergency luminaires must have shielding (controlled/closed by automatic device for a resultant transmittance of less than 10% between the hours of 11 p.m. and 5 a.m.).

FOR EXTERIOR LIGHTING

Partially or fully shield all exterior luminaires with 1000 initial lamp lumens or more to meet the Full Cutoff IESNA Classification so they do not emit light directly to the night sky.

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Light areas only as required for safety and comfort. Do not exceed 80% of the Lighting Power Densities for exterior areas and 50% for building facades and landscape features as defined in ANSI/ASHRAE/IESNA Standard 90.1-2007 for the classified zone.

Classify the project under 1 of the following zones, as defined in IESNA RP-33, and follow all of the requirements for that zone:

LZ1 — Dark (developed areas within national parks, provincial parks, forest land and rural areas)

Design exterior lighting so that all site and building-mounted luminaires produce a maximum initial illuminance value no greater than 0.11 horizontal and vertical lux (0.01 horizontal and vertical footcandles) at the site boundary and beyond. Document that 0% of the total initial designed fixture lumens (sum total of all fixtures on site) are emitted at an angle of 90 degrees or higher from nadir (straight down).

LZ2 — Low (primarily residential zoning, neighbourhood business districts, light industrial with limited nighttime use and residential mixed use areas)

Design exterior lighting so that all site and building-mounted luminaires produce a maximum initial illuminance value no greater than 1.1 horizontal and vertical lux (0.10 horizontal and vertical footcandles) at the site boundary and no greater than 0.11 horizontal lux (0.01 horizontal footcandles) 3 metres (10 feet) beyond the site boundary. Document that no more than 2% of the total initial designed fixture lumens (sum total of all fixtures on site) are emitted at an angle of 90 degrees or higher from nadir (straight down).

LZ3 — Medium (all other areas not included in LZ1, LZ2 or LZ4 such as commercial/industrial, high-density residential)

Design exterior lighting so that all site and building-mounted luminaires produce a maximum initial illuminance value no greater than 2.2 horizontal and vertical lux (0.20 horizontal and vertical footcandles) at the site boundary and no greater than 0.11 horizontal lux (0.01 horizontal footcandles) 4.6 metres (15 feet) beyond the site. Document that no more than 5% of the total initial designed fixture lumens (sum total of all fixtures on site) are emitted at an angle of 90 degrees or higher from nadir (straight down).

LZ4 — High (high-activity commercial districts in major metropolitan areas)

Design exterior lighting so that all site and building-mounted luminaires produce a maximum initial illuminance value no greater than 6.5 horizontal and vertical lux (0.60 horizontal and vertical footcandles) at the site boundary and no greater than 0.11 horizontal lux (0.01 horizontal footcandles) 4.6 metres (15 feet) beyond the site. Document that no more than 10% of the total initial

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designed fixture lumens are emitted at an angle of 90 degrees or higher from nadir (straight down).

LZ2, LZ3 & LZ4 — For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

FOR ALL ZONES

Illuminance generated from a single luminaire placed at the intersection of a private vehicular driveway and public roadway accessing the site, is allowed to use the centerline of the public roadway as the site boundary for a length of 2 times the driveway width centered at the centerline of the driveway.

INTERPRETATIONS

It is acceptable to have a higher light level above LEED requirements (in Lighting Zones 3 and 4) for the areas at entrance or exit doors at the site boundary under the following conditions:

a. the lighting source is provided only at points required for emergency egress purposes;

b. that light only trespasses onto public sidewalks and streets and right-of-ways;

c. the building door illuminated by the non-compliant lighting source is within 4.6 metres of the site boundary;

d. the luminance values meet the LEED 4.6 metre requirements at 4.6 metres beyond the site boundary; and

e. fixtures are full cut-off.

Lighted signage that is required by local Code for safety reasons (such as in the case of a Police Station) may be excluded from the credit calculations, provided the other fixtures and signage follow all of the other credit requirements for illuminance, light trespass, and ambient illumination. While the code requirements may prevent applicants from completely meeting the credit requirements, the applicant should try to address the credit intent as much as possible. This does not exempt all local code requirements.

Light spillage onto public roadways for safety provisions at vehicular entrances and egresses to the site are permissible for hospital occupancies. Measures must be taken to minimize the trespass, and the lighting strategy must continue to address the other requirements pertinent to the Credit for the remainder of the project area.

Light from uplighting that is fully contained within a soffit or within a canopy is not considered uplighting for the purposes of this credit. However uplighting of trees is considering uplighting and must be included in the calculations.

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Light trespass from walkway lighting is acceptable where pedestrian walkways cross the site boundary. Note that this lighting must meet all other credit requirements.

LEASED TENANT SPACE

For NC certification, mandatory lease agreements must either list in detail all requirements of the credit including the lighting analysis that must be done by the tenants or mandate prescriptive lighting measures that align with the base building and owner fit-up tenant spaces.

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1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Outdoor lighting is important for human safety. Illuminating connections between buildings and support facilities such as sidewalks, parking lots, roadways, and community gathering places is necessary for twilight and nighttime use. However, light trespass from poorly designed outdoor lighting systems can affect a site's nocturnal ecosystem, and light pollution limits night sky observations. Through thoughtful design and careful maintenance, outdoor lighting can address night sky visibility issues and site illumination requirements, while minimizing negative impacts on the environment.

Sensitively and creatively designed lighting systems promote a unique appreciation for a place at night. Yet even with the best of luminaries—those designed to reduce light pollution and requiring the lowest wattage—the added light will be reflected off surfaces and into the atmosphere. Using the minimum amount of lighting equipment, limiting or eliminating all landscape lighting, and avoiding light pollution through the careful selection of lighting equipment and controls enables nocturnal life to thrive while still providing for human nighttime activity.

ECONOMIC ISSUES

The initial cost and ongoing operational costs for exterior lighting can be greatly reduced by eliminating luminaries that do not enhance safety. Additionally, using the most efficacious light sources, luminaries, and controls will further reduce the energy costs of these systems. Long-life lamps can further increase operational savings by requiring a less frequent re-lamping cycle. However, the initial cost per luminaire may be somewhat higher because of increased costs associated with internal reflectors and shielding, more efficient lamp and ballast combinations, and controls.

2. RELATED CREDITS

This credit requires adherence to the lighting power densities of ASHRAE 90.1–2007. Any energy savings beyond this baseline, as well as savings stemming from integrated automatic controls, may contribute to achieving the following credit:

- EA Credit 1: Optimize Energy Performance

Automatic occupancy controls to shutoff interior perimeter lighting should be coordinated with occupant controllability objectives, as rewarded under this credit:

- IEQ Credit 6.1: Controllability of Systems—Lighting

3. SUMMARY OF REFERENCED STANDARDS

ANSI/ASHRAE/IESNA Standard 90.1–2007, Energy Standard for Buildings Except Low-Rise Residential Lighting, Section 9 (without amendments)
American Society of Heating Refrigeration, and Air-Conditioning Engineers
http://www.ashrae.org

Standard 90.1–2007 was developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), under an American National Standards Institute (ANSI) consensus process. The Illuminating Engineering Society of North America (IESNA) is a joint sponsor of the standard. Standard 90.1 establishes minimum requirements for the energy-efficient design

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of buildings, except those that are low-rise residential. The provisions of this standard also do not apply to single-family houses; multifamily structures of 3 habitable stories or fewer above grade; mobile and modular homes; buildings without electricity or fossil fuel consumption; or equipment and portions of building systems that use energy primarily for industrial, manufacturing, or commercial processes. The standard provides criteria in the following general categories: building envelope (Section 5); heating, ventilating, and air-conditioning (Section 6); service water heating (Section 7); power (Section 8); lighting (Section 9); and other equipment (Section 10). Within each section there are mandatory provisions as well as additional prescriptive requirements. Some sections also contain a performance alternate. The energy cost budget option (Section 11) allows the user to exceed some of the prescriptive requirements provided energy cost savings are made in other prescribed areas. However, in all cases, the mandatory provisions must still be met.

Section 9 of the standard provides requirements for the lighting of buildings. Only the exterior lighting requirements apply to this credit. Table 1 lists the ASHRAE 90.1–2007 allowable building exterior lighting power densities.

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TABLE 1. LIGHTING POWER DENSITIES FOR BUILDING EXTERIORS

	APPLICATIONS	LIGHTING POWER DENSITIES
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.)	**UNCOVERED PARKING AREAS**	
	Parking Lots and drives	1.6 W/m^2 (0.15W/ft^2)
	BUILDING GROUNDS	
	Walkways less than 3 metres (10 feet) wide	3.3 W/linear metre (1.0W/linear foot)
	Walkways 3 metres (10 feet) wide or greater Plaza areas Special Feature Areas	2.2W/m^2 (0.2W/ft^2)
	Stairways	10.8W/m^2 (1.0W/ft^2)
	BUILDING ENTRANCES AND EXITS	
	Main entries	98W/linear metre of door width (30W/linear foot of door width)
	Other doors	66W/linear metre of door width (20W/linear foot of door width)
	CANOPIES AND OVERHANGS	
	Canopies (free standing and attached and overhangs)	13.5 W/m^2 (1.25W/ft^2)
	OUTDOOR SALES	
	Open areas (including vehicle sales lots)	5.4 W/m^2 (.5W/ft^2)
	Street frontage for vehicle sales lots in addition to "open area" allowance	66 W/linear metre (20W/linear foot)
Non-Tradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building Facades	2.2 W/m^2 (0.2W/ft^2) for each illuminated wall or surface or 16.4 W/linear metre (5.0W/linear foot) for each illuminated wall or surface length
	Automated teller machines and night depositories	270W per location plus 90W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	13.5 W/m^2 (1.25W/ft^2) of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	5.4 W/m^2 (0.5W/ft^2) of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Drive-up windows at fast food restaurants	400W per drive-through
	Parking near 24-hour retail entrances	800W per main entry

Source: Table 9.4.5, ANSI/ASHRAE/IESNA 90.1–2007.

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4. IMPLEMENTATION

INTERIOR BUILDING LIGHTING

OPTION 1

All nonemergency interior lighting fixtures must be automatically controlled and programmed to turn off or have their input power reduced by at least 50% following regular business hours. Controls can be automatic sweep timers, occupancy sensors, or programmed master lighting control panels. The design can also include manual or occupancy based override capabilities that enable lights to be turned on after hours.

Twenty-four-hour operation projects are exempt from the after-hours override automatic shutoff, and thus must follow Option 2.

OPTION 2

All exterior openings, such as windows, must have shielding that can be automatically controlled and programmed to close from 11:00 p.m. to 5:00 a.m. Shielding options include automatic shades that have less than 10% transmittance.

An example is a timer-controlled automated rolling shade with the appropriate light transmittance.

CS

In core and shell buildings, these requirements are limited to the core and shell lighting. This typically includes lobby and core circulation spaces. If no light is provided to tenant spaces as part of the core and shell development, those spaces are exempt from these requirements. Core and shell projects that do not install any interior lighting as part of the project scope have met this requirement.

EXTERIOR LIGHTING POWER DENSITY

Design the project's exterior lighting to meet lighting power densities that are equal to or less than the requirements set forth in SS Credit 8, Figure 1, ASHRAE 90.1–2007, Section 9, Table 9.4.5., Lighting for Exterior Areas.

Projects should light areas only as required for safety and comfort, provide only the light levels necessary to meet the design intent, and select efficient fixtures using efficacious sources to meet the lighting requirements of the site while minimizing light pollution.

EXTERIOR LIGHT DISTRIBUTION

Design the project's exterior lighting to comply with the light pollution requirements for the project's zone. The lighting requirements address the site illumination level at and beyond the site boundary and the luminaire distribution relative to up-lighting. The exterior lighting must meet the light pollution requirements under both pre-curfew and post-curfew conditions. Curfew timers and controls can be effective parts of the overall lighting strategy, but controls cannot be used to make otherwise noncompliant exterior areas comply with the credit.

Consider using low-intensity shielded fixtures and curfew controllers to turn off nonessential site lighting after 10:00 p.m. or immediately after closing (whichever is later) to further reduce the

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effects of light pollution. Minimize the lighting of architectural and landscape features. Where lighting is required for safety, security, egress, or identification utilize down-lighting techniques rather than up-lighting.

For example, in environments that are primarily dark (LZ1), no landscape features should be illuminated and architectural lighting should be designed only when other strategies cannot provide the minimum amount of required lighting. In places with medium or high ambient brightness (LZ3 and LZ4), some low-level lighting of features, facades, or landscape areas may be appropriate in pedestrian areas, or for identifying and marking pedestrian paths in areas where light trespass is not likely to be an issue. However, even in areas of high ambient brightness, all nonessential lighting (including landscape and architectural lighting) should be minimized or turned off after hours. All adjustable luminaires should be properly aimed so that light from the luminaires does not cross project boundaries. Use controls wherever possible to turn off nonessential lighting after normal operating hours or after curfew.

At a minimum, consider the following strategies when designing the exterior lighted environment:

- Employ a lighting professional to assess the project's lighting needs and provide recommendations based specifically on lighting for a sustainable built environment.
- Carefully review and respond to any applicable lighting ordinances or bylaws that might affect the lighting design for the project site.
- Determine the environmental zone that the project falls under from Dark (LZ1) to High Ambient Brightness (LZ4). Understand the design implications of the environmental zone that is determined and study neighbouring areas to identify potential light trespass problems.
- In most cases, it is better to have 2 luminaires with lower light output and good glare control than 1 higher-output luminaire.
- Select all lighting equipment carefully. Any type of luminaire, whether it is full cutoff, semi-cutoff or non-cutoff, can produce excessive brightness in the form of glare. For example, horizontal lamp positions in full cutoff luminaires tend to produce much less glare than vertical lamps.
- Design exterior lighting to produce minimal upward illumination from the luminaire and reflected light off of adjacent surfaces. Select luminaire locations carefully to control glare and contain light within the design area. Pay special attention to luminaires that are located near the property line to ensure that minimal measurable light from these luminaires crosses the LEED project boundary.
- Use the minimum amount of light necessary. Design and develop a control scheme to minimize or turn lighting off after hours or during post-curfew periods.
- Create a computer model of the proposed electric lighting design and simulate system performance. Use this model to calculate the specified illuminances demonstrating that illuminance values are as required at the project site boundary and at the required distance beyond the site boundary. Calculate the vertical light levels along and above the site boundary to a height of at least the highest luminaire on the site.
- After the lighting system is constructed, commission it to make sure that it is installed and operating properly. Perform maintenance on the system on a regular basis to make sure that it continues to operate properly and that light pollution is minimized.

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NC	Credit 8
CS	Credit 8

5. TIMELINE AND TEAM

Once the environmental zone is determined by the lighting designer, often in the schematic design phase, the design can move forward. Consider local light level requirements and the unique aspects of the site in relation to the light pollution thresholds of this credit.

As the exterior lighting is designed, a photometric analysis of the site should be performed at intervals to verify the project's continued compliance with the credit requirements. During the construction documents phase, the landscape architect, civil engineer, lighting designer, architect, electrical engineer, and others as appropriate should coordinate to verify the layout and compliance of the exterior fixtures.

6. CALCULATIONS

INTERIOR BUILDING LIGHTING

There are no calculations associated with this portion of the credit.

EXTERIOR LIGHTING POWER DENSITY

Calculate the exterior lighting power density in accordance with ANSI/ASHRAE/IESNA 90.1–2007 Section 9 (see Table 1) and determine whether it is less than the allowable densities for the project site. Note that individual luminaire wattages must be input watts (not just lamp watts), including all ballast losses.

EXTERIOR SKY GLOW AND LIGHT TRESPASS

To measure compliance with the light trespass requirements, use lighting design software and develop a site illumination model (i.e., photometric site plan). The model should show the full extent of the site and all installed exterior lighting fixtures. Set up a horizontal calculation grid to measure the site illumination at the ground plane (the grid should extend to the property line and 3 metres (10 feet) beyond the site boundary for LZ2, and 4.6 metres (15 feet) beyond the site boundary for LZ3 and LZ4). Set a vertical calculation grid at the property boundary and at the extents of the LZ requirements (3 metres (10 feet) beyond the site boundary for LZ2, and 4.6 metres (15 feet) beyond the site boundary for LZ3 and LZ4) to measure vertical illumination. The calculation grid spacing should be a maximum of 3 metres x 3 metres (10 feet x 10 feet) and should exclude building interior areas.

Using manufacturers' fixture data, determine the initial lamp lumens for each luminaire. Additionally, from photometric data, determine the number of initial lamp lumens that are emitted at or above 90 degrees from nadir. Use these data to determine the percentage of lumens at or above 90 degrees.

Luminaires without photometric distribution data must be assumed to have 100% of their initial lamp lumens at or above 90 degrees. Luminaires with limited field adjustability must be assumed to have maximum tilt applied, and lumens at or above 90 degrees must be calculated from maximum tilted orientation. Luminaires with full range of field adjustability (those that can be aimed above 90 degrees from nadir) must be assumed to have 100% of the emitted fixture lumens at or above 90 degrees.

SS	
NC	Credit 8
CS	Credit 8

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

INTERIOR LIGHTING

- If automatic controls are used for interior lighting, prepare drawings showing their locations. Incorporate the sequence of operation for lighting into drawings and specifications or the building operation plan.
- If automatic shading devices are used to control interior lighting, prepare drawings of the devices, assembly specifications, or product data showing that they block at least 90% of the light, and incorporate the sequence of operation for automatic shading devices into drawings and specifications, or the building operation plan.

EXTERIOR LIGHTING

- Determine the zone classification for a project site.
- Acquire manufacturer's data for lamps used on a project site.
- Prepare a description of the light trespass analysis procedure conducted to determine credit compliance.
- Develop a photometric site plan of parking areas that includes lux or footcandle summary tables for light ratio.

SS	
NC	Credit 8
CS	Credit 8

8. EXAMPLES

EXAMPLE 1. Exterior Lighting Power Density and Trespass Assessment

Table 2 shows an example of how exterior lighting power density calculations are performed, and Table 3 demonstrates the data required to calculate the percentage of lumens emitted at or above 90 degrees from nadir.

TABLE 2. SAMPLE EXTERIOR LIGHTING POWER DENSITY CALCULATION

SITE LIGHTING POWER DENSITY CALCULATION						
SITE LIGHTING FIXTURE	**FIXTURE POWER (WATTS)**	**TOTAL FIXTURES (QTY)**	**TOTAL FIXTURE POWER (WATTS)**	**SITE LOCATION**	**SITE AREA (m^2)**	**LPD (W/m^2)**
Pole Fixture 1	250	14	3,500	Parking 1	3,200	1.1
Pole Fixture 1	250	8	2,000	Parking 2	1,800	1.1
Pole Fixture 2	115	1	115	Walkways 1	88	1.3
Bollard Fixture 1	40	4	160	Walkways 1	88	1.8
Bollard Fixture 1	40	6	240	Courtyard 1	150	1.6
Wall Washer 1	50	5	250	Building Façade N	250	1.0
SITE AREAS						
Identification	Area (m^2)	ASHRAE 90.1.2007 Allowable LPD (W/m^2)	Actual LPD (From Site Lighting Table)	Actual LPD Reduction (%)	Required LPD Reduction (%)	Complies (Yes/No)
Parking 1	3,200	1.6	1.1	31%	20%	YES
Parking 2	1,800	1.6	1.1	31%	20%	YES
Walkways 1 (3 m wide)	88	2.2	1.6	27%	20%	YES
Courtyard 1	150	2.2	1.6	27%	20%	YES
Building Façade N	250	2.2	1.0	55%	50%	YES

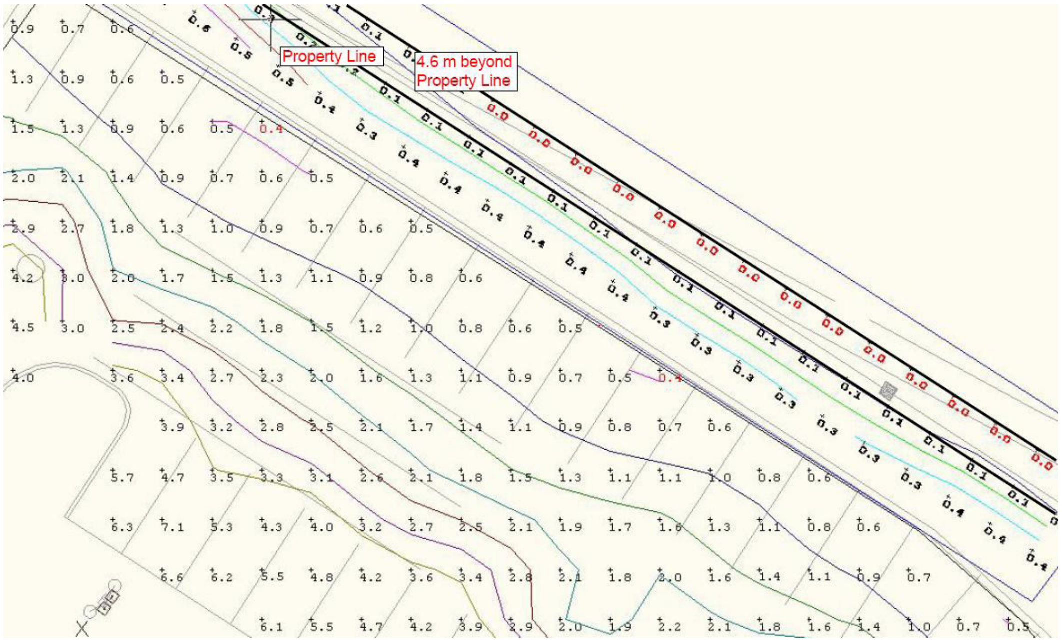
TABLE 3. LAMP LUMEN CALCULATION

LUMINAIRE TYPE	QUANTITY OF INSTALLED LUMINAIRES	INITIAL FIXTURE LUMENS PER LUMINAIRE	TOTAL FIXTURE LUMENS (COLUMN 2 X COLUMN 3)	INITIAL FIXTURE LUMENS FROM LUMINAIRE ABOVE 90 DEGREES (FROM NADIR-STRAIGHT DOWN)	TOTAL FIXTURE LUMENS ABOVE 90 DEGREES (COLUMN 2 X COLUMN 5)
A	10	4,600	46,000	100	1,000
B	20	11,900	238,000	0	0
C	5	2,000	10,000	2,000	10,000
Total			294,000		11,000

SS	
NC	Credit 8
CS	Credit 8

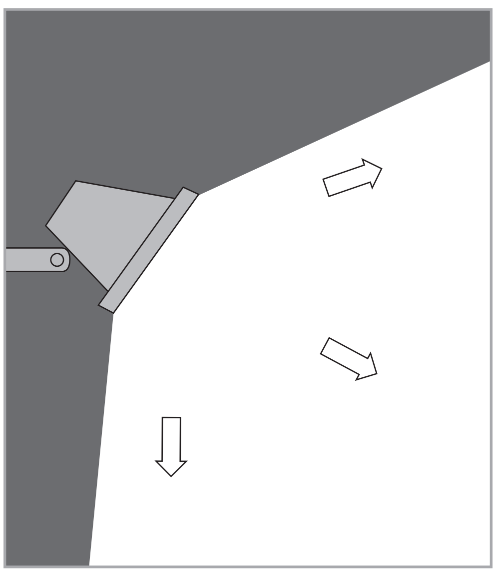
Figure 1 shows the photometric site plan generated by an illumination model. The example is in compliance with the credit requirements for a project located in LZ3: The light level at the property line does not exceed 2.2 lux or 0.2 footcandles, and the light level 4.6 metres (15 feet) beyond the property line does not exceed 0.11 lux or 0.01 footcandles.

FIGURE 1. SAMPLE ILLUMINATION MODEL



Figures 2–5 show how a shielded light can prevent light trespass and light pollution of the night sky.

FIGURE 2. UNSHIELDED FLOODLIGHT



SS	
NC	Credit 8
CS	Credit 8

FIGURE 3. TASK AREA FROM UNSHIELDED FLOODLIGHT

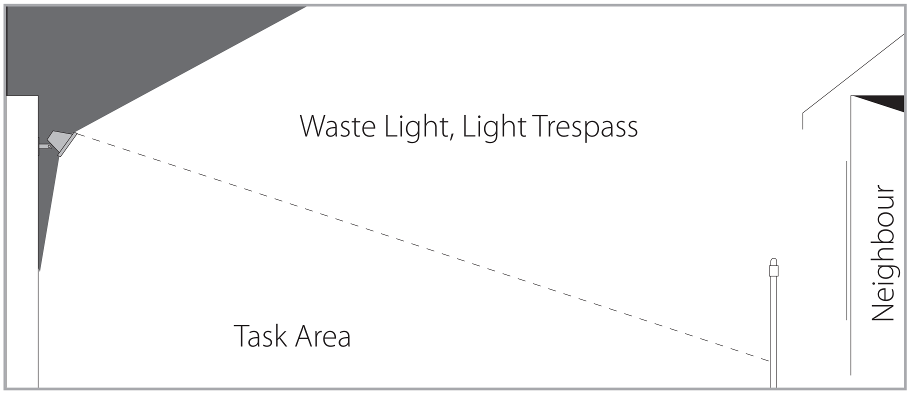


FIGURE 4. SHIELDED FLOODLIGHT

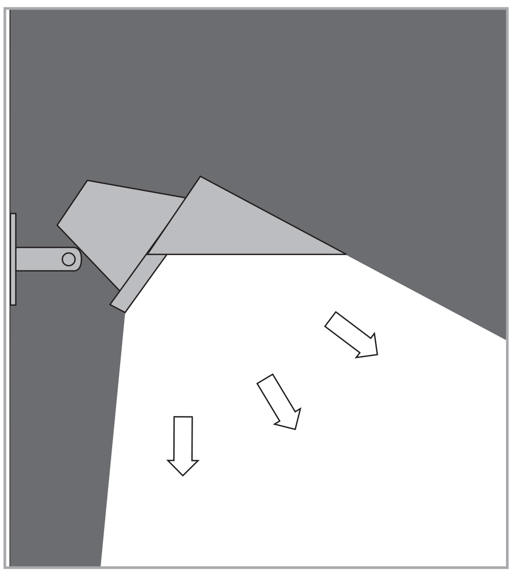
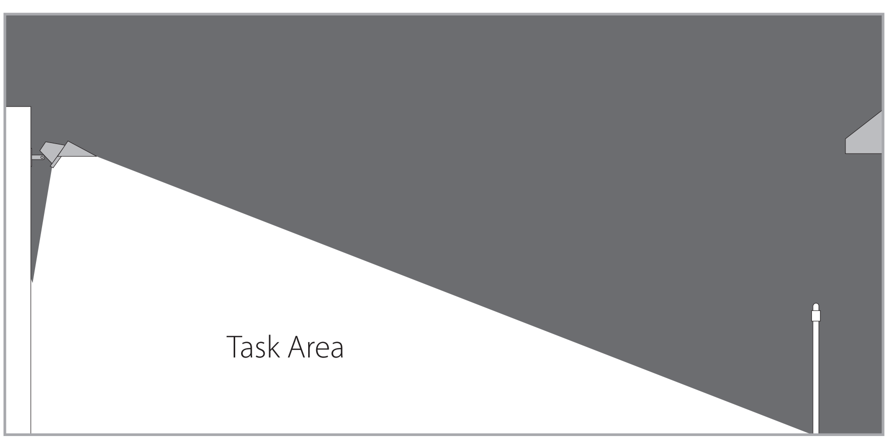


FIGURE 5. TASK AREA FROM SHIELDED FLOODLIGHT



SS	
NC	Credit 8
CS	Credit 8

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations associated with this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Exterior luminaires must be periodically cleaned and re-lamped to maintain optimal light levels. Depending on the number of exterior luminaires, it may be beneficial to implement a schedule and policy for group re-lamping to help avoid lamp burnouts and to minimize the labour costs associated with spot re-lamping. Additionally, if group re-lamping is identified as an operational strategy during the design phase, the initial light levels can often be reduced while still maintaining the design illuminance. A rule of thumb to determine whether group re-lamping is likely to be economically feasible is if the labour cost to change a lamp exceeds the cost per lamp.

12. RESOURCES

WEBSITES

American Society of Heating, Refrigeration, and Air-Conditioning Engineers
http://www.ashrae.org

ASHRAE advances the science of heating, ventilation, air conditioning, and refrigeration for the public's benefit through research, standards writing, continuing education, and publications. To purchase ASHRAE standards and guidelines, visit the bookstore on the ASHRAE website.

Illuminating Engineering Society of North America
http://www.iesna.org

The mission of IESNA is to benefit society by promoting knowledge and disseminating information for the improvement of the lighted environment.

International Dark-Sky Association
http://www.darksky.org

This non-profit agency is dedicated to educating about and providing solutions to light pollution.

Lighting Research Center
http://www.lrc.rpi.edu

A leading university-based research centre devoted to providing objective information about lighting technologies, applications and products to aid facility managers, utilities, lighting designers, engineers and electrical contractors. The web site includes the National Lighting Product Information Program (NLPIP), which provides free publications about lighting topics (such as light pollution) and products.

Royal Astronomical Society of Canada, Light Pollution Abatement Program
http://www.rasc.ca/light/

This program's goal is to reduce levels of light pollution in urban and rural areas by advising governments, businesses and citizens on taking action to reduce unnecessary glare, uplight and light trespass.

SS	
NC	Credit 8
CS	Credit 8

PRINT MEDIA

The IESNA Lighting Handbook, ninth edition, by Illuminating Engineering Society of North America (IESNA, 2000).

Lighting for Exterior Environments RP-33-99, by IESNA Outdoor Environment Lighting Committee (IESNA, 1999).

Concepts in Practice Lighting: Lighting Design in Architecture, by Torquil Barker (B.T. Batsford Ltd., 1997).

The Design of Lighting, by Peter Tregenza and David Loe (E & FN Spon, 1998). ASNI/ASHRAE/IESNA Standard 90.1–2007 User's Manual, effective 2008.

13. DEFINITIONS

Curfew hours are locally determined times when lighting restrictions are imposed. When no local or regional restrictions are in place, 10:00 p.m. is regarded as a default curfew time.

A **footcandle (fc)** is a measure of light falling on a given surface. One footcandle is defined as the quantity of light falling on a 1-square-foot area from a 1 candela light source at a distance of 1 foot (which equals 1 lumen per square foot). Footcandles can be measured both horizontally and vertically by a footcandle meter or light meter.

A **full-cutoff luminaire** has zero candela intensity at an angle of 90 degrees above the vertical axis (nadir or straight down) and at all angles greater than 90 degrees from straight down. Additionally, the candela per 1,000 lamp lumens does not numerically exceed 100 (10%) at an angle of 80 degrees above nadir. This applies to all lateral angles around the luminaire.

Horizontal footcandles occur on a horizontal surface. They can be added together arithmetically when more than 1 source provides light to the same surface.

Light pollution is waste light from building sites that produces glare, is directed upward to the sky, or is directed off the site. Waste light does not increase nighttime safety, utility, or security and needlessly consumes energy.

Light trespass is obtrusive light that is unwanted because of quantitative, directional, or spectral attributes. Light trespass can cause annoyance, discomfort, distraction, or loss of visibility.

Luminaire is a lighting fixture assembly, including lamp, housing, reflector, and ballast (if applicable).

Safety and comfort light levels meet local code requirements and must be adequate to provide a safe path for egress without overlighting the area.

Shielding is a nontechnical term that describes devices or techniques that are used as part of a luminaire or lamp to limit glare, light trespass, or sky glow.

Sky glow is caused by stray light from unshielded light sources and light reflecting off surfaces that then enter the atmosphere and illuminate and reflect off dust, debris, and water vapour. Sky glow can substantially limit observation of the night sky, compromise astronomical research, and adversely affect nocturnal environments.

Vertical footcandles occur on a vertical surface. They can be added together arithmetically when more than 1 source provides light to the same surface.

SS	
NC	NA
CS	Credit 9

TENANT DESIGN AND CONSTRUCTION GUIDELINES

	NC	CS
Credit	NA	SS Credit 9
Points	NA	1 point

INTENT

To educate tenants about implementing sustainable design and construction features in their tenant improvement build-out.

Tenant design and construction guidelines benefit the Core and Shell Development certified project in 2 important ways: First, the guidelines will help tenants design and build sustainable interiors and adopt green building practices; second, the guidelines will help in coordinating *LEED Canada for Commercial Interiors* certifications.

REQUIREMENTS: CS

Publish an illustrated document that provides tenants with the following design and construction information:

- A description of the sustainable design and construction features incorporated in the core and shell project and the project's sustainability goals and objectives, including those for tenant spaces.
- Information on *LEED Canada for Commercial Interiors* and how the core and shell building contributes to achieving these credits.
- Information that enables a tenant to coordinate space design and construction with the core and shell's building systems. Specific *LEED Canada for Commercial Interiors* credit issues to be addressed when applicable include the following:
    - Water use reduction.
    - Optimize energy performance, lighting power.
    - Optimize energy performance, lighting controls.
    - Optimize energy performance, HVAC.
    - Energy use and metering.
    - Measurement and verification.
    - Ventilation and outdoor air delivery.
    - Construction indoor air quality management.
    - Indoor chemical and pollutant source control.

SS	
NC	NA
CS	Credit 9

- Controllability of systems.
    - Thermal comfort.
    - Daylighting and views.
    - Commissioning.
    - Elimination or control of environmental tobacco smoke.
- Recommendations, including examples, for sustainable strategies, products, materials, and services.

SS	
NC	NA
CS	Credit 9

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Because of the speculative nature of the real estate market, a building's core and shell and interior tenant spaces are controlled by completely different entities. Responsibility for environmental impacts is therefore weighted differently for building owners, developers, and tenants. Tenants' potential to reduce energy use through efficient lighting design and daylighting strategies depends on the core and shell construction, and the base building mechanical system will directly influence tenants' ability to optimize occupants' indoor environmental quality.

LEED Canada for Core & Shell buildings also offer ways for tenants to take advantage of the environmental benefits built into the project and can inspire tenants to take their own steps toward environmental stewardship. Core & Shell building efforts to reduce heat islands, plant native landscapes, and install low flow plumbing fixtures can significantly reduce tenants' energy and resource use, particularly where lease agreements require tenants to meter and pay for their own energy costs.

ECONOMIC ISSUES

Producing tenant design and construction guidelines will not have an economic impact on *LEED Canada for Core & Shell* projects; however, the strategies and recommendations in the guidelines can require upfront investments on the part of building tenants. Tenants choosing to certify their build-out projects under the *LEED Canada for Commercial Interiors* Rating System may incur additional costs for commissioning and certification. However, a carefully designed core and shell will provide base building elements that support cost-effective ways for tenants to earn credits under *LEED Canada for Commercial Interiors*.

2. RELATED CREDITS

This credit is related to all *LEED Canada for Core & Shell* credits the project team chooses to pursue within the scope of the LEED project. *LEED Canada for Core & Shell* credits most likely to affect future building tenants are these:

- WE Credit 3: Water Use Reduction
- EA Credit 1: Optimize Energy Performance
- EA Credit 3: Enhanced Commissioning
- EA Credit 5: Measurement and Verification
- IEQ Prerequisite 2: Environmental Tobacco Smoke Control
- IEQ Credit 2: Increased Ventilation
- IEQ Credit 3: Construction Indoor Air Quality Management Plan
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control
- IEQ Credit 6: Controllability of Systems
- IEQ Credit 7: Thermal Comfort
- IEQ Credit 8: Daylighting and Views

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

SS	
NC	NA
CS	Credit 9

4. IMPLEMENTATION

The tenant design and construction guidelines are intended to educate future building tenants on the sustainability goals of the core and shell project, explain how tenants can incorporate green building strategies into the build-out of their own spaces, describe the synergies between *LEED Canada for Core & Shell* and *LEED Canada for Commercial Interiors*, and encourage tenants to pursue *LEED Canada for Commercial Interiors* certification.

The recommendations in the tenant design and construction guidelines are meant to highlight building-specific best practices. The guidelines are not meant to be design requirements for the tenant. Some projects may adopt some or all of the guidelines as tenant requirements; however, that is not necessary to meet the requirements of this credit.

Tenant design and construction guidelines must include the following:

CORE & SHELL SUSTAINABLE DESIGN AND CONSTRUCTION FEATURES

This portion of the tenant design and construction guidelines is meant to help the tenant design team understand and efficiently utilize the base building's systems and design features. Technical information, building features, and base building environmental policies should be clearly communicated. As appropriate for the project, the guidelines will include the following:

Reduced water use. Specify the building water use reduction goals; provide information about the water use fixtures and systems and how they assist in achieving these goals. Fixtures and systems recommendations should also be included. These can be presented in narrative form with product cut sheets.

Optimize energy performance. This section should outline the energy optimization features of the core and shell and provide information and recommendations about how tenants can further reduce energy use through design. Specific features to be highlighted:

Lighting power. The greatest opportunity for tenants to optimize energy consumption is in the area of lighting. *LEED Canada for Core & Shell* building design can dramatically affect lighting power use by providing a base building design that allows for reduced lighting power without compromising light quality. So that tenants can optimize daylighting, a *LEED Canada for Core & Shell* commercial office building design should consider floor-to-ceiling heights, the bay size, the type of glazing, and the depth of occupied spaces. Daylight shelves and glare control devices should also be considered. Skylights for top lighting should be considered for retail or manufacturing projects to further reduce lighting power.

Information on technical and design decisions about the base building should be included in the tenant design and construction guidelines to help the tenant understand and implement strategies to reduce lighting power. Recommendations regarding base building lighting fixtures installed may also be appropriate.

Lighting controls. Lighting power is integrally linked with tenant space lighting controls. Daylighting strategies that have been designed into the core and shell are best if coupled with tenant space layout and lighting controls. Base building design information, potential tenant space layouts, and technical recommendations should all be considered.

Heating, ventilation, and air-conditioning (HVAC). The HVAC system that the core and shell design team chooses will have a considerable effect on the tenant build-out. The information provided should include a description of the HVAC system, along with any energy efficiency features and suggestions as to how they can be best utilized. Building orientation and site issues, such as shading from surrounding buildings, may affect passive solar opportunities available for tenants.

SS	
NC	NA
CS	Credit 9

Energy use and metering. Provide information on the building's expected energy use. Explain how the building's energy use is metered, provide instructions on how tenants can submeter their space, and describe how submetering can help foster tenant energy conservation.

Measurement and verification. Describe the building's measurement and verification plan, including what option is being used and how the core and shell measurement and verification plan will be carried out. Provide information about protocols that the tenants can use to create their own measurement and verification plans.

Ventilation and outdoor air delivery. Provide design and operational information for the ventilation system. This should describe how the air is provided to the space (e.g., underfloor, overhead, displacement, or natural ventilation). Include the amount of outside air that each system is capable of providing so that tenants can determine how much outside air is available to them. This document should describe the control system and identify opportunities for the tenant to adapt or fine-tune the control system by, for example, installing monitoring devices such as CO_2 sensors.

Construction indoor air quality management. The guidelines should highlight areas of the core and shell construction indoor air quality management plan that are applicable to the tenant build-out, particularly where tenant work may be sequenced at the same time.

Indoor chemical and pollutant source control. Illustrate the strategies used to achieve IEQ Credit 5. Because multiple tenants may share air return and supply systems, include information on the benefits of isolating hazardous gases or chemicals.

Controllability of systems. Describe the building's HVAC control systems. If the building incorporates natural ventilation, describe how it can be used and how it works with the building's other systems. For a completely mechanical system, provide details on how the tenants can use the control system to better regulate the thermal comfort in their spaces.

Thermal comfort. Explain how the building's HVAC system will help maintain thermal comfort in the building. Provide the design criteria of the system (including indoor and outdoor conditions) and document any other assumptions made for the thermal comfort calculations (including space internal loads, clothing, and metabolic rate of the people in the space).

Daylighting and views. Many of the issues related to daylighting are addressed in sections on energy optimization; however, views should also be considered. For commercial office buildings, consider supplying a tenant layout early in the project design so that potential tenants can consider the benefits of views within their space layouts.

Employees in retail or manufacturing projects can also benefit from views to the outdoors. Building siting and envelope design should be described.

Core and shell buildings that have been designed to optimize occupants' views to the outdoors should provide illustrations in the guidelines so that space layouts can take full advantage of this amenity. The benefits of views to tenants can be part of the building marketing and lease negotiation process.

Commissioning. Building commissioning can help ensure that a building is operating as intended. Provide details on the core and shell commissioning process. This may include the commissioning plan or report. Provide information on the building's design intent so that the tenant can evaluate whether the space is functioning as designed. Core and shell commissioning documents can also serve as a model for tenants to use for their own commissioning efforts.

SS	
NC	NA
CS	Credit 9

Elimination or control of environmental tobacco smoke. If Option 1 of IEQ Prerequisite 2, Environmental Tobacco Smoke Control, is used, the smoking policy should be part of the tenant design and construction guidelines and clearly communicated during the lease negotiation. If Option 2 of this prerequisite is used, then separation, exhaust, and pressurization requirements will need to be clearly communicated so that they can be included in the tenant's scope of construction.

For mixed-use buildings that include a residential component, describe the methods used to achieve compliance with the prerequisite.

Recommendations for sustainable strategies, products, materials and service. This section of the tenant design and construction guidelines should describe recommended materials, products, and strategies to be employed in the tenant build-out. Descriptions of the sustainable strategies, products, materials, and services used in the core and shell building can be a resource when tenant design teams make selections for their space. For instance, if the base building has installed low-emitting materials (see IEQ Credit 4, Low-Emitting Materials), then the adhesives, sealants, paints, coatings, carpet systems, composite wood, and agrifibre products used should be listed in the guidelines. Sustainable material suppliers, manufactures, local salvaged material retailers, and construction waste recycling facilities may also be listed as resources in the guidelines.

INFORMATION REGARDING THE LEED CANADA FOR COMMERCIAL INTERIORS RATING SYSTEM

This section of the tenant design and construction guidelines is meant to help the tenant pursue *LEED Canada for Commercial Interiors* certification. General information about the *LEED Canada for Commercial Interiors* rating system must be provided, with building-specific examples of the advantages of attaining *LEED Canada for Commercial Interiors* certification. This section should outline the rating system, credit by credit, and describe specific methods that future tenants can use to achieve these credits. Pay particular attention to the synergies between the core and shell designs and how they assist with achieving credits under *LEED Canada for Commercial Interiors*.

5. TIMELINE AND TEAM

The tenant design and construction guidelines should evolve during the core and shell design process with input from the project architect, design team, and building owner. This document is part of the design submittal and should be finalized as project teams complete the design development stage and move into construction documents. The guidelines should be made available to tenants as part of the lease negotiations and must be provided prior to the start of any tenant design work.

6. CALCULATIONS

There are no calculations required for this credit.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measure. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Retain a copy of the tenant design and construction guidelines.

SS	
NC	NA
CS	Credit 9

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations associated with this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

In addition to informing the initial build-out of tenant spaces, tenant design and construction guidelines are useful for informing construction activities over the life of the building, particularly in facilities with frequent tenant turnover, project teams should consider providing guidelines that can be updated. Investigate with the building owner ways to communicate this information to new tenants over the life of the building. Consider expanding the guidelines to cover *LEED Canada for Existing Buildings: Operations & Maintenance* requirements for credits pertaining to facility alterations and additions.

Consider opportunities for optimizing operations at both the tenant scale and the building as a whole. For example, tenant-level metering and responsibility for utility bills provide a powerful incentive for tenants to conserve energy and are therefore rewarded under *LEED Canada for Commercial Interiors*, but having access to whole-building utility data is critical for environmental benchmarking during the operations phase. Include building-level meters in the facility's design, or establish lease agreements that require tenants to disclose utility data to the facility owner or manager.

12. RESOURCES

There are resources for this credit.

13. DEFINITIONS

A **bay** is a component of a standard, rectilinear building design. It is the open area defined by a building element such as columns or a window. Typically, there are multiple identical bays in succession.

SUSTAINABLE SITES ENDNOTES

[1] Statistics Canada. "2006 Census Data – Employed labour force by mode of transportation, both sexes, 2006 counts, for Canada, provinces and territories of residence – 20% sample data". 2008. http://www12.statcan.ca/english/census06/data/highlights/POW/Table603.cfm?Lang=E&T=603&GH=4&SC=1&SO=99&O=A (accessed February 2009).

[2] Akbari Hashem Akbari and Steven Konopacki, "Energy effects of heat-island reduction strategies in Toronto, Canada" (August 26, 2003). Lawrence Berkeley National Laboratory. Paper LBNL-49899. http://repositories.cdlib.org/lbnl/LBNL-49899 (accessed February 2009).

[3] U.S. Environmental Protection Agency "Terms of Environment: Glossary, Abbreviations and Acronyms." http://www.epa.gov/OCEPAterms/ [accessed March 2010].

[4] National Round Table on the Environment and the Economy Media Release "Reward for cleaning up urban contaminated sites as high as $7 billion annually, National Round Table report finds." 2003. http://www.nrtee-trnee.com/eng/news-media/media-releases/20030210-Brownfields.php (accessed December 2009).

[5] U.S. Environmental Protection Agency. "Brownfields and Land Revitalization: About Brownfields." http://www.epa.gov/brownfields/about.htm (accessed November 2008).

[6] Treasury Board of Canada Secretariat, Directive on Contingencies, http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=15786&section=text#Contaminated_site (accessed February 2010).

[7] American Public Transportation Association "Concerns Over Gas Prices Put Spotlight On World's Largest Public Transportation Expo Showcasing New Energy and Environmental Transit Technologies 2005. http://www.apta.com/mediacenter/pressreleases/2005/Pages/050916_gas_concerns.aspx (accessed December 2009).

[8] NRCAN Office of Energy Efficiency Canada's GHG Emissions by Sector, End-Use and Sub-Sector http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/aaa_ca_3_e_4.cfm?attr=0 (accessed January 2010).

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[11] U.S. Environmental Protection Agency. Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices. 2007. www.epa.gov/owow/nps/lid/costs07/factsheet.html (accessed May 2008).

[12] Ibid.

[13] Horton, Gary A. "Water Words Dictionary: A Compilation of Technical Water, Water Quality, Environmental and Water-Related Terms." Nevada Division of Water Resources. Department of Conservation and Natural Resources http://water.nv.gov/WaterPlanning/dict-1/ww-index.cfm (accessed December 2009).

[14] Ibid.

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] U.S. Environmental Protection Agency "Terms of Environment: Glossary, Abbreviations and Acronyms." http://www.epa.gov/OCEPAterms/ [accessed March 2010].

[19] Horton, Gary A. "Water Words Dictionary: A Compilation of Technical Water, Water Quality, Environmental and Water-Related Terms." Nevada Division of Water Resources. Department of Conservation and Natural Resources http://water.nv.gov/WaterPlanning/dict-1/ww-index.cfm (accessed December 2009).

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WATER EFFICIENCY (WE)

OVERVIEW

Canadians consumption of the public water supply continues to increase. Environment Canada estimates that in 2005, Canadians withdrew approximately 50.8 billion cubic metres of water from fresh water sources,[1] representing a 13% increase from the 44.8 billion cubic metres withdrawn in 1996.[2] Municipal water intake is the primary source of water for most buildings and supplies water to the following subsectors: residential, commercial, industrial and institutional. Environment Canada's 2007 Municipal Water Use Report indicates that although average daily water use at the municipal level and residential level, 609 litres per capita and 329 litres per capita respectively, are trending downward, Canadians are still one of the largest consumers of water among OECD countries.[3] Only about 12% of withdrawn water is lost to evaporation or transpiration or incorporated into products or crops; the rest is used, treated, and discharged to the nation's water bodies.[4] Discharged water contaminates rivers, lakes, and potable water with bacteria, nitrogen, toxic metals, and other contaminants.[5]

Using large volumes of water increases maintenance and life-cycle costs for building operations and also increases consumers' costs for additional municipal supply and treatment facilities. Conversely, buildings that use water efficiently can reduce costs through lower fees, less sewage volume, reductions in energy and chemical use, and lower capacity charges and limits.

Efficiency measures can easily reduce water use in average commercial buildings by 30% or more.[6] In addition, non-potable water can be used for landscape irrigation, toilet and urinal flushing, custodial purposes, and building systems. Depending on local water costs, utility savings can be tens of thousands of dollars per year.

The *LEED® Canada for New Construction* and *LEED Canada for Core & Shell* Water Efficiency (WE) prerequisites and credits encourage the use of strategies and technologies that reduce the amount of potable water consumed in buildings. Many water conservation strategies are no-cost; or provide a rapid payback. Other strategies, such as biological wastewater treatment systems and greywater plumbing systems, often require more substantial investment and are cost-effective only under certain building and site conditions.

The Water Efficiency (WE) prerequisites and credits address environmental concerns relating to building water use and disposal and promote the following measures:

MONITORING WATER CONSUMPTION PERFORMANCE

The first step to improving water efficiency is to understand current performance. Tracking water use alongside energy use can help organizations better understand how these resources relate to each other, make integrated management decisions that increase overall efficiency, and verify savings from improvement projects in both energy and water systems. Organizations that manage water and energy performance together can take advantage of this relationship to create greener, more sustainable buildings.

REDUCING INDOOR POTABLE WATER CONSUMPTION

Reducing indoor potable water consumption may require using alternative water sources for non-potable applications and installing building components, such as water-efficient fixtures, flow restrictors on existing fixtures, electronic controls, composting toilet systems, and waterless urinals. Lowering potable water use for toilets, showerheads, faucets, and other fixtures can reduce the total amount withdrawn from natural water bodies. The Region of Waterloo Emergency Medical Services Fleet Centre is a good example of a building that has implemented a comprehensive water reduction strategy. The project included use of low flow fixtures as well as a rainwater collection system that fed the toilets, hose bids and clothes washers. Overall the project showed almost a 60% reduction in water use (under *LEED Canada NC 1.0*). See the case study under WE Prerequisite 1 for more details.

REDUCING WATER CONSUMPTION TO SAVE ENERGY AND IMPROVE ENVIRONMENTAL WELL-BEING

In many buildings, the most significant savings associated with water efficiency result from reduced energy costs. Water efficiency cuts costs by reducing the amount of water that must be treated, heated, cooled, and distributed (at both the building scale and the municipal scale – including water and wastewater infrastructure) —all of which requires energy. Significant energy savings come through efficient use of hot water because water heating in commercial buildings accounts for nearly 15% of total building energy use.[7]

Practicing water conservation measures can also help improve both environmental and human well-being. Environment Canada indicates that 14% of the population served water in 2004 experienced water shortages, while 21% indicated experiencing water quality problems since 2001.[8] Human health and environmental welfare are affected when reservoirs and groundwater aquifers are depleted because lower water levels can concentrate both natural contaminants, such as radon and arsenic, and human pollutants, such as agricultural and chemical wastes. Increasing water efficiency helps keep contaminants at safe levels.

Better water efficiency in commercial buildings will reduce the amount of energy consumed by water treatment facilities.

PRACTICING WATER-EFFICIENT LANDSCAPING

Landscape irrigation practices consume large quantities of potable water. Outdoor uses, primarily landscaping, account for 30% of the water consumed daily.[9] Improved landscaping practices can dramatically reduce and even eliminate irrigation needs. Maintaining or re-establishing native plants on building sites fosters a self-sustaining landscape that requires minimal supplemental water and provides other environmental benefits.

Native plants require less water for irrigation and attract native wildlife, thus creating a building site integrated with its natural surroundings. In addition, native plants tend to require less fertilizer and pesticides, avoiding water quality degradation and other negative environmental impacts.

CREDIT	TITLE	NC	CS
WE Prerequisite 1	Water Use Reduction	Required	Required
WE Credit 1	Water Efficient Landscaping	2, 4 points	2, 4 points
WE Credit 2	Innovative Wastewater Technologies	2 points	2 points
WE Credit 3	Water Use Reduction	2-4 points	2-4 points

WE	
NC	Prerequisite 1
CS	Prerequisite 1

WATER USE REDUCTION

	NC	CS
Prerequisite	WE Prerequisite 1	WE Prerequisite 1
Points	Required	Required

INTENT

To increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

REQUIREMENT: NC & CS

Employ strategies that in aggregate use 20% less water than the water use baseline calculated for the building (not including irrigation).

Calculate the baseline according to the commercial and/or residential baselines outlined below. Calculations are based on estimated occupant usage and must include only the following fixtures and fixture fittings (as applicable to the project scope): water closets, urinals, lavatory faucets, showers, kitchen sink faucets, and pre-rinse spray valves.

COMMERCIAL FIXTURES, FITTINGS AND APPLIANCES	CURRENT BASELINE	
	METRIC	IMPERIAL
Commercial Toilets	6.0 Litres per flush (LPF) Except blow-out fixtures: 13.2LPF	1.6 gallons per flush (GPF)* Except blow-out fixtures: 3.5 GPF
Commercial Urinals	3.8 LPF	1.0 GPF
Commercial lavatory (restroom) faucets	8.3 Litres per minute (LPM) at 414 kilopascals (kPa) private applications only (hotel or motel guest rooms, hospital patient rooms)	2.2 gallons per minute (GPM) at 60 pounds per square inch (psi), private applications only (hotel or motel guest rooms, hospital patient rooms)
	1.9 LPM at 414 kPa all others except private applications	0.5 GPM at 60 psi ** all others except private applications
	0.95 Litres per cycle for metering faucets	0.25 gallons per cycle for metering faucets
Commercial Showerheads	9.5 LPM	2.5 GPM
Commercial pre-rinse spray valves (for food service applications)	Flow rate ≤6.0 LPM (no pressure specified; no performance requirement)	Flow rate ≤ 1.6 GPM (no pressure specified; no performance requirement)

WE	
NC	Prerequisite 1
CS	Prerequisite 1

RESIDENTIAL FIXTURES, FITTINGS AND APPLIANCES	CURRENT BASELINE	
	METRIC	IMPERIAL
Residential Toilets	6.0 LPF at 414 kPa	1.6 GPF*
Residential Lavatory Faucets	8.3 LPM at 414 kPa	2.2 GPM at 60 psi
Residential Kitchen Faucets		
Residential Showerheads	9.5 LPM at 552 kPa per shower stall	2.5 GPM at 80 psi per shower stall***

* *U.S. EPAct 1992 standard for toilets applies to both commercial and residential models.*

** *In addition to U.S. EPAct requirements, the American Society of Mechanical Engineers standard for public lavatory faucets is 0.5 gpm at 60 psi (ASME A112.18.1-2005). This maximum has been incorporated into the U.S. national Uniform Plumbing Code and the International Plumbing Code.*

*** *Residential shower compartment (stall) in dwelling units: The total allowable flow rate from all flowing showerheads at any given time, including rain systems, waterfalls, bodysprays, bodyspas, and jets, must be limited to the allowable showerhead flow rate as specified above 9.5 LPM (2.5 GPM) per shower compartment, where the floor area of the shower compartment is less than 1.6 square metres (2,500 square inches). For each increment of 1.6 square metres (2,500 square inches) of floor area thereafter or part thereof, an additional showerhead with total allowable flow rate from all flowing devices equal to or less than the allowable flow rate as specified above must be allowed. Exception: Showers that emit recirculated non-potable water originating from within the shower compartment while operating are allowed to exceed the maximum as long as the total potable water flow does not exceed the flow rate as specified above.*

Tables adapted from information developed and summarized by the U.S. Environmental Protection Agency (EPA) Office of Water based on requirements of the Energy Policy Act (EPAct) of 1992 and subsequent rulings by the US Department of Energy, requirements of the EPAct of 2005, and the plumbing code requirements as stated in the 2006 editions of the Uniform Plumbing Code or International Plumbing Code pertaining to fixture performance.

The following fixtures, fittings and appliances are outside the scope of water use reduction calculation:

- Commercial Steam Cookers
- Commercial Dishwashers
- Automatic Commercial Ice Makers
- Commercial (family–sized) Clothes Washers
- Residential Clothes Washers
- Standard and Compact Residential Dishwashers

AND

Have in place a permanently installed water meter(s) that measures all potable water use for the entire building and associated grounds.

Calibrate meter(s) following the manufacturer's recommendations if the building owner, management organization or tenant owns the metre. Meters owned by third parties (e.g., utilities or governments) are exempt.

WE	
NC	Prerequisite 1
CS	Prerequisite 1

INTERPRETATIONS

Aerators for public washroom faucets must be tamperproof. If aerators are not tamperproof, the applicant must assume a flow rate of 9.5 L/min.

LEASED TENANT SPACES (NC & CS)

All leased tenant spaces, regardless of being an NC or CS project, must be included in the calculation of water use to demonstrate compliance.

If the regulated fixtures intended for use by tenants are not supplied or specified (through mandatory lease agreements or on fit-up drawings), then the design case fixture water use rates are assumed equal to the maximum values allowed by the local building code or if not specified, the default baseline values as noted above.

Other than washroom or shower fixtures, tenant specific plumbing fixtures (e.g., kitchenettes) are excluded from the credit calculations unless shown on fit-up drawings submitted to demonstrate credit compliance.

The use of treated non-potable water provided by the base building can be used in calculated water savings as long as the plumbing arrangement or mandatory lease agreements necessitate the use of such systems.

The use of mandatory lease agreements to achieve this credit is allowed as noted above; however the mandatory lease agreements must either specify specific fixtures to be used or the specific performance requirements of the fixtures intended for the space.

WE	
NC	Prerequisite 1
CS	Prerequisite 1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Reducing potable water use in buildings for urinals, toilets, showerheads, and faucets decreases the total amount withdrawn from rivers, streams, underground aquifers, and other water bodies. These strategies protect the natural water cycle and save water resources for future generations. In addition, water use reductions, in aggregate, allow municipalities to reduce or defer the capital investment needed for water supply and wastewater treatment infrastructure.

Conserving municipally supplied potable water also reduces chemical inputs at the water treatment works, as well as reduces energy use and the associated greenhouse gas emissions from treatment and distribution. The energy use and emissions generated to supply municipal water vary greatly across North America and depend on the utility's water sources, the distances water is transported, and the type of water treatment applied. End-use water efficiency can greatly reduce negative environmental impacts. Comparing the environmental effects of off-site treatment and supply with those of on-site treatment is a worthwhile exercise. Because water heating in commercial buildings accounts for nearly 15% of building energy use, conservation measures will also reduce end-use energy and energy-related pollution.

ECONOMIC ISSUES

Reductions in water consumption decrease building operating costs and bring about wider economic benefits. Reduced water consumption allows municipalities to lessen or defer the capital investment needed for water supply and wastewater treatment infrastructure, thereby leading to more stable municipal taxes and water rates.

Many cost-effective systems and fixtures currently on the market support compliance with the requirement, but the cost of water efficiency measures varies widely. For example, installing tamper-proof faucet aerators on existing fixtures is a small expense compared with a rainwater-harvesting or greywater-recycling system. High-efficiency toilets and dry fixtures, such as non-water toilet systems, often have higher initial costs than standard models.

Newer technologies may also have higher costs and limited availability because of production constraints, and they may entail different maintenance and repair expenses, such as special cartridge components and cleaning and sealing fluids. Teams should perform a full cost-benefit and life-cycle study before installing such products.

2. RELATED CREDITS

Efforts to increase rainwater harvesting, increase greywater use, and decrease the demand on local water aquifers may support the following credits:

- SS Credit 6.1: Stormwater Design—Quantity Control
- SS Credit 6.2: Stormwater Design—Quality Control
- WE Credit 1: Water-Efficient Landscaping
- WE Credit 2: Innovative Wastewater Technologies
- WE Credit 3: Water Use Reduction

WE	
NC	Prerequisite 1
CS	Prerequisite 1

Additional energy use may be needed for certain reuse strategies. Active systems also require commissioning and should be considered in relation to the following credits:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Credit 3: Enhanced Commissioning
- EA Credit 5: Measurement and Verification

3. SUMMARY OF REFERENCED STANDARDS

The water efficiency baselines meeting these referenced standards are summarized in the Requirements section of WE Prerequisite 1, Water Use Reduction.

The Energy Policy Act (EPAct) of 1992 (and as amended)
This U.S. act addresses energy and water use in commercial, institutional, and residential facilities.

The Energy Policy Act (EPAct) of 2005
This statute became U.S. law in August 2005. *(Although there is not a comparative national code requirement in all of Canada, many provinces and municipalities have similar requirements.)*

International Association of Plumbing and Mechanical Officials Publication IAPMO/ American National Standards Institute UPC 1–2006, Uniform Plumbing Code 2006, Section 402.0, Water-Conserving Fixtures and Fittings
http://www.iapmo.org

UPC defines water-conserving fixtures and fittings for water closets, urinals, and metered faucets. This ANSI-accredited code safeguards life, health, property, and public welfare by regulating and controlling the design, construction, installation, materials, location, operation, and maintenance or use of plumbing systems.

International Code Council, International Plumbing Code 2006, Section 604, Design of Building Water Distribution System
http://www.iccsafe.org

IPC defines maximum flow rates and consumption for plumbing fixtures and fittings, including public and private lavatories, showerheads, sink faucets, urinals, and water closets.

4. IMPLEMENTATION

Effective ways to reduce water use include installing flow restrictors and/or reduced flow aerators on lavatory, sink, and shower fixtures; installing and maintaining automatic faucet sensors and metering controls; installing low-consumption flush fixtures, such as high-efficiency water closets and urinals; installing non-water fixtures; and collecting rainwater.

In certain cases, faucets with low-flow rates are not appropriate. For example, in kitchen sinks and janitors' closets, faucets are used to fill pots and buckets. Using a low-flow rate for tasks where the volume of water is predetermined does not save water and will likely cause frustration. Consider alternative strategies to reduce water use, such as installing special-use pot fillers and high-efficiency faucets or foot pedal–operated faucets.

The American WaterSense, a partnership program sponsored by EPA, helps consumers identify water-efficient products and programs. WaterSense-labelled products exceed the Uniform Plumbing Code and the International Plumbing Code standards for some high-efficiency fixtures or fittings. WaterSense products and other high-efficiency plumbing fixtures, fittings, and appliances can be installed in the same way as conventional EPAct plumbing fixtures, fittings, and appliances.

WE	
NC	Prerequisite 1
CS	Prerequisite 1

Although water-efficient dishwashers, laundry machines, and other water-consuming fixtures are not counted in the calculations for this credit, they may be included in exemplary performance calculations for WE Credit 3, Water Use Reduction.

To determine the most effective strategies for a particular condition, analyze the water conservation options available to the project based on location, code compliance (plumbing and safety), and overall project function. Determine where in the building the most water is used, evaluate potential alternative water-saving technologies, and examine the impacts of alternative fixtures and technologies. Compare the design case water use with the calculated EPAct baseline to determine the optimal water savings for plumbing fixtures and fittings. Once the design case water use has been determined, compare the volumes of water required for each end use with the volumes of alternative sources of water available on-site. Perform a detailed climate analysis to determine the availability of on-site resources and choose strategies that are appropriate and cost-effective.

TABLE 1. UPC AND IPC STANDARDS FOR PLUMBING FIXTURE WATER USE

FIXTURE	UPC AND IPC STANDARDS	EPA WATERSENSE STANDARDS
Water closets (gallons per flush, GPF) (litres per flush, LPF)	1.60 GPF (6 LPF)	1.28 GPF(4.8 LPF)
Urinals (GPF) (LPF)	1.00 GPF (3.8 LPF)	0.5 GPF[a] (1.9 LPF)
Showerheads (GPM*) (LPM)	2.50 GPM (9.5 LPM)	1.5-–2.0 GPM[b] (5.7 – 7.6 LPM)
Public lavatory faucets and aerators (GPM**) (LPM)	0.5 GPM (1.9 LPM)	
Private lavatory faucets and aerators (GPM**) (LPM)	2.2 GPM (8.3 LPM)	1.5 GPM (5.7 LPM)
Public metering lavatory faucets (gallons per metering cycle) (litres per metering cycle)	0.25 gal (0.95 L)	
Kitchen sink faucets	2.20 gal (8.3 L)	
Metering faucets (gallons per cycle) (litres per cycle)	0.25 gal (0.95 L)	

* *When measured at a flowing water pressure of 80 pounds per square inch (psi), (552 kPa).*

** *When measured at a flowing water pressure of 60 pounds per square inch (psi), (414 kPa).*

[a] *On May 22, 2008, EPA issued a notification of intent to develop a specification for high-efficiency urinals. Watersense anticipates establishing a maximum allowable flush volume of 0.5 GPF(1.89 LPF).*

[b] *On August 30, 2007, EPA issued a notification of intent to develop a specification for showerheads. Watersense anticipates establishing a single maximum flow rate between 1.5 GPM (5.7 LPM) and 2.0 GPM (7.6 LPM).*

Some water-saving technologies affect on-site energy performance and require commissioning; this task should be addressed by a project's measurement and verification plan. Calibration is necessary for projects using automatic sensors or flow valves. See EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems, and EA Credit 5, Measurement and Verification, for more information. Space constraints or characteristics of the plumbing fixtures and fittings in existing buildings may hinder water efficiency efforts.

WE	
NC	Prerequisite 1
CS	Prerequisite 1

5. TIMELINE AND TEAM

During predesign, setting water goals and strategy involves the owner, architect, and engineers. Identify local water utilities and governing authorities and research codes and applicable water laws. Learn the process for obtaining permits and approval and set water goals and strategy.

During design development, the engineering team should develop and design water reuse and treatment systems, perform preliminary LEED calculations, and confirm or reassess water goals.

In construction documents, the architect, working with the owner, should specify efficient fixtures and appliances and complete LEED calculations and documentation.

During construction, the design team and owner should confirm proper selection, installation, and operation of water fixtures, fittings, and systems.

6. CALCULATIONS

The following section describes the calculation methodology for determining water savings. The calculated water use reduction for the project is the difference between the calculated design case and a baseline case. The percentage is determined by dividing the design case use by the baseline use. The methodology differs from traditional plumbing design, in which calculations are based on fixture counts; under this prerequisite, the water use calculation is based on fixture and fitting water consumption rates and estimated use by the occupants. Occupants' estimated use is determined by calculating full-time equivalent (FTE) and transient occupants and applying appropriate fixture use rates to each.

It may be advantageous to divide the facility into fixture usage groups, calculate water use for each, and sum the values to determine whole building performance.

FIXTURE USAGE GROUPS

Fixture usage groups are subsets of washroom facilities used by different types of occupants. For each group, complete the template calculator. Indicate which fixtures are involved and which occupants they serve. If all occupants within the building have access to all fixtures, or if all fixtures are standard throughout the building, enter only a single fixture usage group. That is the simpler approach, but it may be more appropriate to define two or more groups to account for different fixtures in one area of the building or special usage patterns by a population within the building. For example, if washrooms on the first floor are used primarily by transient retail customers and washrooms on the second floor are used by office workers, calculate each separately.

The following scenario illustrates the application of different fixture usage groups.

The Riggs Hotel is located in an urban center. The ground floor includes a restaurant open to the public, the hotel lobby, and administrative offices. The upper floors contain guest rooms. Restaurant, back-of-house, and guestroom restroom facilities each have different fixture and fitting models. The project team establishes 3 fixture usage groups to account for the distinct populations in the building and the specific restroom facilities they use: (1) restaurant (customers and restaurant staff), (2) administrative back-of-house (hotel administrators and operations staff), and (3) guest rooms (hotel guests).

WE	
NC	Prerequisite 1
CS	Prerequisite 1

CALCULATING OCCUPANCY

Identify the number of building occupants by occupancy type. In buildings with multiple shifts, use the number of FTEs from all shifts. Include the following:

a. Full-time staff

b. Part-time staff

c. Transients (visitors, retail customers)

d. Residents

For projects that include residential spaces, the number of residents should be estimated based on the number and size of units in the project. Generally, assume 2 residents per 1-bedroom unit, 3 residents per 2-bedroom unit, etc. If occupancy is not known (e.g., mixed-use and core and shell projects for which the tenants of the building are unknown during design), use Appendix 1, Default Occupancy Counts, for occupancy count requirements and guidance. If actual occupancy is known, project teams must use actual counts for calculating occupancy.

Calculate the FTE number of occupants based on a standard 8-hour daily occupancy period (40 hours per week). An 8-hour occupant has an FTE value of 1.0, and part-time occupants have an FTE value based on their hours per day divided by 8. FTE calculations for each shift of the project must be used consistently for all LEED credits.

Estimate the transient building occupants, such as visitors and customers. Transient occupants can be reported as either daily totals or full-time equivalents. When using daily totals for transients, match the fixture uses for each occupancy type with the values shown in Table 2 (e.g., for the daily total of visitors, assume 0.5 lavatory faucet uses per daily visitor). If transients are reported as a daily full-time equivalent value, fixture uses for FTEs must be assumed regardless of the transient population's identity (e.g., for visitors reported as FTEs, assume 3 lavatory faucet uses per visitor FTE). Use a transient occupancy number that is a representative daily average over the course of a year. If the number of transient visitors per day for retail facilities is unknown, refer to Appendix 1, Table 1, for default occupancy. Students should be calculated as FTE or total transients to match their building usage. K-12 students must be calculated as FTEs, while in a university setting students could be transients.

Table 2 provides default fixture use values for different occupancy types. These values should be used in the calculations for this credit unless special circumstances warrant modifications. Most buildings with students, visitors, and retail customers will also have FTE occupants. Half of all visitors are assumed to use a flush fixture and a lavatory faucet in the building and are not expected to use a shower or kitchen sink. A fifth of retail customers are assumed to use a flush and a flow fixture in the building and no shower or kitchen sink. The default for residential occupants is 5 uses per day of water closet and lavatory faucet, 1 shower, and 4 kitchen sink uses.

For consistency across LEED projects, the calculations require the use of a balanced, 1-to-1 gender ratio unless project conditions warrant an alternative. Provide a narrative description to explain any special circumstances.

WE	
NC	Prerequisite 1
CS	Prerequisite 1

TABLE 2A. NON-RESIDENTIAL DEFAULT FIXTURE USES, BY OCCUPANCY TYPE

FIXTURE TYPE	DURATION (second)	USES / DAY		
		FTE	VISITOR	RETAIL CUSTOMER
Water Closet (Female)	n/a	3	0.5	0.2
Water Closet (Male)	n/a	1	0.1	0.1
Urinal (Female)	n/a	0	0	0
Urinal (Male)	n/a	2	0.4	0.1
Lavatory Faucet*	15*	3	0.5	0.2
Shower	300	0.1	0	0
Kitchen Sink	15	1	0	0

**Default duration is 12 seconds for lavatory faucet with autocontrol*

TABLE 2B. RESIDENTIAL DEFAULT FIXTURE USES

FIXTURE TYPE	DURATION (second)	USES / DAY
Water Closet (Female)	n/a	5
Water Closet (Male)	n/a	5
Lavatory Faucet	60	5
Shower	480	1
Kitchen Sink	60	4

DESIGN CASE WATER CONSUMPTION

The design case annual water use is determined by totalling the annual volume of each fixture type and subtracting any non-potable water supply. The design case must use the rated flow rates and flush volumes for installed plumbing fixtures and fittings. Obtain water consumption data from the manufacturer's product literature.

Teams may add fixtures not listed in Table 3 that are regulated by the referenced standards.

WE	
NC	Prerequisite 1
CS	Prerequisite 1

TABLE 3. SAMPLE PLUMBING FIXTURES AND FITTINGS AND WATER CONSUMPTION

FLUSH FIXTURE	FLOW RATE (GPF)	FLOW RATE (LPF)	FLOW FIXTURE	FLOW RATE (Imperial)	FLOW RATE (metric)
Conventional water closet	1.6	6.0	Conventional private lavatory	2.2 GPM	8.3 LPM
High-efficiency toilet (HET), single-flush gravity	1.28	4.8	Conventional public lavatory	0.5 GPM or ≤ 0.25 GPC	1.9 LPM or ≤ 0.95 LPC
HET, single-flush pressure assist	1.0	3.8	Conventional kitchen sink	2.2 GPM	8.3 LPM
HET, dual flush (full-flush)	1.6	6.0	Low-flow kitchen sink	1.8 GPM	6.8 LPM
HET, dual flush (low-flush)	1.1	4.2	Conventional shower	2.5 GPM	9.5 LPM
HET, foam flush	0.05	0.19	Low-flow shower	1.8 GPM	6.8 LPM
Non-water toilet	0.0	0.0			
Conventional urinal	1.0	3.8			
High-efficiency urinal (HEU)	0.5	1.9			
Non-water urinal	0.0	0.0			

Facilities in residences and apartments, private bathrooms in hotels and hospitals, and restrooms in commercial establishments where the fixtures are intended for the use of a family or an individual are considered private or private-use facilities. All other facilities are considered public or public use. If the classification for public or private use is unclear, default to public-use flow rates in performing the calculations associated with this credit.

BASELINE CASE WATER CONSUMPTION

The baseline case annual water use is determined by setting the fixture and fitting water consumption to baseline rates listed in the requirements (as opposed to actual installed values in the design case).

ELIGIBLE FIXTURES

This prerequisite is limited to savings generated by water using fixtures as shown in Table 1.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Determine the type and number of occupants.

WE	
NC	Prerequisite 1
CS	Prerequisite 1

- Retain manufacturers' data showing the water consumption rates, manufacturer, and model of each fixture and fitting.
- Retain approved shop drawings for all water consuming fixtures.
- List plumbing fixtures by usage group, if applicable.
- Define any usage groups.

8. EXAMPLES

There are no examples for this prerequisite.

9. EXEMPLARY PERFORMANCE

This prerequisite is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Local building and health codes differ in their treatment of alternative plumbing fixtures, such as non-water urinals, dual-flush water closets, and non-water toilets. Confirm the legality of nontraditional approaches with code officials before selecting plumbing fixtures.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Consider installing submetering for water delivered to fixture and fittings to help operators manage water consumption and identify problems within the system. Integrating electronic data logging will facilitate consumption trend analysis.

Some water conservation technologies may require special cleaning or maintenance procedures. For example, non-water urinals generally need to be cleaned according to manufacturer's specifications and their chemical traps appropriately maintained. Project teams should provide facility operators with appropriate maintenance information, manufacturers' contact information, and product specifications to facilitate proper operation.

A preventive maintenance program that includes plumbing fixture and fitting inspection and testing ensures that flow valves do not leak and that any sensors are calibrated correctly so that the fixtures flush and/or flow the appropriate amounts at the proper time.

For more information about water-saving opportunities through operations and maintenance, see the *LEED Canada Reference Guide for Existing Buildings: Operations & Maintenance, 2009 Edition*.

12. RESOURCES

WEBSITES

Alliance for Water Efficiency
http://www.a4we.org

The Alliance for Water Efficiency is a stakeholder-based, non-profit organization dedicated to the efficient and sustainable use of water. The Alliance serves as a North American advocate for water efficient products and programs, and provides information and assistance on water conservation efforts.

WE	
NC	Prerequisite 1
CS	Prerequisite 1

American Rainwater Catchment Systems Association
http://www.arcsa.org

ARCSA was founded to promote rainwater catchment systems in the United States. The ARCSA website provides regional resources, suppliers, and membership information, and publications such as the Texas Guide to Rainwater Harvesting.

American Water Works Association, Water Wiser: The Water Efficiency Clearinghouse
http://www.awwa.org/waterwiser

This web clearinghouse provides articles, reference materials, and papers on all forms of water efficiency.

Canadian Water and Wastewater Association
http://www.cwwa.ca

CWWA is a non-profit national body representing the common interests of Canada's public sector municipal water and wastewater services and their private sector suppliers and partners. Their committees and networks represent many areas of water management, including water efficiency. This site hosts many free research publications, including the Maximum Performance (MaP) Testing of Popular Toilet Models with independent test results for a variety of toilets' flush performance.

Canadian Water and Wastewater Association, Canada's Water Efficiency Experiences Database
http://www.cwwa.ca/WEED/Search_e.asp

The water efficiency database was developed by the Canada Water and Wastewater Association and Environment Canada to encourage the exchange of information. The user can select information from the following areas: indoor; outdoor; landscaping; public awareness and education; community activity; infrastructure; regulatory; research, technology and science; economics and geographic location (locations throughout Canada are represented).

Environmental Building News, Water: Doing More with Less
http://www.buildinggreen.com/auth/article.cfm/2008/2/3/Water-Doing-More-With-Less

This website features an article on building water efficiency.

National Climate Data and Information Archive
http://www.climat.meteo.ec.gc.ca/climateData/canada_e.html

This federal website is useful for researching local climate information such as data for rainwater harvesting calculations.

North Carolina Division of Pollution Prevention and Environmental Assistance, Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities
http://www.p2pays.org/ref/01/00692.pdf

This straightforward manual on water efficiency draws from a number of different North Carolina governmental departments.

Provincial/Territorial Water Policy, Legislation and Regulations
http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=24C5BD18-1

This Environment Canada website provides links to water use associations, legislation, regulation and tools for all provinces and territories in Canada.

WE	
NC	Prerequisite 1
CS	Prerequisite 1

Rocky Mountain Institute, Water
http://www.rmi.org/rmi/pid172

This portion of RMI's website is devoted to water conservation and efficiency. The site contains information on watershed management and commercial, industrial, and institutional water use and articles on policy and implementation.

U.S. Department of the Interior, Water Measurement Manual: A Water Resources Technical Publication
http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm

This publication is a guide on effective water measurement practices.

U.S. EPA, How to Conserve Water and Use It Effectively
http://www.epa.gov/OWOW/nps/chap3.html

This document provides guidance for commercial, industrial, and residential water users on saving water and reducing sewage volumes.

U.S. EPA, Water Use Efficiency Program
http://www.epa.gov/owm/water-efficiency

This website provides an overview of EPA's Water Use Efficiency Program and information about using water more efficiently.

U.S. EPA, WaterSense
http://www.epa.gov/watersense

The WaterSense Program helps U.S. consumers save water and protect the environment. Look for the WaterSense label to help choose high-quality, water-efficient products. A variety of products are available, and they do not require a change in lifestyle.

PRINT MEDIA

Constructed Wetlands for Wastewater Treatment and Wildlife Habitat: 17 Case Studies, EPA 832/B-93-005 (U.S. EPA, 1993).

Design and Installation of Non-Potable Water Systems/Maintenance and Field Testing of Non-Potable Water Systems, CSA B128.1/B128.2, (Canadian Standards Association, 2006) www.shopcsa.ca

On-Site Wastewater Treatment Systems Manual (U.S. EPA, 2002). http://www.epa.gov/nrmrl/pubs/625r00008/html/625R00008.htm.

This document provides a focused, performance-based approach to on-site wastewater treatment and system management as well as valuable information on a variety of on-site sewage treatment options.

Water, Sanitary and Waste Services for Buildings, fourth edition, by A. Wise and J. Swaffield (Longman Scientific & Technical, 1995).

13. DEFINITIONS

WE	
NC	Prerequisite 1
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An **aquifer** is an underground water-bearing rock formation or group of formations that supply groundwater, wells, or springs.

Automatic fixture sensors are motion detectors that automatically turn on and turn off lavatories, sinks, water closets, and urinals. Sensors can be hard wired or battery operated.

Blackwater definitions vary, but wastewater from toilets and urinals is always considered blackwater. Wastewater from kitchen sinks (perhaps differentiated by the use of a garbage disposal), showers, or bathtubs is considered blackwater under some provincial or local codes.

Metering controls limit the flow time of water. They are generally manual-on and automatic-off devices, most commonly installed on lavatory faucets and showers.

Non-potable water is water that is not potable, typically rain or greywater.

Non-water (or composting) toilet systems are dry plumbing fixtures and fittings that contain and treat human waste via microbiological processes.

A non-water (or dry) urinal, replaces a water flush with a trap containing a layer of buoyant liquid that floats above the urine, blocking sewer gas and odours.

On-site wastewater treatment is the transport, storage, treatment, and disposal of wastewater generated on the project site.

Potable water meets or exceeds federal and provincial drinking water quality standards and is approved for human consumption by the provincial or local authorities having jurisdiction; it may be supplied from wells or municipal water systems.

Process water is used for industrial processes and building systems such as cooling towers, boilers, and chillers. The term can also refer to water used in operational processes, such as dishwashing, clothes washing, and ice making.

WE	
NC	Prerequisite 1
CS	Prerequisite 1

14. CASE STUDY

REGION OF WATERLOO EMERGENCY MEDICAL SERVICES FLEET CENTRE
LEED Canada-NC 1.0 Gold, 28 June 2005

Location: Cambridge, Ontario
Building Type: Public Safety
Owner Type: Public Health
Building Size: 1,740 m^2
Owner Name: Region of Waterloo
LEED Consultant: Enermodal Engineering Ltd./McCallum Sather Architects
Responsible Firm (for this credit): Enermodal Engineering Ltd.
Photo credit: Enermodal Engineering Ltd.

The Region of Waterloo Emergency Medical Services (EMS) Central Fleet Facility is the headquarters for ambulance dispatch response throughout Waterloo Region. Water use for this type of facility is typically high due to a variety of water loads:

- Bathrooms
- A kitchenette
- Showers for paramedics
- Clothes washing machines for cleaning rags and towels

A major strategy for minimizing this water use was to install low-flow water fixtures throughout the facility, including faucets in the kitchenette and bathrooms. Additionally, waterless urinals and dual flush toilets were installed in washrooms. Clothes washing machines were also selected for water efficiency, although not included in the calculations for WE Credit 3 (Water Use Reduction).

WE	
NC	Prerequisite 1
CS	Prerequisite 1

Besides decreasing the water demand, another method for reducing the amount of potable water used was to utilize rainwater for non-potable water uses, such as toilet flushing and trap primers. (Although not considered in LEED water savings calculations, trap primers represent a significant phantom potable water load that can be eliminated by using non-potable water.) Therefore, a cistern was installed in order to annually supply 82,000 L of rainwater collected from the roof (1,600m^2).

As a result of these strategies, this EMS facility achieved 59% indoor water savings and LEED Canada Gold. Besides indoor water savings to achieve this credit, significant exterior water savings were achieved (WE Credit 1) through the use of drought-resistant native species that require only occasional spot watering (supplied by the cistern).

Lessons learned:

- Over the four years the facility has been in operation, the cistern has worked well and required little maintenance.
- The waterless urinals, which were early prototypes, did not work as well as expected (creating maintenance problems) and were ultimately replaced by the owner. The urinals, however, used non-potable water, so the potable water savings were not affected by this decision.

WE	
NC	Credit 1
CS	Credit 1

WATER EFFICIENT LANDSCAPING

	NC	CS
Credit	WE Credit 1	WE Credit 1
Points	2, 4 points	2, 4 points

INTENT

To limit or eliminate the use of potable water or other natural surface or subsurface water resources available on or near the project site for landscape irrigation.

REQUIREMENTS: NC & CS

OPTION 1. REDUCE BY 50% (2 POINTS)

Reduce potable water consumption for irrigation by 50% from a calculated midsummer baseline case. Landscaped area must constitute at least 5% of the project site area.

Reductions must be attributed to any combination of the following items:

- Plant species, density, and microclimate factor
- Irrigation efficiency
- Use of captured rainwater
- Use of recycled wastewater
- Use of water treated and conveyed by a public agency specifically for non-potable uses

Groundwater seepage that is pumped away from the immediate vicinity of building slabs and foundations can be used for landscape irrigation and meet the intent of this credit. However, the project team must demonstrate that doing so does not affect site stormwater management systems.

OR

OPTION 2. NO POTABLE WATER USE OR IRRIGATION (4 POINTS)

Meet the requirements for Option 1.

AND

PATH 1

Use only captured rainwater, recycled wastewater, recycled greywater, or water treated and conveyed by a public agency specifically for non-potable uses for irrigation.

OR

WE	
NC	Credit 1
CS	Credit 1

PATH 2

Install landscaping that does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment are allowed only if removed within one year of installation.

INTERPRETATIONS

LEASED TENANT SPACES (NC & CS)

For NC certification, if the tenant space includes landscaping, mandatory lease agreements must indicate to future tenants direction on methodology required to achieve this credit based on the approach applied on the base building application.

For CS certification, applicants can still achieve this credit where small areas of the landscaping are under tenant control. These tenant areas of the landscaping are exempt from credit requirements as long as the fraction of their space is small and owners provide guidelines that minimize the use of potable water for landscaping.

CAMPUS

In phased projects this credit may be captured for the entire site development based on a finalized development master plan. Include a copy of the finalized development master plan. Future LEED projects will need to demonstrate individual project compliance.

This credit is allowed to be achieved on a campus-wide basis by demonstrating that the requirements are met at the campus level.

On a campus, the areas served by water using equipment may not exactly align with the defined LEED project. For example, irrigation water may be fed from a different building than the LEED project. This is acceptable provided that there is a building water meter and any other water uses within the LEED project are metered.

WE	
NC	Credit 1
CS	Credit 1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Landscape irrigation practices in North America consume large quantities of potable water. Improved landscaping practices can dramatically reduce and even eliminate irrigation needs. Maintaining or re-establishing native or adapted plants on building sites fosters a self-sustaining landscape that requires minimal supplemental water and attracts native wildlife, creating a building site integrated with its natural surroundings. In addition, native or adapted plants tend to require less fertilizer and pesticides, minimizing water quality degradation and other negative environmental impacts.

Water-efficient landscaping helps conserve local and regional potable water resources. Maintaining natural aquifer conditions is important for providing reliable water sources for future generations. Consideration of water issues during planning can encourage development where resources can support it and prevent development that would exceed the resource capacity.

ECONOMIC ISSUES

Landscaping designed for the local climate and the site's microclimate is the most effective strategy to avoid escalating water costs for irrigation. The cost can be reduced or eliminated through thoughtful planning and careful plant selection and layout. Native or adapted plants further reduce operating costs because they require less fertilizer and maintenance than turf grass.

Although the additional design cost for a drip irrigation system may make it more expensive than a conventional system, a drip system usually costs less to install and has lower water use and maintenance requirements, generally resulting in a short payback period. Many municipalities offer rebates or incentives for water-efficient irrigation systems, dedicated water meters, and rain or moisture sensors.

Using greywater for irrigation also reduces the amount of wastewater delivered to water treatment facilities, which can provide cost savings while reducing both demand on the municipal infrastructure and the negative environmental impacts associated with large-scale treatment facilities. Irrigation system efficiency varies widely, and high-efficiency systems can also reduce potable water consumption. For example, high-efficiency drip irrigation systems can be 95% efficient, compared with 60% to 70% for sprinkler or spray irrigation systems.[10]

2. RELATED CREDITS

The use of native or adapted vegetation on the project site can assist project teams with earning the following credits:

- SS Credit 5.1: Site Development—Protect or Restore Habitat
- SS Credit 5.2: Site Development—Maximize Open Space
- SS Credit 7.2: Heat Island Effect—Roof

In addition to reducing potable water consumption, rainwater capture systems can be used to manage stormwater runoff and can contribute to achieving the following credits:

- SS Credit 6.1: Stormwater Design—Quantity Control
- SS Credit 6.2: Stormwater Design—Quality Control

WE	
NC	Credit 1
CS	Credit 1

Landscape plantings can mitigate climate conditions and reduce building energy consumption by shading hardscape and south-facing windows and by aiding in passive solar design. These strategies can contribute to achieving the following:

- SS Credit 7.1: Heat Island Effect—Nonroof
- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

Water-efficient landscaping varies with the site and region. Design landscaping with climate-tolerant plants that can survive on natural rainfall. Contour the land to direct rainwater runoff through the site and give vegetation an additional water supply. Minimize the area covered with conventional turf grass, and use techniques such as mulching and composting—practices that conserve water and help foster optimal soil conditions.

Recommended design principles include the following:

STEP 1. PLANNING AND DESIGN

- Develop a site map showing existing or planned structures, topography, orientation, sun and wind exposure, use of space, and existing vegetation.
- Perform shadow profiles of landscape areas for each season based on middle-of-the-day conditions and illustrate the plant selections within the profiles.
- Reduce the heat island effect by providing adequate shade from trees and buildings; plant trees to increase shade canopy as necessary.
- Plan water use zones:

  High—regular watering.
  Moderate—occasional watering.
  Low—natural rainfall.

STEP 2. PRACTICAL TURF AREAS

- Plant turf grasses only for functional benefits such as recreational areas, pedestrian use, or specifically for soil conservation.

STEP 3. SOIL ANALYSIS AND PREPARATION

- Analyze soil in each zone.
- Amend soil accordingly.

STEP 4. APPROPRIATE USE OF PLANT MATERIALS

- Choose plants that will easily adapt to the site.
- Consider the mature size and form when choosing plant material for the location and intended purpose.
- Consider growth rate.
- Do not plant monocultures (single species) or an excessive number of species.
- Diversify species to discourage disease or insect infestations.
- Select plant species that need little or no fertilization and, when necessary, specify organic and nonpetrochemical fertilizers.
- Consider the role of plant selection in planning for integrated pest management.

WE	
NC	Credit 1
CS	Credit 1

STEP 5. EFFECTIVE AND EFFICIENT WATERING PRACTICES

- Regularly check irrigation systems for efficient and effective operation; verify watering schedules and duration on a monthly basis.
- Use drip, micromist, and subsurface irrigation systems where applicable; use smart irrigation controllers throughout. Provide computer-controlled monitoring and schedule modifications from a central location.
- Do not irrigate plants or turf between November and April.
- Do not irrigate shrubs between September and June.
- To prevent mould growth, make sure irrigation systems do not allow buildings to become saturated or water to be introduced into building air intakes. Systems should be designed to keep water away from buildings.

STEP 6. MULCH FOR TREES, SHRUBS, AND FLOWER BEDS

- Keep landscape areas mulched to conserve moisture and prevent evaporative water loss from the soil surface to reduce the need for supplemental irrigation during dry periods.

Owners' preferences, use of the grounds, and maintenance expertise can also affect plant selection. However, the intent of this credit is to maximize the use of on-site natural resources to limit or eliminate the use of potable water for irrigation. This goal can be achieved by selecting native or adapted plants that require little or no irrigation, or by irrigating with high-efficiency equipment, captured rainwater, recycled greywater, or treated wastewater. Consider a combination of these strategies: First reduce potable water demand and then meet the irrigation demand in the most sustainable manner.

Planting native or adapted plants is an excellent approach because water conservation is built in and is not reliant on high-tech equipment and controls. In some climates, it is possible to eliminate or significantly cut the need for permanent irrigation with strategies like xeriscaping, which employs native plants.

For buildings without vegetation on the grounds, teams can earn points by reducing the use of potable water for watering any roof and courtyard garden space or outdoor planters, provided the planters and garden space cover at least 5% of the building site area (including building footprint, hardscape area, parking footprint, etc.). If the planters and garden space cover less than 5% of the building site area, the project is ineligible for this credit.

Hose bibs are not considered permanent irrigation and can be used for temporary irrigation during periods of drought. Additionally, temporary irrigation during the first year of building occupancy can help establish healthy plants that will need less water in the future. Project teams pursuing Option 2, No Potable Water Use or Irrigation, by eliminating permanent irrigation may use temporary irrigation for a period of 1 year depending on the needs of the site and the selected vegetation.

Reducing landscaped areas that require irrigation and installing alternative hardscaping materials that do not require irrigation are good ways to reduce landscape irrigation demands but should not be factored into the calculations for this credit.

TECHNOLOGIES

Using irrigation technology, rainwater capture, and advanced on-site wastewater treatment are all excellent ways of achieving this credit; they allow for a broader plant species palette while still conserving potable water supplies. High-efficiency irrigation strategies include the use of microirrigation systems, moisture sensors, rain shut-offs, and weather-based evapotranspiration

WE	
NC	Credit 1
CS	Credit 1

controllers. Drip irrigation systems apply water slowly and directly to the roots of plants, using 30% to 50% less water than sprinklers.[11]

Efficient irrigation rotary heads can provide a greater radius of coverage and dispense water at a lower precipitation rate than more conventional systems. Properly pressurized spray heads and nozzles maximize efficiency by making sure that irrigation water droplets are properly sized and are not affected by wind and sun. For example, when pressure is too high, water droplets become finer and the spray patterns become distorted by wind, thereby decreasing efficiency. Upfront investments in pressure-regulating features like high-efficiency nozzles can save up to 30% on water use.[12]

Smart irrigation controls include soil moisture and evapotranspiration sensors that automatically adjust watering times to local conditions. Whereas conventional controllers turn irrigation on at the same time everyday for a set duration, these sensors conserve water by adjusting irrigation times based on daily weather. Rain sensors enhance water savings further by suspending the daily irrigation cycle based on precipitation levels.

Rainwater collection systems (e.g., cisterns, underground tanks, ponds) can significantly reduce or completely eliminate the amount of potable water used for irrigation. Rainwater can be collected from roofs, plazas, and paved areas and then filtered by a combination of graded screens and paper filters to prepare it for use in irrigation. Metal, clay, or concrete-based roofing materials are ideal for rainwater harvest; asphalt or lead-containing materials will contaminate the water. Rainwater with high mineral content or acidity may damage systems or plants, but pollutants can be filtered out by soil or mechanical systems before being applied to plants. Check local rainfall quantity and quality, since collection systems may be inappropriate in areas with rainfall of low quantity or poor quality. A project may achieve Option 2, No Potable Water Use or Irrigation, by demonstrating that the project's rainwater system's capacity meets almost all of the required thresholds on an average monthly and annual basis, and is designed so that no potable water is used for irrigation.

Using groundwater that must be pumped away from the building's basement or foundation to irrigate the landscape is an innovative way to achieve this credit. However, installing a well specifically to collect groundwater for irrigation does not meet the intent of the credit to reduce potable water use for irrigation. Document the existence of nuisance groundwater and demonstrate the beneficial use of this resource. Additionally, Option 2, No Potable Water Use or Irrigation, can be met when landscape irrigation is provided by raw water that would otherwise be treated specifically for non-potable uses.

Wastewater recovery can be accomplished either on-site or at the municipal level. On-site systems include greywater and wastewater treatment. In addition, many municipalities treat sewage to tertiary standards in central treatment plants, then redistribute that water regionally for irrigation use. Some water treatment facilities supply reclaimed water to off-site customers specifically for non-potable uses such as landscape irrigation. If a public health situation warrants (e.g., irrigating near a swimming pool), as dictated by code, using potable water for irrigation is permissible and does not necessarily preclude achieving this credit.

5. TIMELINE AND TEAM

Early in the design process, the landscape designer should determine the most appropriate use of native vegetation and the most efficient technology for the project site. Include the building owner, architect, civil engineer, and mechanical engineer in evaluating the feasibility of using non-potable water for irrigation. Involve maintenance staff in the design meetings to communicate operations and maintenance needs and ensure that the design meets ongoing water-efficiency goals. After

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NC	Credit 1
CS	Credit 1

the initial landscape design team meeting, the landscape architect or architect should perform the baseline and design irrigation calculations to assess compliance with this credit.

6. CALCULATIONS

To calculate the percentage reduction in potable or natural water use for this credit, establish a baseline water use rate for the project and then calculate the as-designed water-use rate according to the steps listed below.

STANDARD ASSUMPTIONS AND VARIABLES

- All calculations are based on irrigation during July.
- The landscape coefficient (K_L) indicates the volume of water lost via evapotranspiration and varies with the plant species, microclimate, and planting density. The formula for determining the landscape coefficient is given in Equation 3.
- The species factor (k_s) accounts for variation in water needs by different plant species, divided into 3 categories (high, average, and low water need). To determine the appropriate category for a plant species, use plant manuals and professional experience. This factor is somewhat subjective; however, landscape professionals know the general water needs of plant species. Landscapes can be maintained in acceptable condition at about 50% of the reference evapotranspiration (ET_o) value, and thus the average value of k_s is 0.5. If a species does not require irrigation once it is established, then the effective $k_s = 0$ and the resulting $K_L = 0$.
- The density factor (k_d) accounts for the number of plants and the total leaf area of a landscape. Sparsely planted areas will have less evapotranspiration than densely planted areas. An average kd is applied to areas where shading from trees is 60% to 100%. This is equivalent to shrubs and groundcovers that shade 90% to 100% of the landscape area. Low k_d values are found where shading from trees is less than 60%, or where shrub and groundcover shading is less than 90%. For instance, a 25% ground shading from trees results in a k_d value of 0.5. In mixed plantings, where the tree canopy shades understory shrubs and groundcovers, evapotranspiration increases. This represents the highest level of landscape density; the k_d value is 1.0 to 1.3.
- The microclimate factor (k_{mc}) accounts for environmental conditions specific to the landscape, including temperature, wind and humidity. For instance, parking lots increase wind and temperature effects on adjacent landscapes. The average k_{mc} is 1.0; this refers to conditions where evapotranspiration is unaffected by buildings, pavements, reflective surfaces and slopes. High-k_{mc} conditions occur where evaporative potential is increased by heat-absorbing and reflective surfaces or exposure to high winds; examples include parking lots, west sides of buildings, west- and south-facing slopes, medians, and areas experiencing wind tunnel effects. Low-k_{mc} landscapes include shaded areas and areas protected from wind, such as north sides of buildings, courtyards, areas under wide building overhangs, and north-facing slopes.

STEP 1. CREATE THE DESIGN CASE

Determine the landscape area for the project. This number must represent the as-designed landscape area and must use the same project boundary used in all other LEED credits. Sort the total landscape area into the major vegetation types (trees, shrubs, groundcover, mixed, and turfgrass), listing the area for each.

WE	
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CS	Credit 1

Determine the following characteristics for each landscape area: species factor (k_s), density factor (k_d), and microclimate factor (k_{mc}). Recommended values for each are provided in Table 1. Select the low, average, or high value for each parameter as appropriate for the site. Project teams must be prepared to justify any variance from the recommended values.

TABLE 1. LANDSCAPE FACTORS

VEGATATION TYPE	SPECIES FACTOR (k_S)			DENSITY FACTOR (k_d)			MICROCLIMATE CONTROL (k_{mc})		
	LOW	AVERAGE	HIGH	LOW	AVERAGE	HIGH	LOW	AVERAGE	HIGH
Trees	0.2	0.5	0.9	0.5	1.0	1.3	0.5	1.0	1.4
Shrubs	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.3
Ground Cover	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.2
Mixed Trees, Shrubs, Ground Cover	0.2	0.5	0.9	0.6	1.1	1.3	0.5	1.0	1.4
Turf Grass	0.6	0.7	0.8	0.6	1.0	1.0	0.8	1.0	1.2

Calculate the landscape coefficient (K_L) by multiplying the 3 area characteristics, as shown in Equation 1.

Equation 1

$$K_L = k_S \times k_d \times k_{mc}$$

Determine the reference evapotranspiration rate (ET_o) for the region. This rate is a measurement of the total amount of water needed to grow a reference plant (such as grass or alfalfa), expressed in millimetres or inches. The values for ET_o in various regions throughout the Canada can be found in regional agricultural data (see Resources). Evapotranspiration rates for summer months in selected Canadian cities are shown in Table 2. Applicants in other cities should check for local conditions. The ET_o for July is used in the LEED calculation because this is typically the month with the greatest evapotranspiration effects and, therefore, the greatest irrigation demands.

WE	
NC	Credit 1
CS	Credit 1

TABLE 2. EVAPOTRANSPIRATION RATE FOR SELECTED CANADIAN CITIES (mm/MONTH)

CITY	MAY	JUNE	JULY	AUG	SEPT
Victoria	91.5	106.5	121.3	97.3	55.3
Vancouver	97.5	112.6	128.4	103.9	60.0
Calgary	122.1	133.0	134.8	108.6	69.1
Edmonton	122.1	130.7	130.6	97.5	62.8
Saskatoon	129.7	144.7	149.5	126.3	78.4
Regina	131.1	152.2	162.9	145.4	85.6
Winnepeg	133.9	147.4	149.8	125.8	78.6
Toronto	101.6	124.9	138.2	110.4	71.6
Ottawa	109.0	124.7	133.8	105.2	66.5
Montreal	102.9	121.8	132.3	100.6	63.5
Quebec	100.3	118.1	125.1	96.9	59.0
St. John	69.5	87.9	103.6	82.5	53.2
Fredericton	92.9	111.6	118.8	97.2	60.4
Halifax	83.8	102.3	109.1	92.7	59.1

Calculate the project-specific evapotranspiration rate (ET_L) for each landscape area by multiplying the ET_o by the K_L, as shown in Equation 2.

Equation 2

$$ET_L\ (mm) = ET_o \times K_L$$

Determine the irrigation efficiency (IE) by listing the type of irrigation used for each landscape area and the corresponding efficiency. Table 3 lists irrigation efficiencies for different irrigation systems.

TABLE 3. IRRIGATION TYPES AND EFFICIENCIES

TYPE	EFFICIENCY
Sprinkler	0.625
Drip	0.90

Determine, if applicable, the controller efficiency (CE), the percentage reduction in water use from any weather-based controllers or moisture sensor-based systems. This number must be supported by either manufacturer's documentation or detailed calculations by the landscape designer.

Determine, if applicable, the volume of reuse water (harvested rainwater, recycled greywater or treated wastewater) available in July. Reuse water volumes may depend on rainfall volume and frequency, building-generated greywater and wastewater, and on-site storage capacity. On-site reuse systems must be modeled to predict volumes generated on a monthly basis as well as optimal storage capacity. For harvested rainwater calculations, project teams may use either the collected rainwater total for July based on historical average precipitation, or historical data for each month to model collection and reuse throughout the year. The latter method allows the project team to determine what volume of water can be expected in the storage cistern at the beginning of July and add it to the expected rainwater volume collected during the month; it also allows the team to determine the optimal size of the rainwater cistern.

WE	
NC	Credit 1
CS	Credit 1

To calculate total water applied (TWA) and total potable water applied (TPWA) for each landscape area and the installed case, use Equations 3 and 4.

Equation 3

$$\text{Design Case TWA (L)} = \left(\text{Area (m}^2\text{)} \times \frac{ET_L \text{ (mm)}}{IE} \right) \times CE$$

Equation 4

$$\text{Design Case TPWA (L)} = \text{TWA (L)} - \text{Reuse Water}$$

STEP 2. CREATE THE BASELINE CASE

In the baseline case, the k_s, k_d, and IE are set to average values representative of conventional equipment and design practices. The same k_{mc} and the reference ET_o are used in both the design and the baseline cases. If the project substitutes low-water-using plants (such as shrubs) for high-water-using types (such as turf grass), the landscape areas can be reallocated in the baseline case, but the total landscape area must remain the same. The baseline cannot be 100% turf grass if typical landscaping practices in the region include trees, shrubs, and planting beds.

Calculate the TWA for the baseline case using Equation 5.

Equation 5

$$\text{Baseline Case TWA (L)} = \text{Area (m}^2\text{)} \times \frac{ET_L \text{ (mm)}}{IE}$$

STEP 3

Calculate the percentage reduction in total irrigation water use (potable and reuse)

AND

the percentage reduction of potable water use for irrigation.

Calculate the percentage reduction of potable water use according to Equation 6.

Equation 6

$$\begin{array}{l}\text{Percentage Reduction}\\ \text{of Potable Water (\%)}\end{array} = \left(1 - \frac{\text{Design (TPWA)}}{\text{Baseline (TWA)}} \right) \times 100$$

If the percentage reduction of potable water use for irrigation achieved is 50% or more, the requirements for Option 1 are met. If the percentage reduction of potable water use for irrigation achieved is 100% AND the percentage reduction of total water use for irrigation is 50% or more, Option 2 is achieved. If the percentage reduction of potable water use for irrigation is 100%, also calculate the percentage reduction of total water (potable plus reuse) according to Equation 7.

Equation 7

$$\begin{array}{l}\text{Percentage Reduction}\\ \text{of Total Water (\%)}\end{array} = \left(1 - \frac{\text{Design (TWA)}}{\text{Baseline (TWA)}} \right) \times 100$$

WE	
NC	Credit 1
CS	Credit 1

7. DOCUMENTATION GUIDANCE

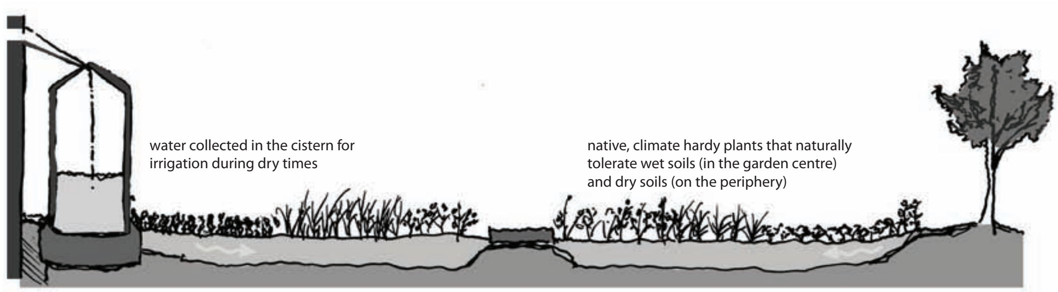
As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Perform calculations of the baseline and design case to show the percentage reduction in water demand, and report what portion of irrigation will come from each non-potable source (if any).
- Prepare a landscape plan showing a planting schedule and irrigation system.
- Retain manufacturer documentation or calculations on controller efficiency, if used.
- Perform calculations on cistern performance.

8. EXAMPLES

FIGURE 1. RAINWATER HARVESTING SYSTEM

Water is collected from the building roof into a cistern, which feeds a drip irrigation system. Use of native plants reduces overall irrigation volumes, making it more likely that collected rainwater volumes will suffice for irrigation needs.



EXAMPLE 1

An office building in Calgary, Alberta has a total site area of 600 square metres. The site comprises three landscape types: shrubs, mixed vegetation, and turf grass. All are irrigated with a combination of potable water and greywater harvested from the building. The reference ET_o for Calgary in July, obtained from the Table 2, is 134.8 mm. The high-efficiency irrigation case uses drip irrigation with an efficiency of 90% and consumes an estimated 12,500 litres of greywater during July. Table 4 shows the calculations to determine total potable water use for the design case.

The baseline case uses the same reference ET_o and total site area. However, it uses sprinklers for irrigation (IE = 0.625), does not take advantage of greywater harvesting, and irrigates only shrubs and turf grass. Calculations to determine total water use for the baseline case are presented in Table 5.

The design case has an irrigation water demand of 38,970 litres. Greywater reuse provides 12,500 litres toward the demand, and this volume is treated as a credit in the water calculation. Thus, the total potable water use in July is 26,470 litres. The baseline case has an irrigation demand of 103,785 litres and uses no greywater. The project thus achieves a potable water savings of 74% and earns 2 points under WE Credit 1.

WE	
NC	Credit 1
CS	Credit 1

TABLE 4. DESIGN CASE (JULY)

LANDCAPE TYPE	AREA (m^2)	SPECIES FACTOR (k_s)	DENSITY FACTOR (k_d)	MICROCLIMATE FACTOR (k_{mc})	K_L	ET_L	IE	TWA (L)
Shrubs	120	Low 0.2	Avg 1.0	High 1.3	0.26	35.0	Drip	4,673
Mixed	390	Low 0.2	Avg 1.1	High 1.4	0.31	41.5	Drip	17,991
Turf grass	90	Avg 0.7	Avg 1.0	High 1.2	0.84	113.2	Sprinkler	16,305
Subtotal TWA (L)								38,970
July rainwater and greywater harvest (L)								(12,500)
TPWA (L)								26,470

TABLE 5. BASELINE CASE (JULY)

LANDSCAPE TYPE	AREA (m^2)	SPECIES FACTOR (k_s)	DENSITY FACTOR (k_d)	MICROCLIMATE FACTOR (k_{mc})	K_L	ET_L	IE	TWA (L)
Shrubs	120	Avg 0.5	Avg 1.0	High 1.3	0.65	87.6	Sprinkler	16,823
Turf grass	480	Avg 0.7	Avg 1.0	High 1.2	0.84	113.2	Sprinler	86,962
Subtotal TWA (L)								103,785

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Much of North America is faced with increasing demands on existing water supplies, making it important to landscape sites appropriately for the climate. Appropriate landscaping should consider the site's climate and microclimate, sun exposure, soil type, drainage, and topography.

In dry climates, emphasize drought-tolerant plants and xeriscape designs. Reducing or eliminating turf grass will lessen the demand on potable water; rocks and stone can be incorporated into the landscape instead. If turf grass is desired, select a species that can endure drought.

In temperate climates, use native plants combined with rain or moisture sensors to avoid unnecessary watering in the wet seasons. The use of captured rainwater can help eliminate the use of potable water for irrigation.

In cold climates, install hardy, native hardy plants that will survive the winter months. Rain or moisture sensors will help prevent excessive watering.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Effective maintenance of the site landscape will require ongoing attention to the condition and effectiveness of any irrigation system and to the condition of the vegetation itself. To facilitate

WE	
NC	Credit 1
CS	Credit 1

effective operation of the irrigation system, consider these strategies:

- Install submetering to help operators manage water consumption and identify problems within the system. Submetering may also present opportunities for operating cost savings, since many water utilities do not levy sewage charges on submetered water volumes that do not reach the sewage system. Consider integrating electronic data logging to facilitate consumption trend analysis.
- Consider developing a site landscape maintenance plan for facility operators that includes landscape and irrigation system design plans, species lists, and equipment specifications.
- Greywater systems may require special maintenance. Provide facility operators with appropriate systems manuals, manufacturers' contact information, and product specifications to facilitate proper operation.
- Provide specific guidance to building operators or landscape maintenance contractors about when and how temporary irrigation for plant establishment should be terminated, and metrics for ensuring the success of the establishment phase.

12. RESOURCES

WEBSITES

Alliance for Water Efficiency
http://www.a4we.org

The Alliance for Water Efficiency is a stakeholder-based, non-profit organization dedicated to the efficient and sustainable use of water. The Alliance serves as a North American advocate for water efficient products and programs, and provides information and assistance on water conservation efforts.

America Rainwater Catchment Systems Association
http://www.arcsa.org/

ARCSA was founded to promote rainwater catchment systems in the United States. The ARCSA website provides regional resources, publications, suppliers, and membership information.

American Water Works Association, WaterWiser: The Water Efficiency Clearinghouse
http://www.waterwiser.org

The clearinghouse includes articles, reference materials, and papers on all forms of water efficiency.

Canadian Water and Wastewater Association
http://www.cwwa.ca

CWWA is a non-profit national body representing the common interests of Canada's public sector municipal water and wastewater services and their private sector suppliers and partners. Their committees and networks represent many areas of water management.

Canadian Water and Wastewater Association, Canada's Water Efficiency Experiences Database
http://www.cwwa.ca/WEED/Search_e.asp

The water efficiency database was developed by the Canada Water and Wastewater Association and Environment Canada to encourage the exchange of information. The user can select information from the following areas: indoor; outdoor; landscaping; public awareness and education; community activity; infrastructure; regulatory; research, technology and science; economics and geographic location (locations throughout Canada are represented).

WE	
NC	Credit 1
CS	Credit 1

City Farmer
http://www.cityfarmer.org/

Canada's Office of Urban Agriculture: Contains information on water efficient lawn care and other practices with links to related organizations.

Effluent Irrigation
http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1190146328535&lang=e

Canada-Saskatchewan Irrigation Diversification Centre. Agriculture and Agri-Food Canada. This paper discusses the potential for effluent irrigation and its sustainability.

Irrigation Association
http://www.irrigation.org

This non-profit organization focuses on promoting products that efficiently use water in irrigation applications.

Irrigation Industry Association of British Columbia
www.irrigationbc.com

While primarily focused on irrigation in BC (including evapotranspiration rates for many municipalities), much of the information applies across Canada.

National Climate Data and Information Archive
http://www.climat.meteo.ec.gc.ca/climateData/canada_e.html

This federal website is useful for researching local climate information such as data for rainwater harvesting calculations.

Rain Bird® ET Manager™ Scheduler
http://www.rainbird.com/landscape/products/controllers/etmanager.htm

This free software provides sufficient local evapotranspiration data for the United States and Canada. Access data from the closest or most climate-appropriate location.

Rocky Mountain Institute, Greywater Systems, Compost Toilets, and Rain Collection
http://www.rmi.org

This web resource from the Rocky Mountain Institute provides general information and links to resources on rain collection and greywater systems.

U.S. EPA, Water Efficient Landscaping: Preventing Pollution and Using Resources Wisely
http://www.epa.gov/watersense/docs/water-efficient_landscaping_508.pdf

This manual provides information about reducing water consumption through creative landscaping techniques.

PRINT MEDIA

Landscape Irrigation: Design and Management, by Stephen W. Smith (John Wiley & Sons, 1996). This text is a comprehensive guide to landscape irrigation strategies, techniques, and hardware.

Turf Irrigation Manual, fifth edition, by Richard B. Choate and Jim Watkins (Telsco Industries, 1994). This manual covers all aspects of turf and landscape irrigation.

WE	
NC	Credit 1
CS	Credit 1

13. DEFINITIONS

Adapted (or introduced) plants reliably grow well in a given habitat with minimal winter protection, pest control, fertilization, or irrigation once their root systems are established. Adapted plants are considered low maintenance and not invasive.

An aquifer is an underground water-bearing rock formation or group of formations that supply groundwater, wells, or springs.

Conventional irrigation refers to the most common irrigation system used in the region where the building is located. A conventional irrigation system commonly uses pressure to deliver water and distributes it through sprinkler heads above the ground.

Drip irrigation delivers water at low pressure through buried mains and submains. From the submains, water is distributed to the soil from a network of perforated tubes or emitters. Drip irrigation is a high-efficiency type of microirrigation.

Evapotranspiration (ET) rate is the amount of water lost from a vegetated surface in units of water depth. It is expressed in millimetres per unit of time.

Greywater is defined by the Uniform Plumbing Code (UPC) in its Appendix G, Gray Water Systems for Single-Family Dwellings, as "untreated household waste water which has not come into contact with toilet waste. Greywater includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washer and laundry tubs. It must not include waste water from kitchen sinks or dishwashers." The International Plumbing Code (IPC) defines greywater in its Appendix C, Gray Water Recycling Systems, as "waste water discharged from lavatories, bathtubs, showers, clothes washers and laundry sinks." Some provincial and local authorities allow kitchen sink wastewater to be included in greywater. Other differences with the UPC and IPC definitions can likely be found in provincial and local codes. Project teams should comply with greywater definitions as established by the authority having jurisdiction in the project areas.

Integrated pest management (IPM) is the coordinated use of knowledge about pests, the environment, and pest prevention and control methods to minimize pest infestation and damage by the most economical means while minimizing hazards to people, property, and the environment.

The **landscape area** of the site is the total site area less the building footprint, paved surfaces, water bodies, and patios.

Microirrigation involves irrigation systems with small sprinklers and microjets or drippers designed to apply small volumes of water. The sprinklers and microjets are installed within a few centimetres of the ground; drippers are laid on or below grade.

Native (or indigenous) plants are adapted to a given area during a defined time period and are not invasive. In North America, the term often refers to plants growing in a region prior to the time of settlement by people of European descent.

Non-potable water is water that is not potable, typically rain or greywater.

Potable water meets or exceeds federal and provincial drinking water quality standards and is approved for human consumption by the provincial or local authorities having jurisdiction; it may be supplied from wells or municipal water systems.

Xeriscaping is a landscaping method that makes routine irrigation unnecessary. It uses drought-adaptable and low-water plants as well as soil amendments such as compost and mulches to reduce evaporation.

WE	
NC	Credit 1
CS	Credit 1

14. CASE STUDY

AQUAQUEST – THE MARILYN BLUSSON LEARNING CENTRE AT THE VANCOUVER AQUARIUM

LEED Canada-NC 1.0 Gold, 1 December 2008

Location: Vancouver, BC
Building Type: Assembly
Owner Type: Non-profit
Building Size: 3,700m^2
Owner Name: Vancouver Aquarium Marine Science Centre
LEED Consultant: Stantec Architecture
Responsible Firm (for this credit): Sharp + Diamond Landscape Architecture
Photo Credit: Colin Jewall

The mission of the Vancouver Aquarium Marine Science Centre is to conserve aquatic life through display and interpretation, education, research, and direct action. In consideration of the Aquarium's mission, water use reduction is an important conceptual component of the design.

Aquaquest's exterior landscaping and living wall includes plants native to the coastal rainforest that characterizes Stanley Park. The hardy, waterwise plants chosen also support biodiversity, offer wildlife habitat, and provide a food source for small animals in the Park. The landscaping and green wall are irrigated by rainwater collected from the roof and stored in an underground cistern. Both the living wall and the landscape feature high efficiency, automatic irrigation systems.

From a habitat perspective, the new building addition replicates a cliff face or escarpment. Therefore, an ecosystem of plants representing a canyon wall and the rainforest was selected to

WE	
NC	Credit 1
CS	Credit 1

withstand the vertical exterior wall conditions and to attract insects, birds and butterflies for viewing. The landscape also features a lower garden and pools typical to the terrain in Stanley Park.

Vancouver Aquarium Rainforest Landscape Plant List:

Adiantum pedatum	Maidenhair Fern
Arctostaphylos uva-ursi	Kinnikinnick
Carex rostrata	Beaked Sedge
Gaultheria shallon	Salal
Mahonia aquifolium	Oregon Grape
Mahonia repens	Creeping Mahonia
Malus fusca	Pacific Crabapple
Polystichum munitum	Sword Fern
Rhododendron macrophyllum	Pacific Rhododendron
Rosa nutkana	Nootka Rose
Symphoricarpus mollis	Trailing Snowberry
Vaccinium ovatum	Evergreen Huckleberry
Vaccinium parvifolium	Red Huckleberry

Vancouver Aquarium Living Wall Plant List:

Dicentra formosa	Pacific Bleeding Heart
Dryopteris expansa	Spiny Wood fern
Fragaria vesca	Woodland strawberry
Gaultheria procumbens	Wintergreen (native eastern Canada)
Polypodium glycyrrhiza	Licorice fern
Tellima grandiflora	Fringecup
Tiarella trifoliata	Foamflower
Vaccinium ovatum	Evergreen huckleberry (blueberry)

WE	
NC	Credit 2
CS	Credit 2

INNOVATIVE WASTEWATER TECHNOLOGIES

	NC	CS
Credit	WE Credit 2	WE Credit 2
Points	2 points	2 points

INTENT

To reduce wastewater generation and potable water demand while increasing the local aquifer recharge.

REQUIREMENTS: NC & CS

OPTION 1

Reduce potable water use for building sewage conveyance by 50% through the use of water-conserving fixtures (e.g., water closets, urinals) or non-potable water (e.g., captured rainwater, recycled greywater, and on-site or municipally treated wastewater).

OR

OPTION 2

Treat 50% of wastewater on-site to tertiary standards. Treated water must be infiltrated or used on-site.

INTERPRETATIONS

LEASED TENANT SPACES (NC & CS)

All leased tenant spaces, regardless of being an NC or CS project, must be included in the calculation of wastewater to demonstrate compliance.

If the regulated fixtures intended for use by tenants are not supplied or specified (through mandatory lease agreements or on fit-up drawings), then the design case fixture water use rates are assumed equal to the maximum values allowed by the local building code or if not specified, the default baseline values as noted by this credit.

The use of treated non-potable water provided by the base building can be used in calculated water savings as long as the plumbing arrangement or mandatory lease agreements necessitate the use of such systems.

The use of mandatory lease agreements to achieve this credit is allowed as noted above; however the mandatory lease agreements must either specify specific fixtures to be used or the specific performance requirements of the fixtures intended for the space.

WE	
NC	Credit 2
CS	Credit 2

CAMPUS

This credit may be obtained through campus shared infrastructure by meeting the above requirements. Demonstrate that infrastructure has the capacity to serve the site when all planned projects are connected.

In phased projects this credit may be captured for the entire build-out based on a finalized development master plan. Include a copy of the finalized development master plan.

The area of the wastewater system is not included as part of the LEED Project Site Area unless it is built as part of the project contracted scope of work.

WE	
NC	Credit 2
CS	Credit 2

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Water closets and urinals do not require the same high level of water quality as faucets and showerheads. Reducing the amount of potable water needed for sewage conveyance reduces the total amount of water withdrawn from natural water bodies. Similarly, reducing or eliminating the volume of sewage that leaves the site reduces public infrastructure, chemical inputs, energy use, and emissions at municipal water treatment works. Water efficiency and reuse can greatly reduce negative environmental impacts.

Take into consideration the environmental impacts of off-site versus on-site treatment and supply. On-site wastewater treatment systems transform perceived "wastes" into resources that can be used on the building site and provide opportunities to enhance occupants' understanding of nutrient cycles. These resources include treated water volumes for potable and non-potable use, as well as nutrients that can be applied to improve the site's soil conditions.

ECONOMIC ISSUES

Wastewater treatment systems and water recovery systems require initial capital investment in addition to regular maintenance over the building's lifetime. Project teams must balance these costs with the anticipated savings in water and sewer bills.

Facilities that generate large amounts of wastewater can realize considerable savings by recycling greywater. However, dual sanitary and greywater distribution piping doubles construction piping costs. In addition, local codes requiring filtration, disinfection treatment, overflow protection, and other measures add to the cost of construction, operation, and maintenance. In some systems, pumps are required for distribution, incurring additional energy costs for operation. If a greywater system is anticipated, project teams should install dual plumbing lines during the initial construction to avoid the substantial costs and difficulty of adding them later.

Collection and use of rainwater for non-potable water applications has significantly fewer code requirements and associated costs. Collecting rainwater reduces the need for runoff devices and minimizes the need for municipal water, decreasing initial and operating costs. Water storage accounts for the highest cost in most rainwater systems.

If on-site water collection or treatment is being considered, compare the available on-site water supply with the amount of water demand projected for a typical year. This analysis can help determine storage capacity and, if treatment is necessary, the cost of water treatment systems. Conducting this type of analysis early in the design process can help identify synergies that reduce the cost of infrastructure, as well as the extent of site disturbance. For example, water storage can be located beneath a parking lot and may prove more economical if installed when the site is graded. Water storage may also be economically feasible if a cistern to collect rainwater is added to a stormwater detention system.

Water treatment can be incorporated into natural or constructed wetlands and add value as a site enhancement. Currently, packaged biological wastewater systems have an initial high cost, relative to the overall building cost, because of the novelty of the technology.

Some municipalities have developed infrastructure to provide a low-cost non-potable water supply, sometimes referred to as a purple pipe system. Reductions in the amount of potable water that a municipality must provide can lead to more stable water rates.

WE	
NC	Credit 2
CS	Credit 2

2. RELATED CREDITS

Efforts to harvest rainwater, reuse greywater, and decrease the demand on local water aquifers may support the following credits:

- SS Credit 6.1: Stormwater Design—Quantity Control
- SS Credit 6.2: Stormwater Design—Quality Control
- WE Prerequisite 1: Water Use Reduction
- WE Credit 1: Water-Efficient Landscaping
- WE Credit 3: Water Use Reduction

Additional energy use may be needed for certain on-site wastewater treatment operations or for reuse strategies. These active systems also require commissioning and should be considered in relation to the following credits:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Credit 3: Enhanced Commissioning
- EA Credit 5: Measurement and Verification

3. SUMMARY OF REFERENCED STANDARDS

The water efficiency baselines meeting these referenced standards are summarized in the Requirements section of WE Prerequisite 1, Water Use Reduction.

The Energy Policy Act (EPAct) of 1992 (and as amended)
This act addresses energy and water use in commercial, institutional, and residential facilities.

The Energy Policy Act (EPAct) of 2005
This statute became U.S. law in August 2005. *Although there is not a comparative national code requirement in all of Canada, many provinces and municipalities have similar requirements.*

International Association of Plumbing and Mechanical Officials, Publication IAPMO/ American National Standards Institute UPC 1–2006, Uniform Plumbing Code 2006, Section 402.0, Water-Conserving Fixtures and Fittings
http://www.iapmo.org

UPC defines water-conserving fixtures and fittings for water closets, urinals, and metered faucets. This ANSI-accredited code safeguards life, health, property, and public welfare by regulating and controlling the design, construction, installation, materials, location, operation, and maintenance or use of plumbing systems.

International Code Council, International Plumbing Code 2006, Section 604, Design of Building Water Distribution System
http://www.iccsafe.org

IPC defines maximum flow rates and consumption for plumbing fixtures and fittings, including public and private lavatories, showerheads, sink faucets, urinals, and water closets.

WE	
NC	Credit 2
CS	Credit 2

4. IMPLEMENTATION

This credit addresses water use in flush fixtures regulated by the US Energy Policy Act of 1992 and subsequent rulings by the US Department of Energy, the requirements of the Energy Policy Act of 2005, and the plumbing code requirements as stated in the 2006 editions of the US Uniform Plumbing Code and International Plumbing Code.

Potable water is used for many functions that do not require high-quality water, including toilet and urinal flushing. Effective methods for reducing potable water use for sewage conveyance include installing high-efficiency and non-water flush fixtures, collecting rainwater, and reusing greywater. Rainwater and greywater systems can significantly reduce potable water demand. Greywater systems reuse the wastewater collected from sinks, showers, and other sources for flushing toilets and urinals and other functions that do not require potable water. Greywater treatment may be required prior to reuse according to specific end use and provincial jurisdiction.

The quality of rainwater is typically higher than collected greywater, so rainwater systems have significantly fewer code requirements and are often less expensive than greywater systems. Rainwater collected from impervious surfaces reduces stormwater runoff and control requirements. Stormwater retention or detention systems can be designed with cisterns to hold rainwater runoff for non-potable use.

The feasibility of wastewater reuse and treatment strategies depends on the project's size and location. Some municipalities provide developments with a convenient and affordable non-potable water supply, sometimes known as a purple pipe system. Close proximity to a municipal or private treatment facility can also open the opportunity to reuse treated wastewater for projects that cannot develop their own wastewater treatment, greywater collection, or rainwater systems on-site.

Large projects or campus settings may have the necessary scale and land to support on-site wastewater treatment. In remote locations, it may be more cost-effective to use an on-site wastewater treatment system than to extend existing infrastructure. On-site wastewater treatment systems avoid the aquifer contamination problems of current septic system technology. Projects that plan to treat wastewater on-site can consider constructed wetlands, mechanical recirculating sand filters, and anaerobic biological treatment reactors.

Raw, untreated rainwater, stormwater, and greywater can be more corrosive than potable water because of microbiological levels and particulate buildup in tanks and lines. Using anticorrosive materials can prevent premature failure from such corrosion.

5. TIMELINE AND TEAM

During predesign, setting water goals and strategy involves the owner, architect, and engineers. Study weather data to determine both average annual precipitation and seasonal precipitation patterns. Identify local water utilities and governing authorities and research codes and applicable water laws. Study the process for obtaining permits and set water goals and strategy.

During schematic design, mechanical and civil engineers can help establish a water budget with estimated volumes for end uses of non-potable water (for flush fixtures, irrigation, process loads). Investigate rainwater, stormwater, municipally supplied non-potable water, treated and untreated greywater, and treated blackwater as sources of supply.

A water budget enables comparison of trade-offs for water conservation strategies and evaluation of the impact of water infrastructure on other systems. In early design stages, architects and engineers can determine square footage areas required for rainwater or stormwater harvesting and

WE	
NC	Credit 2
CS	Credit 2

on-site wastewater treatment to meet specific end-use demands. Estimate the feasibility and cost of different reuse and treatment strategies and compare environmental impacts of on-site versus off-site water supply. Water goals and strategy can then be confirmed or reassessed.

During design development, the engineering team should develop and design water reuse and treatment systems, perform preliminary LEED calculations, and confirm or reassess water goals.

In construction documents, the architect, working with the owner, should specify efficient fixtures and appliances and complete LEED calculations and documentation.

During construction, the design team and owner should confirm proper selection, installation, and operation of water fixtures, fittings, and systems. For any non-potable water systems, the design team should refer to the Canadian Standards Association's *Design and Installation of Non-Potable Water Systems/Maintenance and Field Testing of Non-Potable Water Systems*, CSA B128.1/B128.2, which is recognized as the official Canadian standard in this area.

6. CALCULATIONS

The following section describes the calculation methodology for determining reductions in potable water used for sewage conveyance and wastewater released into the municipal system. Wastewater calculations are based on the annual generation of blackwater volumes from flush fixtures. Flow fixtures are not included in calculations for this credit. The calculated water use reduction for the project is the difference between the calculated design case and a baseline case. The percentage is determined by dividing the design case use by the baseline use. The methodology differs from traditional plumbing design, in which calculations are based on fixture counts; under this credit, the water use calculation is based on fixture and fitting water consumption rates and estimated use by the occupants.

Refer to WE Prerequisite 1, Water Use Reduction, for information on calculating occupancy, defining fixture usage groups, and default values for fixture use by occupant type.

DESIGN CASE WATER CONSUMPTION

The design case annual water use is determined by totalling the annual volume of each fixture type and subtracting any non-potable water supply. The design case must use the rated flow rates and flush volumes for installed plumbing fixtures and fittings. Obtain water consumption data from the manufacturers' product literature.

Perform calculations for each type of blackwater-generating fixture (Table 1).

WE	
NC	Credit 2
CS	Credit 2

TABLE 1. SAMPLE PLUMBING FIXTURES AND FITTINGS AND WATER CONSUMPTION

FLUSH FIXTURE	FLOW RATE (GPF)	FLOW RATE (LPF)
Conventional water closet	1.6	6.0
High-efficiency toilet (HET), single-flush gravity	1.28	4.8
HET, single-flush pressure assist	1.0	3.8
HET, dual flush (full-flush)	1.6	6.0
HET, dual flush (low-flush)	1.1	4.2
HET, foam flush	0.05	0.19
Non-water toilet	0.0	0.0
Conventional urinal	1.0	3.8
High-efficiency urinal (HEU)	0.5	1.9
Non-water urinal	0.0	0.0

If on-site collected rainwater or greywater is used for sewage conveyance, enter the estimated quantity in the calculation. The total annual quantity of non-potable water is subtracted from the total annual design case water use. For greywater and rainwater volumes, calculations are required to demonstrate that these reuse volumes are sufficient to meet water closet demands.

BASELINE CASE WATER CONSUMPTION

The baseline case annual water use is determined by setting the fixture and fitting water consumption to baseline rates listed in the requirements for WE Prerequisite 1 (as opposed to actual installed values in the design case).

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Determine the type and number of occupants.
- Retain manufacturers' data showing the water consumption rates, manufacturer, and model of each fixture and fitting.
- Compile information about system schematics and capacity of any rainwater or greywater systems.
- Retain documentation confirming tertiary treatment.

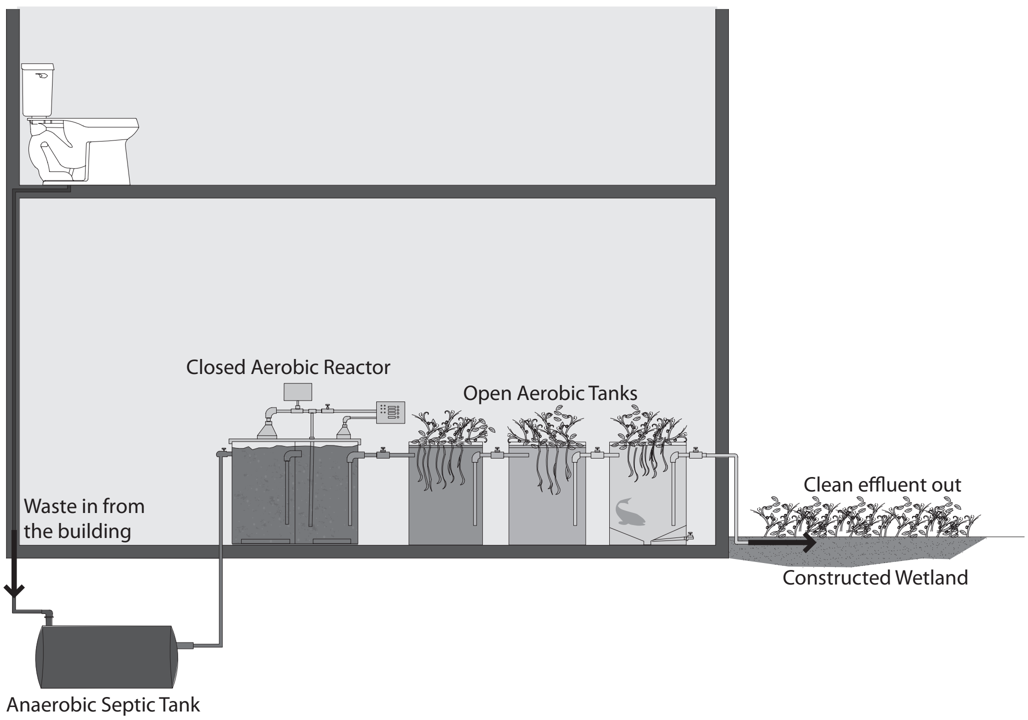
WE	
NC	Credit 2
CS	Credit 2

8. EXAMPLES

EXAMPLE 1. Wastewater Treatment System

On-site biological treatment transforms waste into resources that can be used on the building site. Figure 1 shows the steps for on-site treatment. As solids settle in the anaerobic septic tank, microbes begin to feed and break down the waste. The closed aerobic reactor is aerated by pumps to help remove aromatic compounds. The open aerobic reactors contain plants, algae, snails, and fish that further break down the organic waste. In the constructed wetland, aerobic and anaerobic reactions remove the remaining impurities and nitrates. This creates clean, non-potable water that can be used in irrigation systems, water closets, or cooling towers.

FIGURE 1. ON-SITE BIOLOGICAL TREATMENT OF WASTEWATER



WE	
NC	Credit 2
CS	Credit 2

EXAMPLE 2. Calculating Design and Baseline cases

Example 2 shows sample potable water calculations for sewage conveyance for a 2-story office building with 300 occupants. The calculations are based on a typical 8-hour workday. It is assumed that building occupants are 50% male and 50% female. Male occupants are assumed to use water closets once and urinals twice in a typical workday. Female occupants are assumed to use water closets 3 times. The men's washrooms contain composting toilets and waterless urinals. The women's washrooms contain high-efficiency toilets rated at 4.2 litres per single flush.

First, the design case is considered to determine annual potable water use for sewage conveyance. The building uses non-potable rainwater in the women's washrooms and no water for sewage conveyance (i.e., fixtures are waterless urinals and composting toilets) in the men's washrooms. Table 2 summarizes the sewage generation rates; 351,400 litres of potable water are used annually for sewage conveyance. In the example, 140,000 litres of rainwater are harvested and directed to water closets for flushing.

TABLE 2. DESIGN CASE CALCULATIONS

FIXTURE TYPE	DAILY USES	FLOWRATE IN LPF	OCCUPANTS	SEWAGE GENERATION IN LITRES
Low-flow Water Closet (male)	0	4.2	150	0
Low-flow Water Closet (female)	3	4.2	150	1,890
Composting Toilet (male)	1	0.0	150	0
Composting Toilet (female)	0	0.0	150	0
Waterless Urinal (male)	2	0.0	150	0
Waterless Urinal (female)	0	0.0	150	0
Total Daily Volume				1,890
Annual Work Days				260
Annual Volume				491,400
Rainwater or Greywater Reuse Volume				140,000
Total Annual Volume				351,400

Table 3 summarizes baseline calculations. Sewage conveyance requires an estimated 1,232,400 litres of potable water per year. Comparison of the baseline with the design case indicates that the building realizes a 71% reduction in potable water volumes used for sewage conveyance (1 - 351,400/1,232,400). Thus, this strategy earns 2 points. When developing the baseline, only the fixtures, sewage generation rates, and the water reuse credit are different from the design case; usage rates, occupancy, and number of workdays remain the same.

WE	
NC	Credit 2
CS	Credit 2

TABLE 3. BASELINE CASE CALCULATIONS

FIXTURE TYPE	DAILY USES	FLOWRATE IN LPF	OCCUPANTS	SEWAGE GENERATION IN LITRES
Water Closet (Male)	1	6	150	900
Water Closet (female)	3	6	150	2,700
Urinal (Male)	2	3.8	150	1,140
Urinal (female)	0	3.8	150	0
Total Daily Volume				4,740
Annual Work Days				260
Total Annual Volume				1,232,400

9. EXEMPLARY PERFORMANCE

Projects may be awarded an innovation credit for exemplary performance by demonstrating 100% reduction in potable water use for sewage conveyance, or by demonstrating on-site treatment and either re-use or infiltration of 100% of generated wastewater.

10. REGIONAL VARIATIONS

Consider local climate and weather patterns when determining the feasibility of using rainwater to reduce potable water for plumbing fixture flushing. Depending on seasonal precipitation patterns, rainwater harvesting for on-site use may require a storage strategy. The cost of creating the necessary storage capacity may be justified if strategies for rainwater collection can be combined with the storage of greywater for reuse.

Climatic conditions also affect the viability of on-site treatment options. A cold climate may require a larger surface area for biological treatment.

When considering an on-site rainwater, greywater, or blackwater system, first check with local government agencies for regulations and required permits. Each province has its own standards and requirements for the installation and operation of such systems. Ontario, for example, has standards that encourage the use of greywater systems, whereas other provinces have regulations that may limit or prohibit their use. Codes also may differ in how alternative plumbing fixtures, such as waterless urinals, dual-flush or low-flow water closets, and composting toilets systems, are handled. Confirm the legality of nontraditional approaches with code officials before committing to specific water-saving strategies.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Buildings designed to achieve low sewage conveyance volumes may have equipment or technologies that are unfamiliar to some facility owners and managers. Give them complete operating information, manufacturers' specifications and contact information, and tools for evaluating system effectiveness on an ongoing basis.

To ensure continued water savings and satisfaction for owners and occupants, maintenance staff must be trained in the operation and maintenance of any on-site wastewater treatment systems and specialized equipment. For example, waterless urinals generally need to be cleaned according to manufacturers' specifications and their chemical traps appropriately maintained, and some ultra low volume flushing urinals must also be maintained according to manufacturers' specifications.

12. RESOURCES

WE	
NC	Credit 2
CS	Credit 2

WEBSITES

Alliance for Water Efficiency
http://www.a4we.org

The Alliance for Water Efficiency is a stakeholder-based, non-profit organization dedicated to the efficient and sustainable use of water. The Alliance serves as a North American advocate for water efficient products and programs, and provides information and assistance on water conservation efforts.

American Rainwater Catchment Systems Association
http://www.arcsa.org

ARCSA was founded to promote rainwater catchment systems in the United States. The ARCSA website provides regional resources, suppliers, and membership information, and publications such as the Texas Guide to Rainwater Harvesting.

Canadian Water and Wastewater Association
http://www.cwwa.ca

CWWA is a non-profit national body representing the common interests of Canada's public sector municipal water and wastewater services and their private sector suppliers and partners. Their committees and networks represent many areas of water management, including water efficiency. This site hosts many free research publications, including the Maximum Performance (MaP) Testing of Popular Toilet Models with independent test results for a variety of toilets' flush performance.

Canadian Water and Wastewater Association, Canada's Water Efficiency Experiences Database
http://www.cwwa.ca/WEED/Search_e.asp

The water efficiency database was developed by the Canada Water and Wastewater Association and Environment Canada to encourage the exchange of information. The user can select information from the following areas: indoor; outdoor; landscaping; public awareness and education; community activity; infrastructure; regulatory; research, technology and science; economics and geographic location (locations throughout Canada are represented).

Environmental Building News, Water: Doing More with Less
http://www.buildinggreen.com/auth/article.cfm/2008/2/3/Water-Doing-More-With-Less/

This website features an article on building water efficiency.

National Climate Data and Information Archive
http://www.climat.meteo.ec.gc.ca/climateData/canada_e.html

This federal website is useful for researching local climate information such as data for rainwater harvesting calculations.

Provincial/Territorial Water Policy, Legislation and Regulations
http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=24C5BD18-1

This Environment Canada website provides links to water use associations, legislation, regulation and tools for all provinces and territories in Canada.

WE	
NC	Credit 2
CS	Credit 2

U.S. EPA Publication No. 832/B-93-005, Constructed Wetlands for Wastewater Treatment and Wildlife Habitat: 17 Case Studies, 1993
http://www.epa.gov/owow/wetlands/construc/

The case studies in this document provide brief descriptions of 17 wetland treatment systems that offer water quality benefits while also providing habitat. The projects described include constructed and natural wetlands; habitat creation and restoration; and the improvement of municipal effluent, urban stormwater, and river water quality.

U.S. EPA, WaterSense
http://www.epa.gov/watersense/

The WaterSense Program helps U.S. consumers save water and protect the environment. Look for the WaterSense label to help choose high-quality, water-efficient products. A variety of products are available, and they do not require a change in lifestyle.

Explore the link above to learn about how businesses and organizations can partner with WaterSense.

U.S. EPA, How to Conserve Water and Use It Effectively
http://www.epa.gov/OWOW/nps/chap3.html

This EPA document provides guidance for commercial, industrial, and residential water users on saving water and reducing sewage volumes.

U.S. EPA, On-site Wastewater Treatment Systems Manual
http://www.epa.gov/nrmrl/pubs/625r00008/html/625R00008.htm

This manual provides a focused and performance-based approach to on-site wastewater treatment and system management. It also includes information on a variety of on-site sewage treatment options.

PRINT MEDIA

Design and Installation of Non-Potable Water Systems/Maintenance and Field Testing of Non-Potable Water Systems, CSA B128.1/B128.2, (Canadian Standards Association, 2006) www.shopcsa.ca

Mechanical & Electrical Equipment for Buildings, eighth edition, by Benjamin Stein and John Reynolds (John Wiley & Sons, 1992).

Sustainable Building Technical Manual (Public Technology, Inc., 1996): http://www.pti.org.

Water, Sanitary and Waste Services for Buildings, fourth edition, by A. Wise and J. Swaffield (Longman Scientific & Technical, 1995).

WE	
NC	Credit 2
CS	Credit 2

13. DEFINITIONS

An aquifer is an underground water-bearing rock formation or group of formations that supply groundwater, wells, or springs.

Automatic fixture sensors are motion detectors that automatically turn on and turn off lavatories, sinks, water closets, and urinals. Sensors can be hard wired or battery operated.

Blackwater definitions vary, but wastewater from toilets and urinals is always considered blackwater. Wastewater from kitchen sinks (perhaps differentiated by the use of a garbage disposal), showers, or bathtubs is considered blackwater under some provincial or local codes.

Composting toilet system. See **non-water toilet system.**

Greywater is defined by the American Uniform Plumbing Code (UPC) in its Appendix G, Gray Water Systems for Single-Family Dwellings, as "untreated household waste water which has not come into contact with toilet waste. Greywater includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washer and laundry tubs. It must not include waste water from kitchen sinks or dishwashers." The International Plumbing Code (IPC) defines greywater in its Appendix C, Gray Water Recycling Systems, as "waste water discharged from lavatories, bathtubs, showers, clothes washers and laundry sinks." Some provincial and local authorities allow kitchen sink wastewater to be included in greywater. Other differences with the UPC and IPC definitions can likely be found in provincial and local codes. Project teams should comply with greywater definitions as established by the authority having jurisdiction in the project areas.

Non-potable water is water that is not potable, typically rain or greywater.

Non-water (or composting) toilet systems are dry plumbing fixtures and fittings that contain and treat human waste via microbiological processes.

A non-water (or dry) urinal, replaces a water flush with a trap containing a layer of buoyant liquid that floats above the urine, blocking sewer gas and odours.

On-site wastewater treatment is the transport, storage, treatment, and disposal of wastewater generated on the project site.

Potable water meets or exceeds federal and provincial drinking water quality standards and is approved for human consumption by the provincial or local authorities having jurisdiction; it may be supplied from wells or municipal water systems.

Process water is used for industrial processes and building systems such as cooling towers, boilers, and chillers. The term can also refer to water used in operational processes, such as dishwashing, clothes washing, and ice making.

Tertiary treatment is the highest form of wastewater treatment and includes removal of organics, solids, and nutrients as well as biological or chemical polishing, generally to effluent limits of 10 mg/L biological oxygen demand (BOD) 5 and 10 mg/L total suspended solids (TSS).

WE	
NC	Credit 2
CS	Credit 2

14. CASE STUDY

TORONTO AND REGION CONSERVATION – RESTORATION SERVICES CENTRE
LEED Canada-NC 1.0 Platinum, 6 November 2007

Location: Vaughn, Ontario
Building Type: Conservation Centre
Owner Type: Government - Local
Building Size: 1,095 m^2
Owner Name: Toronto and Region Conservation Authority (TRCA)
LEED Consultant: Enermodal Engineering Ltd.
Responsible Firm (for this credit): Enermodal Engineering Ltd.
Photo Credit: Building - Tom Arban/Mongomery Sisam
Composter - Enermodal Engineering Ltd.

The Restoration Services Centre is a showcase of sustainable design and a centre for the Toronto and Region Conservation Authority's habitat regeneration and restoration projects. The facility supports the TRCA's mission to build a foundation of healthy rivers and shorelines, regional biodiversity, sustainable communities, and business excellence. As an environmental organization with a strong focus on the preservation of local waterways, effective wastewater treatment was of prime importance to TRCA.

The consultant and owner installed an innovative composting toilet and waterless urinal system in place of conventional low flush toilets and waterless urinals. Two large composting chambers are located in the mechanical room directly below three washrooms. A dedicated heat recovery ventilator (HRV) provides continuous ventilation for the washrooms and the composting chambers and all exhaust from the washrooms is cascaded through the toilets and composters before venting out the roof. A standby exhaust fan ensures uninterrupted ventilation during normal HRV service.

The composting toilet uses natural biological decomposition to convert human waste into usable compost for the owner's shrub and tree nurseries on-site. The composter chamber is a polyethylene tank enclosing a living ecosystem in which carbon and nitrogen from toilet waste, with additional carbon from sawdust bulking material and a constant flow of oxygen (air), allow bacteria and other beneficial organisms to convert the organic material to safe, usable compost and liquid fertilizer.

Interestingly, the system is able to use conventional urinals and does not require the more costly,

WE	
NC	Credit 2
CS	Credit 2

purpose-built waterless urinals with their special liquid traps; the continuous ventilation through the waste pipe to the composter provides the necessary containment of sewage odours.

A small on-site septic system was installed for compost tea and grey water in order to avoid connection to the municipal sanitary sewer which is about 400 m away.

Custom-designed fire-stops were required where the toilet and urinal waste pipes penetrated the washroom floors.

Ultimately, TRCA's water use for sewage conveyance is zero and indoor water use was reduced by 80%. These high water savings allowed the building to achieve an innovation credit for potable water use reduction.

Lessons learned:

- Despite being an uncommon technology, the composting toilet (and waterless urinals) satisfactorily operated as intended.
- Conventional urinals can be used as waterless urinals with appropriate design.
- Heat recovery ventilators can be integrated with composting toilets to provide complete washroom and composter ventilation in an energy-efficient manner.

WE	
NC	Credit 3
CS	Credit 3

WATER USE REDUCTION

	NC	CS
Credit	WE Credit 3	WE Credit 3
Points	2-4 points	2-4 points

INTENT

To further increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

REQUIREMENTS: NC & CS

Employ strategies that in aggregate use less water than the water use baseline calculated for the building (not including irrigation).

The minimum water savings percentage for each point threshold is as follows::

PERCENTAGE REDUCTION	POINTS
30%	2
35%	3
40%	4

Calculate the baseline according to the commercial and/or residential baselines outlined below. Calculations are based on estimated occupant usage and must include only the following fixtures and fixture fittings (as applicable to the project scope): water closets, urinals, lavatory faucets, showers, kitchen sink faucets, and pre-rinse spray valves.

WE	
NC	Credit 3
CS	Credit 3

COMMERCIAL FIXTURES, FITTINGS AND APPLIANCES	CURRENT BASELINE	
	METRIC	IMPERIAL
Commercial Toilets	6.0 Litres per flush (LPF) Except blow-out fixtures: 13.2 LPF	1.6 gallons per flush (GPF)* Except blow-out fixtures: 3.5 GPF
Commercial Urinals	3.8 LPF	1.0 GPF
Commercial lavatory (restroom) faucets	8.3 LPM at 414 kilopascals (kPa) private applications only (hotel or motel guest rooms, hospital patient rooms)	2.2 gallons per minute (GPM) at 60 pounds per square inch (psi), private applications only (hotel or motel guest rooms, hospital patient rooms)
	1.9 LPM at 414 kPa all others except private applications	0.5 GPM at 60 psi ** all others except private applications
	0.95 Litres per cycle for metering faucets	0.25 gallons per cycle for metering faucets
Commercial Showerheads	9.5 LPM	2.5 GPM
Commercial pre-rinse spray valves (for food service applications)	Flow rate ≤6.0 LPM (no pressure specified; no performance requirement)	Flow rate ≤ 1.6 GPM (no pressure specified; no performance requirement)

RESIDENTIAL FIXTURES, FITTINGS AND APPLIANCES	CURRENT BASELINE	
	METRIC	IMPERIAL
Residential Toilets	6.0 LPF at 414 kPa	1.6 GPF*
Residential Lavatory Faucets	8.3 LPM at 414 kPa	2.2 GPM at 60 psi
Residential Kitchen Faucets		
Residential Showerheads	9.5 LPM at 552 kPa per shower stall	2.5 GPM at 80 psi per shower stall***

* *U.S. EPAct 1992 standard for toilets applies to both commercial and residential models.*

** *In addition to U.S. EPAct requirements, the American Society of Mechanical Engineers standard for public lavatory faucets is 0.5 gpm at 60 psi (ASME A112.18.1-2005). This maximum has been incorporated into the U.S. national Uniform Plumbing Code and the International Plumbing Code.*

*** *Residential shower compartment (stall) in dwelling units: The total allowable flow rate from all flowing showerheads at any given time, including rain systems, waterfalls, bodysprays, bodyspas, and jets, must be limited to the allowable showerhead flow rate as specified above 9.5 LPM (2.5 GPM) per shower compartment, where the floor area of the shower compartment is less than 1.6 square metres (2,500*

WE	
NC	Credit 3
CS	Credit 3

square inches). For each increment of 1.6 square metres (2,500 square inches) of floor area thereafter or part thereof, an additional showerhead with total allowable flow rate from all flowing devices equal to or less than the allowable flow rate as specified above must be allowed. Exception: Showers that emit recirculated non-potable water originating from within the shower compartment while operating are allowed to exceed the maximum as long as the total potable water flow does not exceed the flow rate as specified above.

Tables adapted from information developed and summarized by the U.S. Environmental Protection Agency (EPA) Office of Water based on requirements of the Energy Policy Act (EPAct) of 1992 and subsequent rulings by the US Department of Energy, requirements of the EPAct of 2005, and the plumbing code requirements as stated in the 2006 editions of the Uniform Plumbing Code or International Plumbing Code pertaining to fixture performance.

The following fixtures, fittings and appliances are outside the scope of water use reduction calculation:

- Commercial Steam Cookers
- Commercial Dishwashers
- Automatic Commercial Ice Makers
- Commercial (family–sized) Clothes Washers
- Residential Clothes Washers
- Standard and Compact Residential Dishwashers

INTERPRETATION

Aerators for public washroom faucets must be tamperproof. If aerators are not tamperproof, the applicant must assume a flow rate of 9.5 L/min.

MURBs

Individual suite metering and billing of residential water use can be considered to result in a 20% reduction in total potable water use. Note that:

1. Applicants must use a Measurement Canada approved submetering system.
2. All projects are first required to comply with the baseline water use after meeting the fixture performance requirements listed above.
3. The allowed 20% reduction in total potable water used to represent the savings from individual suite metering is 20% off the design case water used; not 20% off the baseline case water used.

Example: Baseline case uses 1000 m^3 of water per year. Using fixture improvements, the design case for the proposed building uses only 800 m^3. If suite metering is added, a further 20% to the design case will be allowed, bring the expected water used to 640 m^3 or 36% savings over the baseline case.

LEASED TENANT SPACE (NC & CS)

All leased tenant spaces, regardless of being an NC or CS project, must be included in the calculation of water use to demonstrate compliance.

If the regulated fixtures intended for use by tenants are not supplied or specified (through mandatory lease agreements or on fit-up drawings), then the design case fixture water use rates are assumed equal to the maximum values allowed by the local building code or if not specified, the default baseline values defined as noted above.

Other than washroom or shower fixtures, tenant specific plumbing fixtures (e.g., kitchenettes) are excluded from the credit calculations unless shown on fit-up drawings submitted to demonstrate credit compliance.

The use of treated non-potable water provided by the base building can be used in calculated water savings as long as the plumbing arrangement or mandatory lease agreements necessitate the use of such systems.

The use of mandatory lease agreements to achieve this credit is allowed as noted above; however the mandatory lease agreements must either specify specific fixtures to be used or the specific performance requirements of the fixtures intended for the space.

WE	
NC	Credit 3
CS	Credit 3

1. BENEFITS AND ISSUES TO CONSIDER

See the Benefits and Issues section in WE Prerequisite 1.

2. RELATED CREDITS

See the Related Credits section in WE Prerequisite 1.

3. SUMMARY OF REFERENCED STANDARDS

See the Referenced Standards section in WE Prerequisite 1.

4. IMPLEMENTATION

See the Implementation section in WE Prerequisite 1.

5. TIMELINE AND TEAM

See the Timeline and Team section in WE Prerequisite 1.

6. CALCULATIONS

See the Calculations section in WE Prerequisite 1.

7. DOCUMENTATION GUIDANCE

See the Documentation Guidance section in WE Prerequisite 1.

8. EXAMPLES

See the Examples section in WE Prerequisite 1.

9. EXEMPLARY PERFORMANCE

Projects may earn an Innovation in Design credit for exemplary performance by demonstrating 45% reduction in projected potable water use.

As an alternative path to exemplary performance under WE Credit 3, projects may also apply for an Innovation in Design point for process water savings. Process water reduction must be comprehensive and offer significant water savings. The savings must equal or exceed 10% of the WE Credit 3 baseline use. To calculate the savings establish a baseline for the project's process use that takes into account typical practice. Note that typical practice may include some recycling of water (for example, car washes typically include some recycling of water as standard practice). The process water calculation is to be calculated separately from the WE Credit 3 calculations. A project does not need to meet the WE Credit 3 targets in order to apply for innovation in process water savings.

WE	
NC	Credit 3
CS	Credit 3

10. REGIONAL VARIATIONS

See the Regional Variations section in WE Prerequisite 1.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

See the Operations and Maintenance section in WE Prerequisite 1.

12. RESOURCES

See the Operations and Maintenance section in WE Prerequisite 1.

13. DEFINITIONS

See the Definitions in WE Prerequisite 1.

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ENERGY AND ATMOSPHERE (EA)

OVERVIEW

In 2006, buildings accounted for 30% of energy use and 28% of greenhouse gas emissions in Canada[1]; with approximately half of the energy use and associated greenhouse gas emissions attributed to space heating in commercial/institutional and residential buildings.[2]

Electricity made up approximately 50% of the energy used by commercial/institutional and apartment buildings; representing 27% of all electricity generated in the country.[3] Electricity generated in Canada can be broken down by energy source as follows[4]: 60% hydro; 17% coal; 16% nuclear; 5% natural gas; and the remaining 2% is generated from a combination of diesel fuel oil, light and heavy fuel oil, kerosene, wood, wood waste, spent pulping liquor, petroleum coke, still gas, and coke oven gas.

Generating electricity from fossil fuels, such as oil, natural gas, and coal, negatively affects the environment at each step of production and use, beginning with extraction and transportation, followed by refining and distribution, and ending with consumption. For example, coal mining disrupts natural habitats and can devastate landscapes. Acidic mine drainage degrades regional ecosystems. Coal is rinsed with water, producing billions of gallons of sludge that must be stored in ponds. Mining itself is a dangerous occupation in which accidents and the long-term effects of breathing coal dust can shorten the lifespans of coal miners.

Natural gas, nuclear fission, and hydroelectric generators all have adverse environmental consequences as well. Natural gas is a major source of nitrogen oxide and greenhouse gas emissions. Nuclear power increases the potential for catastrophic accidents and raises significant waste transportation and disposal issues. Hydroelectric generating plants disrupt natural water flows and disturb aquatic habitats.

Green buildings address those issues in two ways. First, they reduce the amount of energy required for building operations, and second, they use more benign forms of energy. The better the energy performance of a building, the fewer greenhouse gases are emitted from energy production. Electricity generation using sources other than fossil fuels also reduces the environmental impacts from a building's energy use. Additionally, improved energy performance results in lower operating costs. As global competition for fuel accelerates, the rate of return on energy efficiency measures improves.

ENERGY PERFORMANCE

The energy performance of a building depends on its design. Its massing and orientation, materials, construction methods, building envelope, and water efficiency as well as the heating, ventilating, and air-conditioning (HVAC) and lighting systems determine how efficiently the building uses energy. Therefore, the most effective way to optimize energy efficiency is to use an integrated, whole-building approach. Collaboration among all team members, beginning at project inception, is necessary in designing building systems.

The Energy and Atmosphere (EA) section of this reference guide promotes three kinds of activities:

TRACKING BUILDING ENERGY PERFORMANCE—DESIGNING, COMMISSIONING, MONITORING

Projects that achieve any level of LEED® certification must at a minimum perform better than the average building. Specific levels of achievement beyond the minimum are awarded a proportional number of points. First, the building must be designed to operate at a high performance level. Next, it must be commissioned to ensure that what has been constructed meets the design intent. Third, a process for measurement and verification should be established to ensure the long-term performance of the building's energy systems.

The design of new facilities must be based on the designated mandatory and prescriptive requirements of MNECB 1997 or ASHRAE 90.1-2007, unless the local code is more stringent. In addition, optimization of building energy performance beyond MNECB 1997 or ASHRAE 90.1-2007 is required in EA Prerequisite 2, Minimum Energy Performance and EA Credit 1 Optimize Energy Performance. This can be accomplished through building energy simulation modelling or prescriptive options.

Commissioning begins with the development of the owner's project requirements, followed at a minimum by additional steps that include creation of a formal commissioning plan, verification of equipment installation, and submission of a final report. Enhanced commissioning includes additional tasks, such as design and contractor submittal reviews, creation of a formal systems manual, verification of staff training, and a follow-up review before the warranty period ends.

Commissioning optimizes energy and water efficiency by ensuring that systems are operating as intended, thereby reducing the environmental impacts associated with energy and water usage. Additionally, commissioning can help ensure that indoor environmental quality is properly maintained. Properly executed commissioning can substantially reduce costs for maintenance, repairs, and resource consumption, and higher indoor environmental quality can enhance occupants' productivity.

Monitoring the performance of building systems begins with establishing a measurement and verification plan based on the best practices developed by the International Performance Measurement and Verification Protocol (IPMVP). The plan must cover at least one year of post-construction occupancy. Monitoring involves using appropriate measuring instruments and can include the energy modelling.

MANAGING REFRIGERANTS TO ELIMINATE CFCS

The release of chlorofluorocarbons (CFCs) from refrigeration equipment destroys ozone molecules in the stratosphere through a catalytic process and harms Earth's natural shield from incoming ultraviolet radiation. CFCs in the stratosphere also absorb infrared radiation and create chlorine, a potent greenhouse gas. Banning the use of CFCs in refrigerants slows the depletion of the ozone layer and mitigates climate change.

The standard practice for new buildings is to install equipment that does not use CFC-based refrigerants. In LEED, points are awarded for systems that use refrigerants with a low potential for causing ozone depletion and climate change.

USING RENEWABLE ENERGY

Teams have two opportunities to integrate renewable energy strategies into the LEED project: using on-site renewable energy systems and buying off-site green power. Projects can integrate systems that incorporate on-site electrical (photovoltaic, wind, hydro, wave, tidal, and biofuel-based), geothermal (deep-earth water or steam), or solar thermal (including collection and storage components) power. Credit for off-site renewable green power is achieved by contracting for a minimum purchase of green power.

Energy generation from renewable sources—such as solar, wind, and biomass—avoids air and water pollution and other environmental consequences associated with producing and consuming fossil and nuclear fuels. Although hydropower is considered renewable, it can have harmful environmental effects, such as degrading water quality, altering fish and bird habitats, and endangering species. Low-impact hydropower, if available, is recommended.

Renewable energy minimizes acid rain, smog, climate change, and human health problems resulting from air contaminants. In addition, using renewable resources avoids the consumption of fossil fuels, the production of nuclear waste, and the environmentally damaging operation of hydropower dams.

Renewable alternatives may be less expensive than traditional power in some areas. Utility and public benefit fund rebates may be available to reduce the initial cost of purchasing and installing renewable energy equipment. In some provinces, net metering can offset on-site renewable energy costs when excess electricity generated on-site is sold back to the utility.

CREDIT	TITLE	NC	CS
EA Prerequisite 1	Fundamental Commissioning of Building Energy Systems	Required	Required
EA Prerequisite 2	Minimum Energy Performance	Required	Required
EA Prerequisite 3	Fundamental Refrigerant Management	Required	Required
EA Credit 1	Optimize Energy Performance	1-19 points	3-21 points
EA Credit 2	On-site Renewable Energy	1-7 points	2, 4 points
EA Credit 3	Enhanced Commissioning	2 points	2 points
EA Credit 4	Enhanced Refrigerant Management	2 points	2 points
EA Credit 5	Measurement and Verification	3 points	NA
EA Credit 5.1	Measurement and Verification—Base Building	NA	3 points
EA Credit 5.2	Measurement and Verification—Tenant Submetering	NA	3 points
EA Credit 6	Green Power	2 points	2 points

EA	
NC	Prerequisite 1
CS	Prerequisite 1

FUNDAMENTAL COMMISSIONING OF BUILDING ENERGY SYSTEMS

	NC	CS
Prerequisite	EA Prerequisite 1	EA Prerequisite 1
Points	Required	Required

INTENT

To verify that the project's energy related systems are installed, calibrated and perform according to the owner's project requirements, basis of design, and construction documents.

Benefits of commissioning include reduced energy use, lower operating costs, reduced contractor callbacks, better building documentation, improved occupant productivity, and verification that the systems perform in accordance with the owner's project requirements.

REQUIREMENTS: NC & CS

The following commissioning process activities must be completed by the project team.

1. Designate an individual as the Commissioning Authority (CxA) to lead, review and oversee the completion of the commissioning process activities.
    a. The CxA must have documented commissioning authority experience in at least 2 building projects.
    b. The individual serving as the CxA must be independent of the project's design and construction management, though they may be employees of the firms providing those services. The CxA may be a qualified employee or consultant of the owner.
    c. The CxA must report results, findings and recommendations directly to the owner.
    d. For projects smaller than 4,650 gross square metres (50,000 gross square feet), the CxA may be a qualified person on the design or construction teams who has the required experience.

2. The owner must document the owner's project requirements. The design team must develop the basis of design. The CxA must review these documents for clarity and completeness. The owner and design team must be responsible for updates to their respective documents.

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3. Develop and incorporate commissioning requirements into the construction documents.
4. Develop and implement a commissioning plan.
5. Verify the installation and performance of the systems to be commissioned.
6. Complete a summary commissioning report.

COMMISSIONED SYSTEMS

Commissioning process activities must be completed for the following energy-related systems, at a minimum (if they are installed as part of the core and shell project):

- Heating, ventilating, air conditioning, and refrigeration (HVAC&R) systems (mechanical and passive) and associated controls.
- Lighting and daylighting controls.
- Domestic hot water systems.
- Renewable energy systems (e.g., wind, solar).

INTERPRETATIONS

LEASED TENANT SPACE (NC)

Under *LEED Canada NC*, base building and tenant building systems must be commissioned to prerequisite requirements. If no mechanical equipment or M/E controls are required to be installed by the tenant, then the tenant fit-up work is exempt from commissioning requirements. If there is tenant fit-up work to be commissioned, then the tenant commissioning agent need only deal with the added equipment/controls. For example, the review of owner's project requirements and basis of design would only apply to the tenant work as the base building systems would have been dealt with by the base building commissioning agent. A tenant lease agreement or contract covering commissioning work for future tenant fit-up is required.

LEASED TENANT SPACE (CS)

Under *LEED Canada CS* certification, all mechanical/lighting equipment and controls installed in the base building and owner fit-up tenant space or as part of the base building contract in leased tenant spaces must be commissioned to prerequisite requirements. Mechanical distribution systems, controls and lighting systems installed as part of tenant fit-up are excluded from commissioning requirements.

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1. BENEFITS AND ISSUES TO CONSIDER

Benefits of commissioning include reduced energy use, lower operating costs, fewer contractor callbacks, better building documentation, improved occupant productivity, and verification that the systems perform in accordance with the owner's project requirements.

ENVIRONMENTAL ISSUES

Facilities that do not perform as intended may consume significantly more resources over their lifetimes than they should. Commissioning can minimize the negative impacts buildings have on the environment by helping verify that buildings are designed and constructed to operate as intended and in accordance with the owner's project requirements.

ECONOMIC ISSUES

If commissioning has not been previously included as part of the project delivery process, the costs associated with commissioning may be met with initial resistance. When the long-term benefits are taken into consideration, however, commissioning can be seen as a cost-effective way to ensure that the building is functioning as designed and that planned energy savings are realized in the operation of the building.

Improved occupant well-being and productivity are other potential benefits when building systems function as intended. Proper commissioning of building systems can reduce employee illness, tenant turnover and vacancy, and liability related to indoor air quality, and it can avoid premature equipment replacement.

2. RELATED CREDITS

The commissioning effort can affect many performance-based features encouraged in the LEED Rating System. Consider commissioning the energy-using systems addressed by the following credits:

- SS Credit 8: Light Pollution Reduction
- WE Credit 1: Water Efficient Landscaping
- WE Credit 2: Innovative Wastewater Technologies
- WE Credit 3: Water Use Reduction
- EA Credit 1: Optimize Energy Performance
- EA Credit 2: On-site Renewable Energy
- EA Credit 5: Measurement and Verification
- IEQ Prerequisite 1: Minimum Indoor Air Quality Performance
- IEQ Credit 1: Outdoor Air Delivery Monitoring
- IEQ Credit 2: Increased Ventilation
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control
- IEQ Credit 6: Controllability of Systems
- IEQ Credit 7: Thermal Comfort

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EA Prerequisite 1, Fundamental Commissioning, sets a minimum threshold for commissioning activities. Additional rigor and verification are awarded in this related credit:

- EA Credit 3: Enhanced Commissioning

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this prerequisite.

4. IMPLEMENTATION

RELATIONSHIP BETWEEN FUNDAMENTAL AND ENHANCED COMMISSIONING

LEED Canada for New Construction and *LEED Canada for Core & Shell* address building commissioning in 2 places, EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems, and EA Credit 3, Enhanced Commissioning.

For LEED design and construction projects, the scope of services for the commissioning authority (CxA) and project team should be based on the owner's project requirements. The commissioning process activities must address the commissioned systems noted in the EA Prerequisite 1 requirements. Other systems, such as the building envelope, stormwater management systems, water treatment systems, and information technology systems, may also be included in the commissioning process at the owner's discretion. EA Credit 3 requires that the CxA be involved early in the process to help facilitate a commissioning design review and a commissioning documentation review. As the project nears completion, enhanced commissioning requires oversight of staff training, a walk-through 10 months after completion, and the completion of a systems manual.

5. TIMELINE AND TEAM

The commissioning process is a planned, systematic quality-control process that involves the owner, users, occupants, operations and maintenance staff, design professionals, and contractors. It is most effective when begun at project inception. All members of the project team are encouraged to participate in the commissioning activities as part of a larger commissioning team. The team approach to commissioning can speed the process and add a system of checks and balances.

The overall commissioning effort identified in both EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems, and EA Credit 3, Enhanced Commissioning, is shown in Table 1 as divided into 12 basic steps. The steps are presented in sequential order; however, some tasks can begin at various points in the project or be completed at various points in the project. For example, the development of the commissioning plan may begin in the design phase, have multiple updates during the project, and be considered completed at some point during the construction phase.

Some of the steps are required for EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems, and some are required for EA Credit 3, Enhanced Commissioning. Table 1 outlines the commissioning tasks, the team members primarily responsible for performing each project requirement, and the requirements common to EA Prerequisite 1 and EA Credit 3.

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TABLE 1. TASKS AND RESPONSIBILITIES FOR EA PREREQUISITE 1 AND EA CREDIT 3

PROJECT PHASES	COMMISSIONING TASKS (STEPS 1–12)	RATING SYSTEM TASKS	FUNDAMENTAL	ENHANCED
Pre-design, Design Phase				
Request for proposal architect and engineer selection	1. Designate commissioning authority (CxA)	EA Prerequisite 1, Task 1 EA Credit 3, Task 1	Owner or project team	Owner or project team
Owners project requirements, basis of design	2. Document owner's project requirements; Develop basis of design	EA Prerequisite 1, Task 2	Owner or CxA* Design team	Owner or CxA Design team
Schematic design	3. Review owner's project requirements and basis of design	EA Prerequisite 1, Task 2 EA Credit 3, Task 2	CxA**	CxA
Design development	4. Develop and implement commissioning plan	EA Prerequisite 1, Task 4	Project team or CxA*	Project team or CxA
Construction documents	5. Incorporate commissioning requirements into construction documents	EA Prerequisite 1, Task 3	Project team or CxA*	Project team or CxA
	6. Conduct commissioning design review prior to mid-construction documents	EA Credit 3, Task 2	N/A	CxA
CONSTRUCTION PHASE				
Equipment procurement Equipment installation	7. Review contractor submittals applicable to systems being commissioned	EA Credit 3, Task 3	N/A	CxA
Functional testing test and balance Performance testing acceptance	8. Verify installation and performance of commissioned systems	EA Prerequisite 1, Task 5	CxA	CxA
Operations and maintenance (O&M) manuals	9. Develop systems manual for commissioned systems	EA Credit 3, Task 4	N/A	Project team or CxA
O&M training	10. Verify that requirements for training are completed	EA Credit 3, Task 5	N/A	Project team or CxA
Substantial completion	11. Complete a summary commissioning report	EA Prerequisite 1, Task 6	CxA	CxA

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OCCUPANCY				
Systems monitoring	12. Review building operation within 10 months after substantial completion	EA Credit 3, Task 6	N/A	CxA

* *Although EA Prerequisite 1 does not require the CxA to be on the project team until just before the equipment installation phase, if brought in earlier, he or she can also help the owner develop the project requirements and assist with other important commissioning tasks.*

** *Some commissioning tasks can be performed by the owner or other project team members. However, the review of the owner's project requirements and basis of design must be performed by the CxA. For EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems, this may be performed at any time before verification of equipment installation and acceptance.*

STEP 1

Designate an individual as the commissioning authority (CxA) to lead, review, and oversee the completion of the commissioning process activities.

Ideally, the project team should designate an individual as the CxA as early as possible in the project timeline, preferably during pre-design. The qualified individual designated as the CxA serves as an objective advocate for the owner and is responsible for the following:

- Directing the commissioning team and process in the completion of the commissioning requirements.
- Coordinating, overseeing, and/or performing the commissioning testing.
- Reviewing the results of the systems performance verification.

The qualified CxA should have experience with 2 other projects of similar managerial and technical complexity (the projects do not necessarily need to be LEED projects).

The owner may want to specify additional qualifications for the CxA, depending on the scope and nature of the commissioning. CxA certification programs are administered by various industry groups.

For projects larger than 4,650 gross square metres (50,000 square feet), the individual serving as the CxA on a LEED project must be independent of the project's design and construction teams.

The CxA may be a qualified staff member of the owner, an owner's consultant to the project, or an employee of a firm providing design and/or construction management services. The CxA may not, however, have responsibility for design (e.g., be the engineer of record) or for construction. The CxA must report results, findings, and recommendations directly to the owner.

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For projects smaller than 4,650 gross square metres (50,000 square feet), the CxA may be a qualified staff member of the owner, an owner's consultant to the project, or an individual on the design or construction team (such as the engineer of record) and may have additional project responsibilities beyond leading the commissioning services.

For projects pursuing EA Credit 3, Enhanced Commissioning, the CxA may not be an employee of the design firm(s) of record but may be contracted through the architectural firm of record (but not the engineering firm of record).

TABLE 2. COMMISSIONING AUTHORITY QUALIFICATIONS

PARTY ACTING AS COMMISSIONING AUTHORITY (CxA)	FUNDAMENTAL COMMISSIONING PREREQUISITE [3, 5, 6]		ENHANCED COMMISSIONING CREDIT [4, 5, 6]
	< 4,650 (m^2) [< 50,000 (sf)]	≥ 4,650 (m^2) [≥ 50,000 (sf)]	
Employee or subcontractor of general contractor with construction responsibilities	Yes		
Employee or subcontractor, with construction responsibilities, of construction manager who holds constructor contracts	Yes		
Employee or subcontractor, with project design responsibilities, of the architect or engineer of record	Yes		
Disinterested employee or subcontractor of General contractor or construction manager[1]	Yes	Yes[7]	
Disinterested employee or subcontractor of architect or engineer[1]	Yes	Yes[7]	
Independent subcontractor to architect[2]	Yes	Yes	Yes
Independent construction manager not holding constructor contracts[2]	Yes	Yes	Yes
Independent consultant contracted to owner[2]	Yes	Yes	Yes
Owner employee or staff	Yes	Yes	Yes

[1] "Disinterested" means an employee or subcontractor who has no project design or construction responsibilities other than commissioning. The CxA may have other duties on the project related to being an advocate for the owner, such as LEED documentation and certification, and verification of pre- and post-occupancy energy performance, but cannot be involved in the design, supervision of construction or construction of any of the building systems.

[2] "Independent" means an employee or subcontractor who is disinterested and is employed by a firm that is not the design or construction firm nor a subsidiary of the design or construction firm (even if separately incorporated.)

[3] EA Prerequisite 1 requirements (see table 1 above).

[4] EA Credit 3 requirements (the CxA must review the owner's project requirements, basis of design, and design documents prior to mid-construction documents phase and perform a back-check).

[5] The same CxA overseeing the enhanced commissioning tasks must also oversee the fundamental commissioning tasks.

[6] Regardless of who employs the CxA, he or she "shall have documented commissioning authority experience in at least two building projects" and ideally meet the minimum qualifications of having "a high level of experience in energy systems design, installation and operation, commissioning planning and process management, hands-on field experience with energy systems performance, interaction, startup, balancing, testing, trouble¬shooting, operation, and maintenance procedures and energy systems automation control knowledge."

[7] Although this is allowed, a third party (independent) firm is preferred.

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STEP 2

The owner must document the project requirements. The design team must develop the basis of design. The owner and design team are responsible for updates to their respective documents.

Clear and concise documentation of the owner's project requirements and the basis of design is a valuable part of any successful project delivery and commissioning process. These documents are used throughout the commissioning process to provide a baseline and focus for validating systems' energy and environmental performance.

OWNER'S PROJECT REQUIREMENTS

The owner's project requirements must be completed by the owner, CxA, and project team prior to the approval of contractor submittals of any commissioned equipment or systems. Updates during the design and construction process are the primary responsibility of the owner.

The owner's project requirements should detail the functional requirements of a project and the expectations of the building's use and operation as they relate to the systems to be commissioned. The owner's project requirements should address the following issues, as applicable to the project:

Owner and user requirements
Describe the primary purpose, program, and use of the proposed project (e.g., office building with data center, academic building addition and new gymnasium) and any pertinent project history. Provide any overarching goals relative to program needs, future expansion, flexibility, quality of materials, and construction and operational costs.

Environmental and sustainability goals
Describe any specific environmental or sustainability goals (e.g., LEED certification).

Energy efficiency goals
Describe overall project energy efficiency goals relative to the local energy code, ASHRAE standard, MNECB, or LEED. Describe any goals or requirements for building orientation, landscaping, façade, fenestration, envelope and roof features that will affect energy use.

Indoor environmental quality requirements
For each program or area, describe the intended use, anticipated occupancy schedules, space environmental requirements (including lighting, temperature, humidity, acoustics, air quality, and ventilation), desired adjustability of system controls, and accommodations for after-hours use.

Equipment and system expectations
Describe the desired level of quality, reliability, type, automation, flexibility and maintenance requirements for each of the systems to be commissioned. When known, provide specific efficiency targets, desired technologies, or preferred manufacturers for building systems.

Building occupant and O&M personnel requirements
Describe how the facility will be operated and by whom. Describe the desired level of training and orientation required for the building occupants to understand and use the building systems.

BASIS OF DESIGN

The design team must document the basis of design for the systems to be commissioned prior to approval of contractor submittals of any commissioned equipment or systems. Updates during the design and construction process are the responsibility of the design team.

The basis of design describes the systems to be commissioned and outlines any design

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assumptions that are not otherwise included in the design documents. This document should be updated with each subsequent design submission, with increasing specificity as applicable.

The basis of design should include the following, as applicable:

Primary design assumptions

Include space use, redundancy, diversity, climatic design conditions, space zoning, occupancy, operations, and space environmental requirements.

Standards

Include applicable codes, guidelines, regulations, and other references that will be put into practice.

Narrative descriptions

Include performance criteria for the HVAC&R systems, lighting systems, hot water systems, on-site power systems, and other systems to be commissioned.

STEP 3

The CxA must review the owner's project requirements and the basis of design for clarity and completeness. The owner and design team are responsible for updates to their respective documents.

The CxA must ensure that the basis of design reflects the owner's project requirements. Both documents must be reviewed by the CxA for completeness prior to the approval of contractor submittals of any commissioned equipment or systems.

STEP 4

Develop and implement a commissioning plan.

Unique to a particular project, the commissioning plan is the reference document that identifies the strategies, aspects, and responsibilities within the commissioning process for each phase of a project, for all project team members. This document outlines the overall process, schedule, organization, responsibilities, and documentation requirements of the commissioning process.

The commissioning plan is developed at the start of the commissioning process, preferably during design development, and is updated during the course of a project to reflect any changes in planning, schedule, or other aspects.

The following list outlines required components of the commissioning plan.

- Commissioning Program Overview
    - Goals and objectives.
    - General project information.
    - Systems to be commissioned.
- Commissioning Team
    - Team members, roles, and responsibilities.
    - Communication protocol, coordination, meetings, and management.

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- Commissioning Process Activities
    - o Documenting the owner's project requirements.
    - o Preparing the basis of design.
    - o Developing systems functional test procedures.
    - o Verifying systems performance.
    - o Reporting deficiencies and the resolution process.
    - o Accepting the building systems.

Project teams pursuing the enhanced commissioning credit (EA Credit 3) may need to expand the commissioning plan to include the following commissioning process activities:

- Documenting the commissioning review process.
- Reviewing contractor submittals.
- Developing the systems manual.
- Verifying the training of operations personnel.
- Reviewing building operation after final acceptance.

TABLE 3. REQUIRED COMMISSIONING PLAN COMPONENTS

REQUIRED COMMISSIONING PLAN COMPONENTS
Brief overview of commissioning process.
List of all systems and assemblies included in commissioning authority's scope of work.
Identification of commissioning team and its responsibilities.
Description of management, communication, and reporting of commissioning process.
Overview of commissioning process activities for pre-design, design, construction, and occupancy and operations phases, including development of owner's project requirements, review of basis of design, schematic design, construction documents and submittals, construction phase verification, functional performance test development and implementation, and 10-month warranty review.
List of expected work products.
List of commissioning process milestones.

STEP 5

Develop and incorporate commissioning requirements into the construction documents.

Typically, the project specifications are used to inform contractors of their responsibilities in the commissioning process. These specifications may describe the components listed in Table 4.

Often, all commissioning requirements are outlined in a section of the general conditions of the construction specifications. Placing all commissioning requirements in a single location gives responsibility for commissioning work to the general contractor, who can then assign responsibility to subcontractors. It is also valuable to refer to commissioning requirements on the drawings, in any bid forms, and in specification sections related to the systems to be commissioned.

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TABLE 4. COMMISSIONING REQUIREMENTS FOR CONSTRUCTION DOCUMENTS

COMMISSIONING REQUIREMENTS FOR CONSTRUCTION DOCUMENTS
Commissioning team involvement.
Contractors' responsibilities.
Submittal review procedures for commissioned systems.
Operations and maintenance documentation, system manuals.
Meetings.
Construction verification procedures.
Startup plan development and implementation.
Functional performance testing.
Acceptance and closeout.
Training.
Warranty review site visit.

STEP 6

The CxA should conduct at least 1 commissioning design review of the owner's project requirements, basis of design, and design documents prior to mid-construction documents phase and back-check the review comments in the subsequent design submission.

This step is required by EA Credit 3, Enhanced Commissioning, but is not mandatory for achievement of EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems.

The CxA should review the owner's project requirements, basis of design, and design documents to give the owner and design team an independent assessment of the state of the design for the commissioned systems. Typically, a design review performed by the CxA focuses on the following issues:

- Ensuring clarity, completeness, and adequacy of the owner's project requirements.
- Verifying that all issues discussed in the owner's project requirements are addressed adequately in the basis of design.
- Reviewing design documents for achieving the owner's project requirements and basis of design and coordination of commissioned systems.

Additional reviews by the CxA throughout the design and construction process may be advisable and appropriate depending on the project duration, phasing, and complexity.

STEP 7

The CxA should review contractor submittals applicable to the systems being commissioned for compliance with the owner's project requirements and basis of design. This review must be concurrent with the architect's or engineer's reviews and submitted to the design team and the owner.

This step is required by EA Credit 3, Enhanced Commissioning, but is not mandatory for achievement of EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems.

The CxA should review the contractor submittals and identify any issues that might otherwise result in rework or change orders. The CxA should specifically evaluate the submittals for the following:

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- Conformance with the owner's project requirements and basis of design.
- Fulfilling operation and maintenance requirements.
- Facilitating performance testing.

The CxA review of contractor submittals does not typically replace or alter the scope or responsibility of the design team's role in approving submittals.

STEP 8

Verify the installation and performance of the systems to be commissioned.

Commissioning is conducted to verify the performance of commissioned systems as installed to meet the owner's project requirements, basis of design, and contract documents.

Verification of the installation and performance of commissioned systems typically includes 3 steps for each commissioned system: installation inspection, performance testing, and comparison of the results with the owner's project requirements and the basis of design.

- Installation inspections (sometimes called pre-functional inspections) are a systematic set of procedures intended to identify whether individual system components have been installed properly. Often this process occurs at startup of individual units of equipment and involves using "pre-functional checklists" or "startup and checkout forms" to ensure consistency in the inspections and document the process. Installation inspections may be performed by the CxA, the installing contractor, or others, depending on the procedures outlined in the commissioning plan. Installation inspections provide quality control to ensure that relatively minor issues (e.g., an improperly wired sensor, a control valve installed backward) are discovered and corrected prior to systems performance testing.
- Systems performance testing (sometimes called functional performance testing) occurs once all system components are installed, energized, programmed, balanced, and otherwise ready for operation under part- and full-load conditions. Testing should include each process in the sequence of operations under central and packaged equipment control, including startup, shutdown, capacity modulation, emergency and failure modes, alarms, and interlocks to other equipment.

  Systems performance testing typically relies on testing procedures developed by the CxA specifically for the system to be tested. A wide variety of methods may be used to simulate and evaluate that the system being tested performs as expected (per the owner's project requirements, basis of design, and contract documents) in all modes of operation.

  Systems performance testing may be performed by some combination of the CxA, the installing contractor, and others, depending on the procedures outlined in the commissioning specifications and the commissioning plan. It may reveal problems with the performance of the commissioned systems and may require significant follow-up and coordination among members of the project team.
- Evaluation of results is the final step. At each point in the process of installation inspections and systems performance testing, the CxA should evaluate whether the installed systems meet the criteria for the project as set forth by in the owner's project requirements and the basis of design documents.

Any discrepancies or deficiencies should be reported to the owner, and the team should work collaboratively to find an appropriate resolution.

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STEP 9

Develop a systems manual that gives future operating staff the information needed to understand and optimally operate the commissioned systems.

This step is required by EA Credit 3, Enhanced Commissioning, but is not mandatory for achievement of EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems.

Provide a systems manual in addition to the O&M manuals submitted by the contractor. The systems manual generally focuses on operating rather than maintaining the equipment, particularly the interactions.

The systems manual should include the following for each commissioned system:

- Final version of the basis of design.
- System single-line diagrams.
- As-built sequences of operations, control drawings, and original setpoints.
- Operating instructions for integrated building systems.
- Recommended schedule of maintenance requirements and frequency, if not already included in the project O&M manuals.
- Recommended schedule for retesting of commissioned systems with blank test forms from the original commissioning plan.
- Recommended schedule for calibrating sensors and actuators.

STEP 10

Verify that the requirements for training operating personnel and building occupants have been completed.

This step is required by EA Credit 3, Enhanced Commissioning, but is not mandatory for achievement of EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems.

Establish and document training expectations and needs with the owner. Many common training topics are identified in Table 5. Ensure that operations staff and occupants receive this training and orientation. Pay particular attention to new or uncommon sustainable design features that could be overridden or removed because of a lack of understanding. Document that the training was completed according to the contract documents.

Have a contract in place to review operation with O&M staff and occupants, including a plan for resolution of outstanding commissioning-related issues 10 months after substantial completion.

EA	
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TABLE 5. COMMON TRAINING TOPICS

COMMON TRAINING TOPICS
General purpose of system (design intent).
Use of O&M manuals.
Review of control drawings and schematics.
Startup, normal operation, shutdown, unoccupied operation, seasonal changeover, manual operation, control setup and programming troubleshooting, and alarms.
Interactions with other systems.
Adjustments and optimizing methods for energy conservation.
Health and safety issues.
Special maintenance and replacement sources.
Occupant interaction issues.
System response to different operating conditions.

STEP 11

Complete a summary commissioning report.

After installation inspections and performance verification items have been completed, the results are tabulated and assembled into a commissioning report. Supporting information can be compiled as a Cx record but is not required in the summary.

The summary commissioning report should include the following:

- Executive summary of the process and the results of the commissioning program, including observations, conclusions, and any outstanding items.
- History of any system deficiencies identified and how they were resolved, including any outstanding issues or seasonal testing scheduled for a later date.
- Systems performance test results and evaluation.
- Confirmation from the CxA indicating whether individual systems meet the owner's project requirements, basis of design, and contract documents.

In addition, for projects pursuing EA Credit 3, Enhanced Commissioning, the summary commissioning report should include the following:

- Summary of the design review process.
- Summary of the submittal review process.
- Summary of the O&M documentation and training process.

EA	
NC	Prerequisite 1
CS	Prerequisite 1

TABLE 6. COMMISSIONING REPORT COMPONENTS

COMMISSIONING REPORT COMPONENTS
Owner's project requirements.
Summary of design and submittal review process (EA Credit 3)
Project commissioning specifications.
Verification of installation (construction checklist).
Functional performance testing results and forms.
O&M documentation evaluation (EA Credit 3).
Training program evaluation (EA Credit 3).
Description of commissioning process benefits.
Outstanding issues.
Contract and plan for resolution within 10 months of substantial completion (EA Credit 3).

STEP 12

Ensure the involvement by the CxA in reviewing building operation 10 months after substantial completion with O&M staff and occupants. Include a plan for resolving outstanding issues.

This step is required by EA Credit 3, Enhanced Commissioning, but is not mandatory for achievement of EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems.

The CxA should coordinate with the owner and the O&M staff to review the facility and its performance within 10 months of substantial completion. All unresolved construction deficiencies as well as any deficiencies identified in this post-occupancy review should be documented and corrected under manufacturer or contractor warranties.

The CxA review of the building operation with operations staff and occupants should identify any problems in operating the building as originally intended. Any significant issues identified by the CxA that will not be corrected should be recorded in the systems manual.

DISTRICT ENERGY SYSTEMS

For projects with district energy systems, specific technical guidance can be found in the *LEED Canada Interpretation Guide for District Energy Systems* on CaGBC's website (http://www.cagbc.org). Follow the guidance in effect at the time of LEED project registration.

EA	
NC	Prerequisite 1
CS	Prerequisite 1

CS

Not all energy-related systems are installed as part of a Core & Shell project. Energy-related systems include heating, ventilating, air-conditioning, and refrigeration (HVAC&R) systems, associated controls, lighting, daylighting controls, domestic hot water systems, and renewable energy systems (wind, solar, etc.). Commissioning is required for any of these systems that are part of the Core & Shell project. Some commissioning activities will be limited because of the installed systems or components. Systems performance testing procedures are generally designed for complete system installations, and core and shell systems may not be complete. For example, in a core and shell office, the air-handling unit of the variable air volume (VAV) system may be installed, but the VAV boxes and ductwork may not yet be in place in the tenant spaces. Testing procedures may have to be changed or eliminated for systems that are incomplete. Document all the systems that will be installed as part of the Core & Shell project and commission these systems.

6. CALCULATIONS

There are no calculations required for this prerequisite.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED letter templates for the complete descriptions of all required documentation.

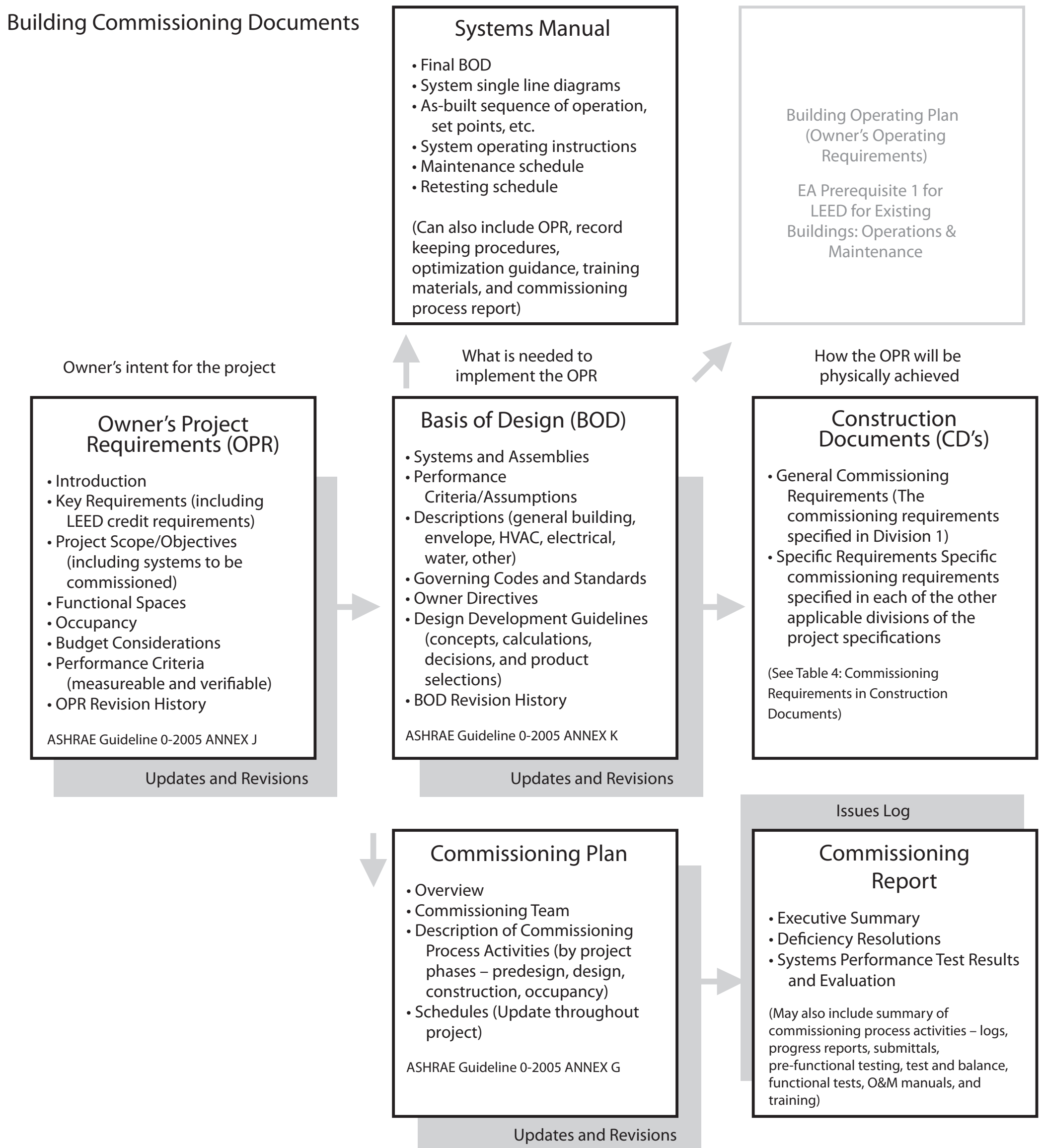
- Update the commissioning plan at milestones throughout the project. This should happen, at a minimum, during the design development phase, the construction documents phase, and just prior to the kick-off meeting with the general contractor.
- Prepare a systems list that indicates which systems have been included within the scope of commissioning.
- Obtain confirmation that the commissioning authority has documented experience on at least 2 building projects and meets the qualifications requirements of Table 2.
- Retain copies of the owner's project requirements, basis of design, commissioning specifications, commissioning report, and systems manual.

EA	
NC	Prerequisite 1
CS	Prerequisite 1

8. EXAMPLES

EXAMPLE 1

The example below demonstrates the interconnectedness of the owner's project requirements, basis of design, construction documents, commissioning plan, commissioning report, and systems manual.



EA	
NC	Prerequisite 1
CS	Prerequisite 1

EXAMPLE 2. Summary Report Outline

The outline below is a guide for what can be included in the summary commissioning report. There is no required order of presentation, only that these primary report components (applicable to the commissioning scope) are included in the report.

The final report that goes to the owner should include copies of issue and testing logs, meeting minutes, and interim process reports.

SUMMARY COMMISSIONING REPORT

Executive Summary

Provide a brief description of project (size, space types, occupancy, etc.), highlighting commissioning goals.

Provide a brief narrative on the scope of commissioning, highlighting the systems to be commissioned, process activities, and examples of significant issues:

1. Pre-design activities (if any)
2. Design activities (if any)
3. Construction activities
4. Post-occupancy activities (if any)

Highlight any significant systemic issues that were uncovered during the commissioning process.

Provide recommendations for future project commissioning activities.

Deficiency Resolution

Provide a more detailed summary of the types of issues uncovered and how they were resolved. These issues are best presented in order of project phases (e.g., during design, during construction). A copy of the issues log is typically included as an appendix.

Systems Performance Test Results and Evaluation

Summarize observations on test results and evaluations for pre-functional tests, test and balance, functional tests, and post-occupancy testing (if applicable).

9. EXEMPLARY PERFORMANCE

This prerequisite is not eligible for exemplary performance under the Innovation in Design section.

EA	
NC	Prerequisite 1
CS	Prerequisite 1

10. REGIONAL VARIATIONS

The significance of commissioning tasks may vary with the climate. For example, in most regions in Canada, the functioning of heating systems, such as boilers, is a critical issue. Suboptimal performance for heating systems in cold climates can result in high utility bills, wasted energy, and added emissions. In regions with humid summers, the introduction of hot, humid outside air must be controlled, and suboptimal performance for cooling systems could raise utility bills. In other regions, equipment such as economizers and evaporative cooling will be used for extended periods and must function correctly.

Regional climates tend to drive the selection of systems and the associated commissioning and maintenance decisions. For example, including the commissioning of the building envelope may be more important in certain regions than in others. Adding the commissioning of water systems may be important in arid regions.

Regardless of the types of equipment selected, each project can greatly benefit from a systematic approach to ensuring that the right equipment and systems are specified, ordered, installed, and tested to ensure proper operation and performance.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

So that building systems operate effectively for the life of the building, use the commissioning process and outcomes to develop documents that will help facility managers run the building consistent with the design intent and equipment specifications. These documents should include the following:

- Building operating plan (owner's operating requirements). This plan defines the delivered conditions required by building management and occupants for the successful operation of a building. It identifies the spaces, uses, occupancy types, and required conditions. It includes the time-of-day schedules of every system, the mode of operation for each system when it is running, and the desired indoor conditions or setpoints for each schedule or mode. This information is initially developed in the basis of design.
- Systems narrative. The systems narrative is a summary description of each of the following types of base building systems installed in the project building: space heating, space cooling, ventilation, domestic water heating, humidification and/or dehumidification, and lighting. The description should include summaries of the central plant, distribution, and terminal units, as applicable, as well as the controls associated with these systems.
- Sequence of operations. The sequence of operations represents system-level documentation that defines what operational states are desired under what conditions. This can include which systems are running or idle; whether operations are full-load or part-load; staging or cycling of compressors, fans, or pumps; proper valve positions; desired system water temperatures and duct static air pressures, depending on other variables (e.g., outside air temperatures, room air temperatures, and/or relative humidity); and any reset schedules or occupancy schedules. The sequence of operations should include specific information on operating phases (warmup, occupied, unoccupied), setpoints and controls, and feedback systems to monitor performance.
- Preventive maintenance plan. This plan should reflect manufacturers' recommendations for the ongoing operation of the base building systems.
- Commissioning report. Ensure that the commissioning report adequately identifies problems that are likely to re-emerge or merit particular attention on an ongoing basis.

EA	
NC	Prerequisite 1
CS	Prerequisite 1

12. RESOURCES

WEBSITES

American Society of Heating, Refrigerating and Air-Conditioning Engineers
http://www.ashrae.org

ASHRAE advances the science of heating, ventilation, air conditioning, and refrigeration for the public's benefit through research, standards writing, continuing education, and publications. According to the ASHRAE website, "membership is open to any person associated with the field including indoor air quality, building design and operation, and environmental control for food processing and industry."

Building Commissioning Association
http://www.bcxa.org/resources/index.htm

BCxA promotes building commissioning practices that maintain high professional standards and fulfill building owners' expectations. The association offers a 5-day intensive course focused on how to implement the commissioning process and that is intended for commissioning authorities with at least 2 years of experience.

California Commissioning Collaborative
http://www.cacx.org

The California Commissioning Collaborative is a group of government, utility, and building services professionals committed to developing and promoting viable building commissioning practices in California. Its online library, available at http://resources.cacx.org/library/, has more than 300 resources, including articles, papers, guides, and sample commissioning documents.

Energy Design Resources, Cx Assistant Commissioning Tool
http://www.ctg-net.com/edr2002/cx/

This web-based tool provides project-specific building commissioning information to design teams and enables users to evaluate probable commissioning cost, identify appropriate commissioning scope, and access project-related sample commissioning specifications.

Natural Resources Canada, Recommissioning Guide for Building Owners and Managers
http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/buildings_communities/buildings/recommissioning/publications/2008167.html

This Recommissioning Guide distributed by Natural Resources Canada is an adaptation of the document entitled A Retrocommissioning Guide for Building Owners (the "US-EPA Guide") originally developed by Portland Energy Conservation, Inc. (PECI)

Oregon Office of Energy, Commissioning for Better Buildings in Oregon
http://egov.oregon.gov/ENERGY/CONS/BUS/comm/bldgcx.shtml

This website and document of the same name contain a comprehensive introduction to the commissioning process, including research, financial benefits, and case studies.

Portland Energy Conservation Inc.
http://www.peci.org

PECI develops the field for commissioning services by helping building owners understand the value of commissioning and by producing process and technical information for commissioning providers. Their focus includes owners of private and public buildings and a range of building types. PECI manages the annual National Conference on Building Commissioning.

EA	
NC	Prerequisite 1
CS	Prerequisite 1

PRINT MEDIA

ASHRAE Guideline 0–2005: The Commissioning Process, (American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2005). http://www.ashrae.org

ASHRAE Guideline 1–1996: The HVAC Commissioning Process, (American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1996). http://www.ashrae.org

ASHRAE Guideline 4–1993: Preparation of Operations & Maintenance Documentation for Building Systems (American Society of Heating, Refrigerating and Air-Conditioning Engineers: 1993). http://www.ashrae.org

The Building Commissioning Handbook, second edition, By John A. Heinz and Rick Casault (The Building Commissioning Association, 2004). http://www.bCxA.org

Portland Energy Conservation Model Commissioning Plan and Guide Specifications (PECI, 1998). http://www.peci.org

Building Commissioning Guide, Office of Energy Efficiency and Renewable Energy Federal Energy Management Program (U.S. Department of Energy). http://www.eere.energy.gov

Commissioning for Better Buildings in Oregon (Oregon Office of Energy). http://egov.oregon.gov/ENERGY/CONS/BUS/comm/bldgcx.shtml

13. DEFINITIONS

Basis of design includes design information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations, and guidelines.

Commissioning (Cx) is the process of verifying and documenting that a building and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements.

The **commissioning authority (CxA)** is the individual designated to organize, lead, and review the completion of commissioning process activities. The CxA facilitates communication among the owner, designer, and contractor to ensure that complex systems are installed and function in accordance with the owner's project requirements.

The **commissioning plan** is a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

The **commissioning process** is a systematic quality-focused effort to ensure that building systems are designed, specified, procured, installed, and functioning in accordance with the owner's intent. The process uses planning, documentation, and verification of testing to review and oversee the activities of both designer and constructor.

The **commissioning report** documents the commissioning process, including a commissioning program overview, identification of the commissioning team, and description of the commissioning process activities.

Commissioning specification is the contract language used in the construction documents to detail the objective, scope, and implementation of the construction and acceptance phases of the commissioning process as developed in the design phase of the commissioning plan. This allows the construction contractor to ensure that these activities are considered in proposals for the construction work.

EA	
NC	Prerequisite 1
CS	Prerequisite 1

The **commissioning team** includes those people responsible for working together to carry out the commissioning process.

A **district energy system (DES)** is a central plant and distribution system that provides energy (heat, cooling and/or electricity) to a group of buildings in a small district. Examples include central plants on university campuses or those that serve the downtown cores of cities. Large-scale utilities that supply energy to large regions, provinces or municipalities, are not considered DESs. Refer to the *LEED Canada Interpretation Guide for District Energy Systems* for further information.

Downstream equipment consists of all heating or cooling systems, equipment, and controls located within the project building and site associated with transporting thermal energy into heated or cooled spaces. This includes the thermal connection or interface with the district energy system, secondary distribution systems in the building, and terminal units.

Enhanced commissioning is a set of best practices that go beyond fundamental commissioning to ensure that building systems perform as intended by the owner. These practices include designating a commissioning authority prior to the construction documents phase, conducting commissioning design reviews, reviewing contractor submittals, developing a systems manual, verifying operator training, and performing a post-occupancy operations review.

Fundamental commissioning is a set of essential best practices used to ensure that building performance requirements have been identified early in the project's development and to verify that the designed systems have been installed in compliance with those requirements. These practices include designating a commissioning authority, documenting the owner's project requirements and basis of design, incorporating commissioning requirements into the construction documents, establishing a commissioning plan, verifying installation and performance of specified building systems, and completing a summary commissioning report.

An **installation inspection** examines components of the building systems to determine whether they are installed properly and ready for systems performance testing.

Owner's project requirements is a written document that details the ideas, concepts, and criteria that are determined by the owner to be important to the success of the project.

Systems performance testing is the process of determining the ability of commissioned systems to perform in accordance with the owner's project requirements, the basis of design, and construction documents.

Upstream equipment consists of all heating or cooling systems, equipment, and controls that are associated with a district energy system but are not part of the project building's thermal connection or do not interface with the district energy system. It includes the central energy plant and all transmission and distribution equipment associated with transporting the thermal energy to the project building and site.

Verification is the range of checks and tests carried out to determine whether components, subsystems, systems, and interfaces between systems operate in accordance with the contract documents.

EA	
NC	Prerequisite 2
CS	Prerequisite 2

MINIMUM ENERGY PERFORMANCE

	NC	CS
Prerequisite	EA Prerequisite 2	EA Prerequisite 2
Points	Required	Required

INTENT

To establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental and economic impacts associated with excessive energy use.

REQUIREMENTS: NC & CS

Select 1 of the 3 compliance path options described below. Whichever compliance path is chosen for this prerequisite must also be utilized for EA Credit 1: Optimize Energy Performance, if that credit is sought.

OPTION 1. WHOLE BUILDING ENERGY SIMULATION:

EITHER

PATH 1. Model National Energy Code For Buildings (MNECB)

Demonstrate a 23% cost improvement in the proposed building performance rating for new buildings or a 19% cost improvement in the proposed building performance rating for major renovations to existing buildings, compared with the reference building performance rating.

Calculate the reference building performance rating according to the Model National Energy Code for Buildings 1997 (MNECB) using a computer simulation model for the whole building project.

To achieve this prerequisite, the proposed design must meet the following criteria:

- Comply with the mandatory provisions of the MNECB 1997.
- Inclusion of all the energy costs within and associated with the building project.
- Compare against a baseline building that complies with the reference building requirements as defined in the MNECB 1997.

OR

EA	
NC	Prerequisite 2
CS	Prerequisite 2

PATH 2. ASHRAE 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings

Demonstrate a 10% cost improvement in the proposed building performance rating for new buildings, or a 5% cost improvement in the proposed building performance rating for major renovations to existing buildings, compared with the baseline building performance rating.

Calculate the baseline building performance rating according to the building performance rating method in Appendix G of ANSI/ASHRAE/IESNA Standard 90.1-2007 (with errata but without addenda[a]) using a computer simulation model for the whole building project.

Appendix G of Standard 90.1-2007 requires that the energy analysis done for the building performance rating method include all energy costs associated with the building project. To achieve this prerequisite, the proposed design must meet the following criteria:

- Comply with the mandatory provisions (Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) in Standard 90.1-2007 (with errata but without addenda);
- Inclusion of all the energy costs within and associated with the building project.
- Compare against a baseline building that complies with Appendix G of Standard 90.1-2007 (with errata but without addenda).

Regardless of the path chosen (MNECB 1997 or ASHRAE 90.1-2007), the following requirements apply.

- The whole building project simulation must follow the procedures defined in the referenced standard and the *LEED Canada Energy Modelling Rules*.
- For the purposes of this analysis, process energy is considered to include, but is not limited to, office and general miscellaneous equipment, computers, elevators and escalators, kitchen cooking and refrigeration, laundry washing and drying, lighting exempt from the lighting power allowance (e.g., lighting integral to medical equipment) and other (e.g., waterfall pumps).
- Regulated (non-process) energy includes lighting (e.g., for the interior, parking garage, surface parking, façade, or building grounds, etc. except as noted above), heating, ventilation and air conditioning (HVAC) (e.g., for space heating, space cooling, fans, pumps, toilet exhaust, parking garage ventilation, kitchen hood exhaust, humidification, etc.), and service water heating for domestic or space heating purposes.

[a] Project teams wishing to use ASHRAE approved addenda for the purposes of this prerequisite may do so at their discretion. Addenda must be applied consistently across all LEED credits.

EA	
NC	Prerequisite 2
CS	Prerequisite 2

- Process loads must be identical for both the baseline building performance rating and for the proposed building performance rating. However, project teams may follow the exceptional calculation method (ANSI/ASHRAE/IESNA 90.1-2007, G2.5) or the *LEED Canada Energy Modelling Rules* to document measures that reduce process loads. Documentation of process load energy savings must include a list of the assumptions made for both the base and proposed design, and theoretical or empirical information supporting these assumptions.
- For the purposes of demonstrating compliance to EA Prerequisite 2, no credit or penalty is given for the performance of a District Energy System (DES).

OR

OPTION 2. PRESCRIPTIVE COMPLIANCE PATH: ASHRAE Advanced Energy Design Guide

Comply with the prescriptive measures of the ASHRAE Advanced Energy Design Guide appropriate to the project scope, outlined below. Project teams must comply with all applicable criteria as established in the Advanced Energy Design Guide for the climate zone in which the building is located.

PATH 1. ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004

The building must meet the following requirements:

- Less than 1,860 square metres (20,000 square feet).
- Office occupancy.

PATH 2. ASHRAE Advanced Energy Design Guide for Small Retail Buildings 2006

The building must meet the following requirements:

- Less than 1,860 square metres (20,000 square feet).
- Retail occupancy.

PATH 3. ASHRAE Advanced Energy Design Guide for Small Warehouses and Self-Storage Buildings 2008

The building must meet the following requirements:

- Less than 4,645 square metres (50,000 square feet).
- Warehouse of self-storage occupancy.

PATH 4. ASHRAE Advanced Energy Design Guide for K-12 School Buildings

The building must meet the following requirements:

- Less than 18,600 square metres (200,000 square feet).
- K-12 school occupancy.

EA	
NC	Prerequisite 2
CS	Prerequisite 2

OR

OPTION 3. PRESCRIPTIVE COMPLIANCE PATH: Advanced Buildings™ Core Performance™ Guide

Comply with the prescriptive measures identified in the Advanced Buildings™ Core Performance™ Guide developed by the New Buildings Institute. The building must meet the following requirements:

- Less than 9,290 square metres (100,000 square feet).
- Comply with Section 1: Design Process Strategies, and Section 2: Core Performance Requirements.
- Office, school, public assembly, and retail projects less than 9,290 square metres (100,000 square feet) must comply with Section 1 and Section 2 of the Core Performance Guide.
- Other project types less than 9,290 square metres (100,000 square feet) implement the basic requirements of the Core Performance Guide.
- Health care, warehouse, laboratory projects or other building types that differ significantly from office or retail projects are ineligible for this path (for NC & CS projects).

ALL OPTIONS must meet all the requirements below:

Have an energy meter(s) that measures all energy use, for both building and site energy uses.

Calibrate meter(s) following the manufacturer's recommendations if the building owner, management organization or tenant owns the meter. Meters owned by third parties (e.g., utilities or governments) are exempt.

INTERPRETATIONS

The percentage energy savings are calculated based on the total building energy cost including all plug/receptacle loads and all process/non-regulated loads. Energy simulations must include these loads and the loads must be representative of those expected in the building. In most cases, the default values in the MNECB and ASHRAE 90.1 are a reasonable estimate for plug loads; however, the applicant may vary these loads provided documentation can be provided to support the changes. The model must include all significant process loads, including cooking, elevators, low-temperature refrigeration, ice rinks, laundry, sterilization, pools, saunas, process exhaust and appliances.

Plug and process loads in the proposed building may be different from those in the baseline/reference building when the design includes energy savings measures that are not standard practice (e.g., heat recovery in ice rinks, Energy Star appliances).

It may be possible to waive the MNECB suite metering requirement for social housing

EA	
NC	Prerequisite 2
CS	Prerequisite 2

projects, but it must be reviewed on a case-by-case basis through individual Credit Interpretation Requests. Condos or co-ops are excluded from any exemption and must be submetered.

Only entrances that meet the ASHRAE 90.1-2007 definition of building entrance are required to have a vestibule. Other exclusions as per MNECB and ASHRAE still apply.

In most cases, the proposed and reference buildings will have the same breathing zone ventilation rate. However, excessive ventilation rates are not consistent with an energy efficient building. As such, the reference building ventilation rate shall not be greater than 20% above the ASHRAE 62-2007 or superseding standards ventilation rate (see the *LEED Canada Energy Modelling Rules* for guidance on how to handle ventilation rates).

The proposed building may have a total building ventilation rate less than the reference building due to demand control ventilation or more effective ventilation air delivery (see the *LEED Canada Energy Modelling Rules*).

The energy use of the task lighting (IEQ Credit 6.1) must be included in the energy model and lighting allowances in EA Prerequisite 2 and EA Credit 1.

For indirect lighting systems designed to be used with task lighting, either include an allowance for task lighting (20 watts per person) or use the additional lighting installed or shown on project fit-up drawings.

For projects in New Brunswick, the Core Performance Guide for New Brunswick is an acceptable alternative to the Advanced Buildings™ Core Performance™ Guide developed by the New Buildings Institute for Option 3.

For Option 1 Whole Building Energy Simulation, the simulation model must comply with the following documents, hereafter collectively referred to as the *LEED Canada Energy Modelling Rules*. These Rules also apply to EA Credit 1, Option 1 – Whole Building Energy Simulation:

Path 1 – MNECB Compliance Path

- Model National Energy Code for Buildings (MNECB), 1997
- Performance Compliance for Buildings, Specifications for Calculation Procedures for Demonstrating Compliance to the Model National Energy Code for Buildings Using Whole Building Performance, May 1999
- ecoEnergy EE4 Software Modelling Guide
- *LEED Canada 2009 Supplementary Energy Modelling Guidelines*
- *LEED Canada 2009 Interpretation Guide for District Energy Systems*

Path 2 – ASHRAE 90.1 – 2007 Compliance Path

- ANSI/ASHRAE/IESNA Standard 90.1-2007, Appendix G
  Note: MNECB procedures apply in the absence of specific guidance by Appendix G
- *LEED Canada 2009 Supplementary Energy Modelling Guidelines*
- *LEED Canada 2009 Interpretation Guide for District Energy Systems*

EA	
NC	Prerequisite 2
CS	Prerequisite 2

When multiple buildings are treated as one project, EA Prerequisite 2 and EA Credit 1 requirements need only be met at the project level, not at the individual building level.

LEASED TENANT SPACE (NC & CS)

This prerequisite and related credit EA Credit 1 provides direction for Core and Shell projects, as well as New Construction projects with leased tenant space not fit-up for certification.

Leased tenant space lighting and associated controls must either be installed, supplied, shown on fit-up drawings or have a mandatory lease agreement defining maximum lighting power density to get credit for lighting energy savings. If no lighting is supplied or specified in the mandatory lease agreement, then the proposed tenant lighting is equal to the reference or baseline tenant lighting as per Model National Energy Code for Buildings (MNECB) or ASHRAE 90.1:2007. For leased spaces that are not fully fit-up and only minimal lighting is provided (under the Illuminating Engineering Society of North America (IESNA) recommended lighting levels), the proposed lighting power density must be increased to provide light levels meeting the IESNA recommendations. This will be calculated by increasing the current lighting power by the ratio of the IESNA lighting level to the installed lighting level. For indirect lighting systems designed to be used with task lighting, either include an allowance for task lighting (20 watts per person) or use the additional lighting installed or shown on fit-up drawings.

Energy saving measures in the leased tenant spaces must either be installed, supplied, shown on fit-up drawings or have a mandatory lease agreement to get credit for energy savings. Equipment not meeting this criteria shall be modelled with efficiencies equal to the minimum prescriptive requirements of MNECB or ASHRAE 90.1-2007 (depending on the compliance path chosen).

EA	
NC	Prerequisite 2
CS	Prerequisite 2

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Energy efficiency reduces the environmental burdens associated with producing and using energy. Fossil fuels, such as coal and oil, are the most common source of energy used in buildings. However, these fuels are also finite resources. The process of extracting and consuming energy from fossil fuels causes many environmental impacts, including air and water pollution, land degradation, solid waste generation, and greenhouse gas emissions. Mounting evidence connects fossil-fuel based energy use with climate change as well as serious risks to environmental and human health and safety. In 2006, the Canadian industrial and commercial sectors accounted for nearly half of the nation's energy use related greenhouse gas emissions (approximately 46%).[5] Furthermore, greenhouse gases and other emissions increase every year as overall energy consumption increases. Between 1990 and 2006, annual greenhouse gas emissions from Canadian energy use increased by 18.5%.[6] As the far-reaching implications of global climate change are becoming more apparent and serious, reducing emissions through energy efficiency becomes more important.

In addition to fossil fuels, other sources of energy also carry environmental costs. Hydropower activities, for example, can alter aquatic ecosystems and harm endangered species. Nuclear power plants pose an environmental threat when they are decommissioned without appropriate storage sites for spent fuel. Given both the environmental impacts inherent in most energy-production processes and our limited energy supplies, efficiency measures are an important strategy for managing the impacts of energy consumption.

ECONOMIC ISSUES

Optimizing energy performance can reduce overall operating costs. Changing operational strategies to avoid energy use—for example, turning off lights and HVAC systems when the building is unoccupied—can often be done at zero or very low initial cost and rapid payback. Even seemingly small conservation measures can be significant; for instance, replacing a single incandescent lamp with a fluorescent lamp, which uses up to 75% less energy, can save more than $30 in energy costs over the lifetime of the lamp.[7]

2. RELATED CREDITS

The *LEED Canada for New Construction* and *Core & Shell* rating systems address building energy efficiency in 2 places: EA Prerequisite 2, Minimum Energy Performance, and EA Credit 1, Optimize Energy Performance. Energy consumption for the building can be reduced by ensuring that the project exceeds the building code requirements for envelope, lighting, and HVAC systems. Further, energy use can be directly affected through the use of climatically appropriate roofing materials and careful optimization of exterior lighting. Refer to these credits:

- EA Credit 1: Optimize Energy Performance
- SS Credit 7.2: Heat Island Effect—Roof
- SS Credit 8: Light Pollution Reduction
- RP Credit 1: Durable Building

In addition to reducing energy use through efficiency measures, project teams can mitigate energy use impacts by using renewable energy. Refer to these credits:

- EA Credit 2: On-site Renewable Energy
- EA Credit 6: Green Power

EA	
NC	Prerequisite 2
CS	Prerequisite 2

Building energy performance and indoor environmental quality issues, such as ventilation, occupant controllability, and the amount of daylight, must be carefully coordinated. Energy-efficient buildings should not compromise the health and well-being of occupants. Increased ventilation in buildings may require additional energy use, which may in turn cause air and water pollution. However, the additional need for energy can be mitigated by using heat-recovery ventilation and/or economizer strategies. Review the strategies in these credits:

- IEQ Prerequisite 1: Minimum Indoor Air Quality Performance
- IEQ Credit 1: Outdoor Air Delivery Monitoring
- IEQ Credit 2: Increased Ventilation
- IEQ Credit 6: Controllability of Systems
- IEQ Credit 7: Thermal Comfort
- IEQ Credit 8: Daylight and Views

Because water use, especially domestic hot water, requires significant energy use, water use reductions can lead to energy savings. Consider meeting the requirements for these credits:

- WE Credit 3: Water Use Reduction

3. SUMMARY OF REFERENCED STANDARDS

Model National Energy Code for Buildings (MNECB)

Canadian Commission on Building and Fire Codes, National Research Council of Canada.

The Model National Energy Code for Buildings (MNECB) is a model energy efficiency code published in September 1997 by the National Research Council Canada (NRCC).

The Model National Energy Code for Buildings (MNECB) was developed by the National Research Council of Canada, the organization that is responsible for the National Building Code of Canada, as a model code for adaptation or adoption by Canadian provinces and municipalities. The MNECB was developed with input from many committees and all provinces and was published in 1997, but there has been little adoption by authorities.

The code sets minimum energy efficiency standards for commercial building construction in Canada. The MNECB contains mandatory requirements for architectural, mechanical, and electrical design items. To evaluate energy efficiency, the proposed design is compared to a similar building that just meets the requirements of the MNECB. The energy savings can be achieved through improvements to the interior lighting systems, building envelope, HVAC systems, central plant equipment (e.g. boilers, chillers), and domestic hot water systems.

ANSI/ASHRAE/IESNA Standard 90.1–2007: Energy Standard for Buildings Except Low-Rise Residential, and Informative Appendix G, Performance Rating Method

American National Standards Institute
American Society of Heating, Refrigerating and Air-Conditioning Engineers Illuminating Engineering Society of North America
http://www.ashrae.org
ANSI/ASHRAE/IESNA Standard 90.1–2007 was formulated by ASHRAE under an ANSI consensus process. IESNA is a joint sponsor of the standard.

ANSI/ASHRAE/IESNA Standard 90.1–2007 establishes minimum requirements for the energy-efficient design of buildings, with these exceptions: single-family houses; multifamily structures of 3 habitable stories or fewer above grade; manufactured houses (mobile and modular homes); buildings that do not use either electricity or fossil fuel; and equipment and portions of buildings

EA	
NC	Prerequisite 2
CS	Prerequisite 2

systems that use energy primarily for industrial, manufacturing, or commercial processes. Building envelope requirements are provided for semi-heated spaces, such as warehouses. Please refer to ASHRAE 90.1–2007, Section 2 for further details.

The standard provides criteria in the general categories shown in Table 1. Within each section are mandatory provisions and additional prescriptive requirements. Some sections also contain a performance alternative.

The energy cost budget method (Section 11) allows the project team to exceed some of the prescriptive requirements, provided energy cost savings are made in other areas. However, in all cases, the mandatory provisions must still be met.

TABLE 1. ENERGY STANDARD REQUIREMENTS ADDRESSED BY ASHRAE 90.1-2007

ASHRAE 90.1-2007 COMPONENTS
Section 5. Building envelope (including semi-heated spaces, such as warehouses)
Section 6. Heating, ventilation, and air-conditioning (including parking garage ventilation, freeze protection, exhaust air recovery, and condenser heat recovery for service water heating)
Section 7. Service water heating (including swimming pools)
Section 8. Power (including all building power distribution systems)
Section 9. Lighting (including exit signs, building exterior, grounds, and parking garages)
Section 10. Other equipment (including all permanently wired electrical motors)

ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004

http://www.ashrae.org
The *Advanced Energy Design Guide* series provides a sensible approach to achieving advanced levels of energy savings without having to resort to detailed calculations or analysis. This guide is for office buildings up to 1,860 square metres (20,000 square feet); such buildings make up the bulk of office space in North America. The strategies provide benefits and savings for the building owner while maintaining the quality and functionality of the office space.

ASHRAE Advanced Energy Design Guide for Retail Buildings 2006
http://www.ashrae.org
The *Advanced Energy Design Guide* series provides a sensible and easy approach to achieving advanced levels of energy savings without having to resort to detailed calculations or analysis. This guide focuses on retail buildings up to 1,860 square metres (20,000 square feet) that use unitary heating and air-conditioning equipment; such buildings represent a significant amount of commercial retail space in North America.

ASHRAE Advanced Energy Design Guide for Small Warehouses and Self-Storage Buildings 2008
http://www.ashrae.org
The *Advanced Energy Design Guide* series provides a sensible and easy approach to achieving advanced levels of energy savings without having to resort to detailed calculations or analysis. This guide focuses on warehouses up to 4,645 square metres (50,000 square feet) and self-storage buildings that use unitary heating and air-conditioning equipment; such facilities make up a significant amount of commercial warehouse space in North America.

EA	
NC	Prerequisite 2
CS	Prerequisite 2

ASHRAE Advanced Energy Design Guide for K-12 School Buildings
http://www.ashrae.org
The *Advanced Energy Design Guide* series provides a sensible and easy approach to achieving advanced levels of energy savings without having to resort to detailed calculations or analysis. This guide focuses on elementary, middle and high school buildings, which have a wide variety of heating and air-conditioning requirements. Options for daylighting, an important component in schools, are included.

New Building Institute, Advanced Buildings™ Core Performance™ Guide

The Advanced Building program provides a prescriptive plan for exceeding the energy performance requirements of ASHRAE 90.1–2004. The program was designed to provide a predictable alternative to energy performance modelling and a simple set of criteria for increasing building energy performance significantly. To use this option, projects cannot have a window-to-wall ratio greater than 40%.

The Advanced Building Core Performance program updates and replaces the Advanced Building Benchmarked program. Core Performance is calibrated to exceed the requirements of ASHRAE 90.1–2004 in all climate zones.

Information about the Core Performance program requirements and a range of additional reference material is available at http://www.advancedbuildings.net.

Several aspects of the Core Performance program overlap with other LEED credits and prerequisites. Following the Core Performance program is not an alternative path to achieving any LEED credits other than EA Credit 1, Optimize Energy Performance, but Core Performance may facilitate earning other LEED credits and prerequisites.

ENERGY COMPUTER SIMULATION MODELLING BASICS

As part of the design process, an energy modelling expert must use approved energy simulation software, such as, DOE-2, DOE EnergyPlus, EE4, eQUEST or other CaGBC approved software (refer to CaGBC's website, http://www.cagbc.org), to determine building energy performance. In such programs, the proposed building is first simulated to reflect the structure's current design. Next, the proposed building model is modified to reflect a building that "just meets" the prescriptive requirements of MNECB 1997 or ASHRAE 90.1-2007 as well as standard practice. The difference in energy use and cost between these 2 building models is then quantified. Creating such an energy model early in the design informs decision makers about potential materials and systems and their impact on the building's energy performance.

4. IMPLEMENTATION

OPTION 1. WHOLE BUILDING ENERGY SIMULATION

LEED Canada provides two modelling options or paths to meet this Prerequisite: one based on ASHRAE 90.1-2007; and one based on the Canadian Model National Energy Code for Buildings (MNECB). Either path may be used; however, the path used for EA Prerequisite 2 must also be used to demonstrate performance in EA Credit 1. The *LEED Canada Energy Modelling Rules* provides guidance in the application of these paths.

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CS	Prerequisite 2

OVERVIEW OF STANDARDS

Since the MNECB was based on the ASHRAE 90.1-1989, the MNECB and ASHRAE Standard 90.1 are very similar in structure, with some modifications that reflect Canadian standards and the cost and availability of energy. Both standards establish minimum requirements for the energy-efficient design of buildings, except low-rise residential buildings. The provisions of these standards do not apply to single-family houses, multifamily structures of three habitable stories or fewer above grade, manufactured houses (mobile and modular homes), and unheated buildings. Some clauses in these standards relate to the design of parking garages associated with the building.

Both ASHRAE 90.1 and the MNECB are cited by many jurisdictions across Canada with some (e.g., Ontario) requiring that either standard be met for code compliance. A detailed study [Hepting, 2004] compared the energy performance of buildings designed to ASHRAE 90.1 and MNECB/CBIP requirements across the nation. ASHRAE 90.1-1999 was found to be more stringent than the MNECB and the differing requirements for the two paths have been set to compensate for these differences.

The standards have three sets of requirements: Mandatory, Prescriptive, and Performance. **Mandatory Requirements** are energy efficiency measures required to be included in the design. These are typically simple prescriptive measures that are considered good building practice, such as controlling lights by light switches and low wattage exit signs. Mandatory requirements must be met regardless of how the project demonstrates compliance.

Both standards also have two methods of demonstrating compliance: prescriptive or performance. In the **Prescriptive approach**, the building must meet minimum equipment efficiency and insulation levels that affect building energy use. The standards provide criteria for building envelope; heating, ventilating and air-conditioning; service water heating; power; lighting; and other equipment. Although the prescriptive path is available to meet MNECB and ASHRAE 90.1-2007, it is not acceptable under LEED.

The other method is to demonstrate project compliance using the **Performance approach**. In the Performance approach, a computer simulation tool is used to model the building, which is used to calculate the annual energy consumption of the design, and an equivalent that is barely compliant with the Standard. Two building computer models are used in this method, a Reference (or "baseline") model that just meets the standard's Prescriptive and Mandatory requirements; and a "Proposed" model with the same energy features as the design. With the Performance approach designers can trade off between Prescriptive requirements: for example, use less insulation in walls in exchange for higher efficiency heating equipment, provided the total energy use is not increased above the Reference model's. It is important to understand that there are some parameters that in most cases cannot be varied between the two models, such as airtightness, hours of operation, outdoor air ventilation rates (with some limitations), thermostat setpoints and occupancy. Energy savings cannot be accrued by setting these parameters different in the proposed and reference buildings (unless specifically allowed in the *LEED Canada Energy Modelling Rules*).

ENERGY CODE STRUCTURE (BASED ON ASHRAE 90.1-2007)

This section describes the structure of ASHRAE 90.1-2007. Since the MNECB is based on an older version of ASHRAE, it has a very similar structure to ASHRAE 90.1-2007 and for the sake of brevity only the one standard is presented. However, there are important differences in the mandatory requirements of each standard. Furthermore, this outline is a summary of the ASHRAE 90.1-2007 requirements and is not exhaustive. Project teams should ensure that they

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have a complete understanding of the full standards.

Each section of ASHRAE 90.1-2007 describes the scope of the provisions (e.g., definitions and relevant building elements), lists the mandatory provisions, and lists the requirements for complying with the standard.

Section 5. Building Envelope Requirements (ASHRAE 90.1-2007)

These requirements apply to enclosed spaces whose heating system has an output capacity of 3.4 Btu/hour/square foot or more, and to spaces whose cooling system has a sensible output capacity of 5 Btu/hour/square foot or more.

ASHRAE 90.1-2007 Section 5.4 describes mandatory provisions for insulation installation (5.4.1); window, skylight, and door ratings (5.4.2); and air leakage (5.4.3). Section 5.5 contains the prescriptive provisions for fenestration and opaque assemblies.

Climate zone assignments for Canada and other countries can be determined from ASHRAE 90.1– 2007, Tables B-2 and B-3.

Prescriptive building envelope requirements are determined based on the building's climate zone classification (ASHRAE Standard 90.1–2007, Tables 5.5-1 to 5.5-8). For projects following the prescriptive compliance method, all building envelope components must meet the minimum insulation and maximum U-factor and solar heat gain coefficients (SHGC) requirements listed for the project's climate zone. Window area must be less than 40% of the gross wall area, and the skylight area must be less than 5% of the gross roof area.

The project may exceed the envelope prescriptive requirements if the project uses an energy simulation model to document points earned for EA Credit 1, Optimize Energy Performance.

Section 6. Heating, Ventilation and Air-Conditioning Requirements (ASHRAE 90.1– 2007)

The requirements of Section 6 apply to all building HVAC systems. Mandatory provisions for HVAC performance are documented in ASHRAE 90.1–2007, Section 6.4, and include minimum system efficiency requirements (6.4.1), load calculation requirements (6.4.2), controls requirements (6.4.3), HVAC system construction and insulation requirements (6.4.4), and completion requirements (6.4.5).

ASHRAE 90.1–2007, Section 6.4.3.4, lists minimum control schemes for thermostats (off-hours, including setback and optimum start/stop), stair and elevator vents, outdoor air supply and exhaust vents, heat pump auxiliary heat, humidification and dehumidification, freeze protection, snow- and ice-melting systems, and ventilation for high-occupancy areas.

Because manual control is not addressed by the Appendix G modelling methodology, any manual control features of the project must be submitted under the exceptional calculation methodology for case-by-case review. Be prepared to demonstrate convincingly that a manual control strategy is appropriate and workable for this project.

ASHRAE 90.1–2007, Section 6.5, provides a prescriptive compliance option. Prescriptive provisions are included for air and water economizers (6.5.1); simultaneous heating and cooling limitations (6.5.2); air system design and control, including fan power limitation and variable speed drive control (6.5.3); hydronic system design and control, including variable flow pumping (6.5.4); heat rejection equipment (6.5.5); energy recovery from exhaust air and service water heating systems (6.5.6); kitchen and fume exhaust hoods (6.5.7); radiant heating systems (6.5.8); and hot gas bypass limitations (6.5.9).

Project teams must meet the minimum efficiency requirements for system components listed

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in ASHRAE 90.1–2007, Tables 6.8.1A-G, even if using the energy cost budget or performance-based compliance methods.

Exceptions

For projects served by existing HVAC systems, such as a central plant on a campus or district heating and cooling, the exception to Section 6.1.1.2 applies. The existing systems and existing equipment are not required to comply with the standard.

Occupant-controlled swirl floor diffusers meet the intent of the ASHRAE 90.1–2007, Section 6.4.3.1, requirement for individually controlled zone controls, similar to operable windows in a naturally ventilated and cooled space.

Section 7. Service Water Heating Requirements (ASHRAE 90.1–2007)

These requirements include mandatory provisions (7.4) and a choice of prescriptive (7.5) or performance-based compliance (Appendix G). Mandatory provisions include requirements for load calculations (7.4.1), efficiency (7.4.2), piping insulation (7.4.3), controls (7.4.4), pool heaters and pool covers (7.4.5), and heat traps for storage tanks (7.4.6).

Section 8. Power Requirements (ASHRAE 90.1-2007, Section 8.4.1)

These requirements address mandatory provisions related to voltage drop.

Section 9. Lighting Requirements (ASHRAE 90.1-2007)

These requirements apply to all lighting installed on the building site, including interior and exterior lighting. Mandatory provisions include minimum requirements for controls (9.4.1), tandem wiring (9.4.2), luminaire source efficacy for exit signs (9.4.3), exterior lighting power definitions (9.4.5), and luminaire source efficacy for exterior lighting fixture (9.4.4). Per 9.4.1.2, occupancy controls are required in classrooms, conference rooms, and employee lunch and break rooms. Interior lighting compliance must be documented using either the building area method (9.5) or the space-by-space method (9.6). See the Implementation and Calculations sections for additional guidance on lighting power calculations.

Section 10. Other Equipment Requirements (ASHRAE 90.1-2007)

This section includes mandatory provisions for electric motors (10.4).

Section 11. Energy Cost Budget Method (ASHRAE 90.1-2007)

The energy cost budget method is no longer an alternative option for compliance with this prerequisite.

Appendix G. The Performance Rating Method (ASHRAE 90.1-2007)

Appendix G demonstrates the required method for EA Credit 1, Optimize Energy Performance. If the project is using the performance rating method to achieve points under EA Credit 1, the EA Credit 1 documentation can be used to prove compliance with the performance requirements (the second part) of this prerequisite. The performance rating method does not exempt the project from also meeting the mandatory ASHRAE 90.1-2007 requirements listed for this prerequisite.

EA Credit 1 includes a more detailed discussion of the performance rating method.

EA	
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CS	Prerequisite 2

Additional Strategies

In a campus setting with a central plant, improving plant efficiency affects all buildings on the district heating and cooling system. By installing a combined heat and power system designed to meet thermal and electrical base loads, a facility can greatly increase its operational efficiency and decrease energy costs.

Guidance on Combined Heat and Power (CHP) Systems

See EA Credit 1, Optimize Energy Performance, for guidance on CHP systems supplying electricity and/or recovered thermal energy.

Credit for Natural Ventilation Strategies

Projects may be able to take credit for natural ventilation in the energy modelling. However, projects demonstrating natural ventilation savings will be evaluated on a case-by-case basis. To demonstrate the process and the results, be prepared to provide the following:

- Detailed project description.
- Clear identification of the areas with natural ventilation.
- Detailed description or references that document the modelling algorithms and/or methodology for the natural ventilation portion of the energy model.
- All thermostat, fan, infiltration, and other appropriate schedules for naturally ventilated areas.
- Verification that the range of unmet load hours is similar for both the design and the baseline building, to ensure that savings are not claimed for hours outside the control parameters.

The team must clearly demonstrate that the operational schedule used to model the natural ventilation system aligns with occupants' anticipated behaviour. For example, the model cannot assume that natural ventilation will occur when no one is in the building to operate the system.

CS

In Core & Shell buildings, not all the components addressed by MNECB or ASHRAE 90.1–2007 may be designed or defined. For these types of projects, show compliance for the scope of work that is controlled by the core and shell project team.

For example, if there is no lighting scope of work in the Core & Shell, the team need not demonstrate compliance with the lighting standard but must show compliance with the other provisions. Refer to Leased Tenant Space Interpretations for more guidance.

OPTION 2 AND 3. PRESCRIPTIVE COMPLIANCE PATHS

For implementation information on Option 2 (Prescriptive Compliance Path: ASHRAE Advanced Energy Design Guide) or Option 3 (Prescriptive Compliance Path: Advanced Buildings™ Core Performance™ Guide), please see EA Credit 1.

EA	
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CS	Prerequisite 2

5. TIMELINE AND TEAM

The project team should start the energy simulation modelling early in the design phase to gain insights for design decisions and an indication of how to achieve certain levels of energy cost reductions.

6. CALCULATIONS

Follow the calculation and documentation methodology as prescribed in the *LEED Canada Energy Modelling Rules* (see Interpretations).

AREA CALCULATIONS

A conditioned conservatory or greenhouse space cannot be excluded on the basis of horticultural "process loads" when it qualifies as an amenity for the occupants or users of the facility rather than as the primary facility function (see ASHRAE 90.1–2007's definition of process load). Conditioning for the conservatory space must be included in the energy simulation and savings calculations.

To calculate the gross floor area of a building, include both conditioned and unconditioned spaces. Under the ASHRAE 90.1-2007 path, if the area exceeds the 2,300 m^2 (25,000-square-foot), HVAC systems must comply with the mandatory requirements in Section 6.4. However, only those areas that are heated or cooled per Section 2.2(1) of the standard must meet the envelope requirements.

LIGHTING POWER CALCULATIONS

Lighting power calculations for performance-based compliance methods must use either the building area method or the space-by-space method. For both methods, the total installed interior lighting power is calculated by summing the luminaire wattages for all permanently installed general, task and furniture lighting, where the luminaire wattage includes lamps, ballasts, current regulators, and control devices. If the project is pursuing IEQ Credit 6.1, all lighting used to achieve this credit must be included in the energy model.

Building area method calculations can be used only if the project involves the entire building or a single independent occupancy within a multioccupancy building. Allowable lighting power for this method is calculated by multiplying the allowable lighting power density for the given building type (found in ASHRAE 90.1–2007, Table 9.5.1) by the interior building area.

Allowable lighting for the space-by-space method is determined by multiplying the allowable lighting power density for each space function in the building (found in ASHRAE 90.1–2007, Table 9.6.1) by the corresponding area for each space function, then summing the results. The project complies if the total installed interior lighting power is lower than the interior lighting power allowance calculated using either the building area or the space-by-space method.

The exterior lighting power allowance is calculated by multiplying the allowed lighting power for each exterior surface (found in ASHRAE 90.1–2007, Table 9.4.5) by the total area or length associated with that surface, summing the results, and then multiplying this number by 1.05. For nontradable exterior lighting surfaces, the allowed lighting power can be used for the specific application only; it cannot be traded among surfaces or with other exterior lighting. For projects following the MNECB compliance path, exterior lighting calculations must follow the ASHRAE 90.1-2007 standard.

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CS	Prerequisite 2

7. DOCUMENTATION GUIDANCE

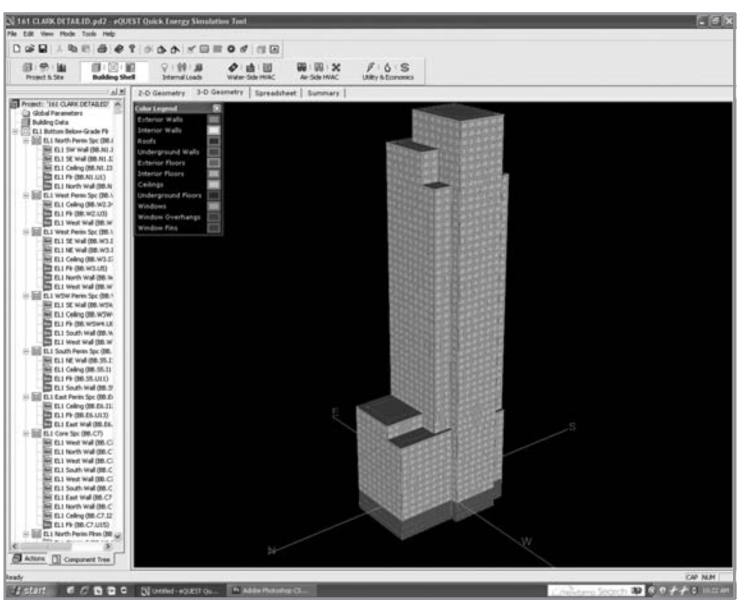
As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED letter templates for the complete descriptions of all required documentation.

- For ASHRAE compliance, list any addenda used.
- Determine the climate zone for the project location.
- Calculate energy use by type.
- Maintain a list of energy end uses for the project building (for both the baseline case and the design case).
- If the project is using a computer energy simulation, adhere to *LEED Canada Energy Modelling Rules* and retain the final report indicating the annual energy cost of the baseline and design cases as well as the simulation output files. Also prepare a modelling report describing the assumptions used in the model. Computer simulation files must be prepared by or reviewed by an individual on the CaGBC's Experienced Modeller List (refer to CaGBC's website, http://www.cagbc.org).
- If the project is using the prescriptive compliance path, assemble documentation demonstrating that the project meets all requirements applicable to the selected prescriptive path.

8. EXAMPLES

Energy simulation software packages, such as DOE-2, DOE EnergyPlus, EE4, or eQuest enable the creation of a representative model. Energy simulation software can be used to demonstrate compliance with the performance requirements of MNECB or ASHRAE 90.1-2007, as an alternative to the prescriptive requirements. Figure 2 shows an example of a 3-D building model.

FIGURE 2. SCREENSHOT FROM BUILDING SIMULATION SOFTWARE



EA	
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9. EXEMPLARY PERFORMANCE

This prerequisite is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Regional variance is already represented in MNECB and ASHRAE 90.1-2007 which account for the climate types and their minimum envelope and glazing property requirements.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Once the building is completed, it is critical to maintain efforts to support energy efficiency. Ensuring that the building systems are functioning properly and tracking energy use can save energy and operating costs. *LEED Canada for Existing Buildings: Operations & Maintenance* covers this topic in EA Prerequisite 2, Minimum Energy Efficiency Performance, and EA Credit 1, Optimize Energy Performance.

Promote energy efficiency by ensuring that the building management has a firm grasp of anticipated energy loads as well as the necessary tools for tracking and analysis.

Provide facility management with a breakdown of anticipated end energy uses based on any modelling results. The breakdown will provide a baseline to help operators evaluate ongoing energy consumption patterns and catch any system inefficiencies.

12. RESOURCES

WEBSITES

ecoENERGY Validation of New Building Designs
http://oee.nrcan.gc.ca/commercial/newbuildings/validation.cfm

As part of the ecoENERGY Efficiency Initiative, Natural Resources Canada (NRCan) offers a free service that validates the energy performance level of your building design. Energy-efficient buildings are better for the environment with increased comfort, lower operating costs and higher resale values.

ENERGY STAR® Buildings Upgrade Manual
http://www.energystar.gov/index.cfm?c=business.bus_upgrade_manual

This manual is a strategic guide for planning and implementing energy-saving building upgrades. It provides general methods for reviewing and adjusting system control settings, plus procedures for testing and correcting calibration and operation of system components such as sensors, actuators, and controlled devices.

Model National Energy Code for Buildings 1997 and Performance Compliance for Buildings
http://www.nrc-cnrc.gc.ca/eng/ibp/irc/codes/97-energy-code-buildings.html

The Model National Energy Code of Canada for Buildings (MNECB) is intended to help you design energy-efficient buildings. It sets out minimum requirements for features of buildings that determine their energy efficiency, taking into account regional construction costs, regional heating fuel types and costs and regional climatic differences. The MNECB has, in addition to sections on the building envelope and water heating, detailed information on lighting, HVAC systems and electrical power, which can offer major energy savings.

EA	
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CS	Prerequisite 2

New Buildings Institute, Inc.
http://www.newbuildings.org

The New Buildings Institute is a nonprofit, public-benefits corporation dedicated to making buildings better for people and the environment. Its mission is to promote energy efficiency in buildings through technology research, guidelines, and codes.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy
http://www.eere.energy.gov

This extensive website for energy efficiency links to DOE-funded sites that address buildings and energy. Of particular interest is the tools directory, which includes the Commercial Buildings Energy Consumption Tool for estimating end-use consumption in commercial buildings. This tool allows the user to define a set of buildings by principal activity, size, vintage, region, climate zone, and fuels (main heat, secondary heat, cooling, and water heating) and view the resulting energy consumption and expenditure estimates in tabular form.

U.S. EPA, Combined Heat and Power Partnership
http://www.epa.gov/chp

Information on cogeneration, also called combined heat and power, is available from EPA through the CHP Partnership. The CHP Partnership is a voluntary program seeking to reduce the environmental impact of power generation by promoting the use of CHP. The Partnership works closely with energy users, the CHP industry, state and local governments, and other clean energy stakeholders to facilitate the development of new projects and to promote their environmental and economic benefits.

PRINT MEDIA

ANSI/ASHRAE/IESNA Standard 90.1–2007 User's Manual (ASHRAE, 2008).
The ANSI/ASHRAE/IESNA 90.1–2007 User's Manual was developed as a companion document to the ANSI/ASHRAE/IESNA 90.1–2007, Energy Standard for Buildings Except Low-Rise Residential Buildings. The manual explains the new standard and includes sample calculations, useful reference material, and information on the intent and application of the standard. It is abundantly illustrated and contains numerous examples and tables of reference data. It also includes a complete set of compliance forms and worksheets that can be used to document compliance with the standard. The manual is helpful to architects and engineers applying the standard to the design of buildings, plan examiners and field inspectors who must enforce the standard in areas where it is adopted as code, and contractors who must construct buildings in compliance with the standard. A compact disk is included that contains electronic versions of the compliance forms found in the manual.

EA	
NC	Prerequisite 2
CS	Prerequisite 2

13. DEFINITIONS

Baseline building performance is the annual energy cost for a building design intended for use as a baseline for rating above standard design, as defined in ASHRAE 90.1-2007, Appendix G.

Building Floor Area is the sum of the floor areas of the spaces within the building including basements, mezzanine and intermediate-floored tiers, and penthouses with headroom height of 7.5 ft (2.2 meters) or greater. It is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features. (ASHRAE 90.1 – 2007)

Combined heat and power (CHP), or **cogeneration**, generates both electrical power and thermal energy from a single fuel source.

An **economizer** is a device used to make building systems more energy efficient. Examples include HVAC enthalpy controls, which are based on humidity and temperature.

An **energy simulation model**, or **energy model**, is a computer-generated representation of the anticipated energy consumption of a building. It permits a comparison of energy performance, given proposed energy efficiency measures, with the baseline.

An **ENERGY STAR** rating is a measure of a building's energy performance compared with that of similar buildings, as determined by the ENERGY STAR Portfolio Manager. A score of 50 represents average building performance.

Interior lighting power allowance is the maximum lighting power (in watts) allowed for the interior of a building.

Lighting **power density** is the installed lighting power, per unit area.

Luminaire is a lighting fixture assembly, including lamp, housing, reflector, and ballast (if applicable).

Model National Energy Code for Buildings (MNECB) 1997 contains cost-effective minimum requirements for energy efficiency in new buildings. The MNECB applies to all buildings, other than houses of three storeys or less, and to additions of more than 10 m^2 to such buildings. The MNECB is prepared under the auspices of the Canadian Commission on Building and Fire Codes (CCBFC) and was first published in 1997 by the National Research Council Canada (NRC).

Proposed building performance is the annual energy cost calculated for a proposed design, as defined in MNECB and ASHRAE 90.1-2007, Appendix G.

FUNDAMENTAL REFRIGERANT MANAGEMENT

	NC	CS
Prerequisite	EA Prerequisite 3	EA Prerequisite 3
Points	Required	Required

INTENT

To reduce stratospheric ozone depletion.

REQUIREMENTS: NC & CS

Zero use of chlorofluorocarbon (CFC)-based refrigerants in new base building heating, ventilating, air conditioning and refrigeration (HVAC&R) systems. When reusing existing base building HVAC equipment, complete a comprehensive CFC phase-out conversion prior to project completion. Phase-out plans extending beyond the project completion date will be considered on their merits.

Projects using Existing District Chilled Water Plants:

The CFC phase-out must be completed by 2015 and either comply with the requirements of the authority having jurisdiction or meet the following conditions, whichever is more stringent:

- The replacement or upgrade to alternative refrigerants, as determined by a third party assessment, is not economically viable (e.g. simple payback of the replacement is greater than 10 years).
- Operation complies with U.S. EPA Clean Air Act Title VI, Rule 608 governing refrigerant management and reporting.
- A comprehensive preventative maintenance program is established to minimize CFC leaks to less than 1% annually and the leakage over the remainder of the unit life is maintained below 30%.
- The CFC based chillers are used as the lag chillers and do not deliver more than 25% of the total cooling from the plant.

INTERPRETATIONS

There are no interpretations for this prerequisite.

EA	
NC	Prerequisite 3
CS	Prerequisite 3

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Chlorofluorocarbons (CFCs), used in refrigeration equipment, cause significant damage to Earth's protective ozone layer when they are released into the atmosphere. The reaction between CFC and ozone molecules in the stratosphere destroys the ozone and reduces the stratosphere's ability to absorb a portion of the sun's ultraviolet radiation. Eliminating the use of CFC-based refrigerants in new equipment and implementing a phase-out of existing CFC-based refrigerants in existing equipment help slow the depletion of the ozone layer and reduce the effects of climate change.

ECONOMIC ISSUES

The standard practice in new buildings is to install equipment that does not use CFCs. However, existing buildings may already have CFC-based refrigeration equipment. Energy, demand, and maintenance savings realized from upgrading equipment may offset the cost of converting or replacing existing systems.

2. RELATED CREDITS

This prerequisite represents a minimum threshold for refrigerant selection. To achieve greater environmental benefit, install environmentally preferable refrigerants or no refrigerants, as detailed in this credit:

- EA Credit 4: Enhanced Refrigerant Management

3. SUMMARY OF REFERENCED STANDARDS

U.S. EPA Clean Air Act, Title VI, Section 608, Compliance with the Section 608 Refrigerant Recycling Rule
http://www.epa.gov/ozone/title6/608/608fact.html

Under Section 608 of the Clean Air Act, EPA has established regulations on using and recycling ozone-depleting compounds. An overview of the pertinent regulations and information about compliance can be found on this website.

4. IMPLEMENTATION

Replace or retrofit any CFC-based refrigerants in the existing base building HVAC&R and fire-suppression systems. If the building is connected to an existing chilled water system, that system must either be CFC-free or the project team must demonstrate a commitment to phasing out CFC-based refrigerants no later than 2015. An alternative compliance path for buildings connected to a central chilled water system is given in the prerequisite requirements.

Consider the characteristics of various CFC substitutes. Refrigerants have varying applications, lifetimes, ozone-depleting potentials (ODPs), and global-warming potentials (GWPs). Table 1 shows the ODPs and direct GWPs of many common refrigerants. Choose refrigerants that have short environmental lifetimes, small ODP values, and small GWP values.

No ideal alternative for CFCs has been developed, and some alternatives are not suitable for retrofits. See EPA's list of substitutes for ozone-depleting substances (http://www.epa.gov/ozone/snap).

EA	
NC	Prerequisite 3
CS	Prerequisite 3

TABLE 1. OZONE DEPLETION AND GLOBAL WARMING POTENTIALS OF REFRIGERANTS (100-YEAR VALUES)

CHLOROFLUOROCARBONS	ODP	GWP	COMMON BUILDING APPLICATIONS
CFC-11	1.0	4,680	Centrifugal chillers
CFC-12	1.0	10,720	Refrigerators, chillers
CFC-114	0.94	9,800	Centrifugal chillers
CFC-500	0.605	7,900	Centrifugal chillers, humidifiers
CFC-502	0.221	4,600	Low-temperature refrigeration
HYDROCHLOROFLUOROCARBONS			
HCFC-22	0.04	1,780	Air-conditioning, chillers
HCFC-123	0.02	76	CFC-11 replacement
HYDROFLUOROCARBONS			
HFC-23	~ 0	12,240	Ultra-low-temperature refrigeration
HFC-134A	~ 0	1,320	CFC-12 or HCFC-22 replacement
HFC-245fA	~ 0	1,020	Insulation agent, centrifugal chillers
HFC-404A	~ 0	3,900	Low-temperature refrigeration
HFC-407C	~ 0	1,700	HCFC-22 replacement
HFC-410A	~ 0	1,890	Air conditioning
HFC-507A	~ 0	3,900	Low-temperature refrigeration
NATURAL REFRIGERANTS			
Carbon dioxide (CO_2)	0	1.0	
Ammonia (NH_3)	0	0	
Propane	0	3	

MINIMIZE REFRIGERANT LEAKAGE

Refrigerants cannot damage the atmosphere if they are contained and never released to the environment. Unfortunately, in real-world applications, some or all refrigerants in HVAC&R equipment leak out, often undetected, during installation, operation, charging, servicing, or decommissioning of equipment, both indoor and outdoor.

Adhering to federal and provincial regulation and best practices for refrigerant management and equipment maintenance can minimize refrigerant emissions. Manufacturers may offer leakage rate guarantees for certain types of major HVAC&R equipment (such as chillers) as part of a long-term service contract.

In Canada, regulatory responsibility for ozone layer protection is shared by the federal and provincial governments. The federal government is responsible for regulating federal facilities which are not covered by provincial regulations and implementing controls needed to meet Canada's obligations under the Montreal Protocol. The provincial governments control recovery, recycling and the releases of ozone-depleting substances.[8]

EA	
NC	Prerequisite 3
CS	Prerequisite 3

The federal government has prohibited new uses of CFCs and Halons and has restrictions on the import and export of bulk shipments, and on certain uses. There are also federal ODS regulations (covering releases, recovery, etc.) that apply to federal facilities and undertakings.[9]

Canada's Federal Halocarbon Regulations, 2003 prohibits the charging of chillers with CFCs at the next overhaul of the chiller effective January 1, 2005.[10] An exemption is available between January 1, 2005 and December 31, 2009, to permit the charge of the chiller with CFCs following an overhaul and allow for the continued operation of that chiller with the condition that the chiller is either converted or replaced to no longer contain CFCs 12 months after the date of recharge.[11] The regulations will prohibit the operation of chillers with CFCs effective January 1, 2015.

Provinces restrict emissions of CFCs and Halons, and mandate recovery. Some provinces have banned the refilling of automotive air conditioning systems with CFCs. In all jurisdictions, it is prohibited to vent CFCs or Halons (except to extinguish a fire).[12] CFC phase-out information for Canadian Provinces can be found at: http://www.hrai.ca/PDFs/factsheets/CFCPhaseoutJurisdictionChart.pdf

As part of the U.S. commitment to implementing the Montreal Protocol, the Environmental Protection Agency has established regulations for responsible management of ozone-depleting substances (ODS). Under Section 608 in the Clean Air Act of 1990, EPA 's regulations:

- require practices that maximize recycling of ozone-depleting compounds (both CFCs and HCFCs) during the servicing and disposal of air-conditioning and refrigeration equipment;
- set certification requirements for recycling and recovery equipment, technicians, and reclaimers, and prohibit the sale of refrigerant to uncertified technicians;
- require persons servicing or disposing of air-conditioning and refrigeration equipment to confirm with EPA that they have acquired recycling or recovery equipment and are complying with the requirements of the rule;
- require the repair of substantial leaks in air-conditioning and refrigeration equipment with a charge of greater than 50 pounds;
- establish safe disposal requirements to ensure removal of refrigerants from goods that enter the waste stream with the charge intact (e.g., vehicle air-conditioners, home refrigerators, and room air-conditioners); and
- prohibit individuals from knowingly venting ozone-depleting compounds that are used as refrigerants (generally CFCs and HCFCs) into the atmosphere while maintaining, servicing, repairing, or disposing of air-conditioning or refrigeration equipment (including appliances).

Applicants are required to comply with Canadian federal/provincial regulations or EPA regulations, whichever is more stringent.

DISTRICT ENERGY SYSTEMS

For projects with district energy systems, specific technical guidance can be found in the *LEED Canada Interpretation Guide for District Energy Systems* on CaGBC's website (http://www.cagbc.org). Follow the guidance in effect at the time of LEED project registration.

EA	
NC	Prerequisite 3
CS	Prerequisite 3

5. TIMELINE AND TEAM

Consult with a mechanical engineer or HVAC&R specialist to confirm the presence of CFC-based refrigerants in the base building HVAC&R systems. If CFC-based refrigerants are located, the building owner should develop a phase-out plan and convert to less environmentally harmful refrigerants. Do not install any systems with CFC-based refrigerants.

6. CALCULATIONS

There are no calculations associated with this prerequisite.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED letter templates for the complete descriptions of all required documentation.

- For major renovations, where applicable, develop and track the phase-out plan. If equipment containing CFCs will not be phased out by project completion provide a narrative detailing why phase out has not been completed and when the phase-out will be completed.
- Assemble manufacturers' documentation demonstrating the type of refrigerant used by the base building's HVAC&R systems.
- For projects that use district chilled water plant with systems using CFC-Based Refrigerants develop a phase-out plan including performance period dates, a comprehensive preventative maintenance plan to minimize CFC leaks and a third party report on the economic viability of CFC replacement.

8. EXAMPLES

There are no examples for this prerequisite.

9. EXEMPLARY PERFORMANCE

This prerequisite is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations for this prerequisite.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Provide facility operators with complete records (such as LEED application materials) for all refrigerant-containing systems. Ensure that equipment labels are in place and accessible to building operators, and provide them with a copy of any CFC phase-out plan.

EA	
NC	Prerequisite 3
CS	Prerequisite 3

12. RESOURCES

WEBSITES

ASHRAE Service Life and Maintenance Cost Database
www.ashrae.org/database

This database provides current information on the service life and maintenance costs of typical HVAC equipment.

Canadian Environmental Protection Act, 1999. Federal Halocarbon Regulations, 2003 (FHR 2003)
http://laws.justice.gc.ca/eng/SOR-2003-289/index.html

This regulation applies to air conditioning, refrigeration, fire extinguishing and solvent systems that are located on federal or aboriginal land; or owned by departments, boards, agencies of the Government of Canada, Crown corporations and federal works and undertakings. In addition to other requirements, this regulation restricts the installation of systems that are intended to operate with CFCs and Halons.

Environment Canada's Stratospheric Ozone Web Site
http://www.ec.gc.ca/ozone

This site provides information on the history of stratospheric ozone layer depletion, the science of ozone depletion, Canada's Ozone Layer Protection Program and the regulatory approach to protect the ozone layer, as well as information on a number of other topics.

Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.
http://ec.gc.ca/ozone/default.asp?lang=En&n=127A4F77-1

This Code provides guidelines for the reduction of atmospheric emissions of halocarbons used in refrigeration and air conditioning applications.

U.S. EPA, Benefits of CFC Phase-Out
http://www.epa.gov/ozone/geninfo/benefits.html

This EPA document details the benefits of phasing out CFC and includes brief case studies.

U.S. EPA, Building Owners Save Money, Save the Earth; Replace Your CFC Air Conditioning Chiller
http://www.epa.gov/ozone/title6/608/chiller1_07.pdf

This EPA brochure documents the environmental and financial reasons to replace chlorofluorocarbon chillers with new, energy-efficient equipment.

U.S. EPA, Significant New Alternatives Policy
http://www.epa.gov/ozone/snap/index.html

SNAP is an EPA program to identify alternatives to ozone-depleting substances. The program maintains up-to-date lists of environmentally friendly substitutes for refrigeration and air-conditioning equipment, solvents, fire-suppression systems, adhesives, coatings, and other substances.

EA	
NC	Prerequisite 3
CS	Prerequisite 3

PRINT MEDIA

Building Systems Analysis and Retrofit Manual (SMACNA, 1995).

CFCs, HCFC and Halons: Professional and Practical Guidance on Substances that Deplete the Ozone Layer (CIBSE, 2000).

The Refrigerant Manual: Managing the Phase Out of CFCs (BOMA International, 1993).

13. DEFINITIONS

Chlorofluorocarbons (CFCs) are hydrocarbons that are used as refrigerants and cause depletion of the stratospheric ozone layer.

The **leakage rate** is the speed at which an appliance loses refrigerant, measured between refrigerant charges or over 12 months, whichever is shorter. The leakage rate is expressed in terms of the percentage of the appliance's full charge that would be lost over a 12-month period if the rate stabilized. (EPA Clean Air Act, Title VI, Rule 608)

Refrigerants are the working fluids of refrigeration cycles that absorb heat from a reservoir at low temperatures and reject heat at higher temperatures.

EA	
NC	Credit 1
CS	Credit 1

OPTIMIZE ENERGY PERFORMANCE

	NC	CS
Credit	EA Credit 1	EA Credit 1
Points	1-19 points	3-21 points

INTENT

To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.

REQUIREMENTS: NC & CS

Select 1 of the 3 compliance path options described below. Project teams documenting achievement using any of the 3 options are assumed to be in compliance with EA Prerequisite 2: Minimum Energy Performance.

OPTION 1. WHOLE BUILDING ENERGY SIMULATION (1-19 points for NC, 3-21 points for CS)

EITHER

PATH 1. Model National Energy Code For Buildings (MNECB)

Demonstrate a percentage cost improvement in the proposed building performance rating compared with the reference building performance rating. Calculate the reference building performance according to the Model National Energy Code for Buildings 1997 (MNECB) using a computer simulation model for the whole building project. The minimum energy cost savings percentage for each point threshold is as follows:

EA	
NC	Credit 1
CS	Credit 1

NEW BUILDINGS	EXISTING BUILDING RENOVATIONS	POINTS FOR NC	POINTS FOR CS
25%	21%	1	3
27%	23%	2	4
28%	25%	3	5
30%	27%	4	6
32%	28%	5	7
33%	30%	6	8
35%	32%	7	9
37%	33%	8	10
39%	35%	9	11
40%	37%	10	12
42%	39%	11	13
44%	40%	12	14
45%	42%	13	15
47%	44%	14	16
49%	45%	15	17
50%	47%	16	18
52%	49%	17	19
54%	50%	18	20
56%	52%	19	21

The energy analysis done for the building performance rating method must include all the energy costs associated with the building project. To achieve points under this credit, the proposed design must meet the following criteria:

- Compliance with the mandatory provisions of the MNECB 1997.
- Inclusion of all the energy costs within and associated with the building project.
- Comparison against a baseline building that complies with the reference building requirements as defined in the MNECB 1997.

OR

EA	
NC	Credit 1
CS	Credit 1

PATH 2. ASHRAE 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings

Demonstrate a percentage cost improvement in the proposed building performance rating compared with the baseline building performance rating. Calculate the baseline building performance according to Appendix G of ANSI/ASHRAE/IESNA Standard 90.1-2007 (with errata but without addenda[a]) using a computer simulation model for the whole building project. The minimum energy cost savings percentage for each point threshold is as follows:

NEW BUILDINGS	EXISTING BUILDING RENOVATIONS	POINTS FOR NC	POINTS FOR CS
12%	8%	1	3
14%	10%	2	4
16%	12%	3	5
18%	14%	4	6
20%	16%	5	7
22%	18%	6	8
24%	20%	7	9
26%	22%	8	10
28%	24%	9	11
30%	26%	10	12
32%	28%	11	13
34%	30%	12	14
36%	32%	13	15
38%	34%	14	16
40%	36%	15	17
42%	38%	16	18
44%	40%	17	19
46%	42%	18	20
48%	44%	19	21

[a] Project teams wishing to use ASHRAE approved addenda for the purposes of this credit may do so at their discretion. Addenda must be applied consistently across all LEED credits.

EA	
NC	Credit 1
CS	Credit 1

Appendix G of Standard 90.1-2007 requires that the energy analysis done for the building performance rating method include all the energy costs associated with the building project. To achieve points under this credit, the proposed design must meet the following criteria:

- Compliance with the mandatory provisions (Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) in Standard 90.1-2007 (with errata but without addenda);
- Inclusion of all the energy costs within and associated with the building project.
- Comparison against a baseline building that complies with Appendix G to Standard 90.1-2007 (with errata but without addenda).

Regardless of the path chosen (MNECB 1997 or ASHRAE 90.1-2007), the following requirements apply:

- The whole building project simulation must follow the procedures defined in the referenced energy standard and the *LEED Canada Energy Modelling Rules*.
- For the purpose of this analysis, process energy is considered to include, but is not limited to, office and general miscellaneous equipment, computers, elevators and escalators, kitchen cooking and refrigeration, laundry washing and drying, lighting exempt from the lighting power allowance (e.g., lighting integral to medical equipment) and other (e.g., waterfall pumps).
- Regulated (non-process) energy includes lighting (e.g., for the interior, parking garage, surface parking, façade, or building grounds, etc. except as noted above), heating, ventilating, and air conditioning (HVAC) (e.g., for space heating, space cooling, fans, pumps, toilet exhaust, parking garage ventilation, kitchen hood exhaust, humidification, etc.), and service water heating for domestic or space heating purposes.
- For this credit, process loads must be identical for both the baseline building performance rating and for the proposed building performance rating. However, project teams may follow the exceptional calculation method (ANSI/ASHRAE/IESNA 90.1-2007 G2.5) or the *LEED Canada Energy Modelling Rules* to document measures that reduce process loads. Documentation of process load energy savings must include a list of the assumptions made for both the base and proposed design, and theoretical or empirical information supporting these assumptions.

OR

OPTION 2. PRESCRIPTIVE COMPLIANCE PATH: ASHRAE Advanced Energy Design Guide (1 point)

Comply with the prescriptive measures of the ASHRAE Advanced Energy Design Guide appropriate to the project scope, outlined below. Project teams must comply with all applicable criteria as established in the Advanced Energy Design Guide for the climate zone in which the building is located.

EA	
NC	Credit 1
CS	Credit 1

PATH 1. ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004

The building must meet the following requirements:

- Less than 1,860 square metres (20,000 square feet).
- Office occupancy.

PATH 2. ASHRAE Advanced Energy Design Guide for Small Retail Buildings 2006

The building must meet the following requirements:

- Less than 1,860 square metres (20,000 square feet).
- Retail occupancy.

PATH 3. ASHRAE Advanced Energy Design Guide for Small Warehouses and Self-Storage Buildings 2008

The building must meet the following requirements:

- Less than 4,645 square metres (50,000 square feet).
- Warehouse of self-storage occupancy.

PATH 4. ASHRAE Advanced Energy Design Guide for K-12 School Buildings

The building must meet the following requirements:

- Less than 18,600 square metres (200,000 square feet).
- K-12 school occupancy.

OR

OPTION 3. PRESCRIPTIVE COMPLIANCE PATH: Advanced Buildings™ Core Performance™ Guide (1-3 points)

Comply with the prescriptive measures identified in the Advanced Buildings™ Core Performance™ Guide developed by the New Buildings Institute. The building must meet the following requirements:

- Less than 9,290 square metres (100,000 square feet).
- Comply with Section 1: Design Process Strategies, and Section 2: Core Performance Requirements.
- Health care, warehouse, laboratory projects or other building types that differ significantly from office or retail projects are ineligible for this path (for NC & CS projects).

Points achieved under Option 3 (1 point):

- 1 point is available for all projects (office, school, public assembly, and retail projects) less than 9,290 square metres (100,000 square feet) that comply with Sections 1 and 2 of the Core Performance Guide.

Additional points available under Option 3 (up to 2 additional points):

- Up to 2 additional points are available to projects that implement performance strategies listed in Section 3: Enhanced Performance. For every 3 strategies implemented from this section, 1 point is available.
- The following strategies are addressed by other aspects of LEED and are not eligible for additional points under EA Credit 1:
  - 3.1— Cool Roofs
  - 3.8— Night Venting
  - 3.13— Additional Commissioning

INTERPRETATIONS

All Interpretations under EA Prerequisite 2 also apply to EA Credit 1.

EA	
NC	Credit 1
CS	Credit 1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Energy efficiency reduces the environmental burdens associated with producing and using energy. Fossil fuels, such as coal and oil, are the most common source of energy used in buildings. However, these fuels are also finite resources. The process of extracting and consuming energy from fossil fuels causes many environmental impacts, including air and water pollution, land degradation, solid waste generation, and greenhouse gas emissions. Mounting evidence connects fossil-fuel based energy use with climate change as well as serious risks to environmental and human health and safety. In 2006, the Canadian industrial and commercial sectors accounted for nearly half of the nation's energy use related greenhouse gas emissions (approximately 46%).[13] Furthermore, greenhouse gases and other emissions increase every year as overall energy consumption increases. Between 1990 and 2006, annual greenhouse gas emissions from Canadian energy use increased by 18.5%.[14] As the far-reaching implications of global climate change are becoming more apparent and serious, reducing emissions through energy efficiency becomes more important.

In addition to fossil fuels, other sources of energy also carry environmental costs. Hydropower activities, for example, can alter aquatic ecosystems and harm endangered species. Nuclear power plants pose an environmental threat when they are decommissioned without appropriate storage sites for spent fuel. Given both the environmental impacts inherent in most energy-production processes and our limited energy supplies, efficiency measures are an important strategy for managing the impacts of energy consumption.

ECONOMIC ISSUES

Some energy-efficiency measures may not require additional first costs. Many measures that do result in higher capital costs may generate savings from lower energy use, smaller equipment, reduced space needs for mechanical and electrical equipment, and utility rebates. These savings may vastly exceed the incremental capital costs associated with the energy-efficiency measures over the life of the project.

Even seemingly small conservation measures can be significant; for instance, replacing 1 incandescent lamp with a fluorescent lamp will save over $30 in energy costs over the operating lifetime of the lamp.[15]

2. RELATED CREDITS

The *LEED Canada for New Construction* and *Core & Shell* rating systems address building energy efficiency in 2 places: EA Prerequisite 2, Minimum Energy Performance, and EA Credit 1, Optimize Energy Performance. Energy consumption for the building can be reduced by ensuring that the project exceeds the building code requirements for envelope, lighting, and HVAC systems. Further, energy use can be directly affected through the use of climatically appropriate roofing materials and careful optimization of exterior lighting. Refer to these credits:

- EA Prerequisite 2: Minimum Energy Performance
- SS Credit 7.2: Heat Island Effect—Roof
- SS Credit 8: Light Pollution Reduction
- RP Credit 1: Durable Building

EA	
NC	Credit 1
CS	Credit 1

In addition to reducing energy use through efficiency measures, project teams can mitigate energy use impacts by using renewable energy. Refer to these credits:

- EA Credit 2: On-site Renewable Energy
- EA Credit 6: Green Power

Building energy performance and indoor environmental quality issues, such as ventilation, occupant controllability, and the amount of entering daylight, must be carefully coordinated. Energy-efficient buildings should not compromise the health and well-being of occupants. Increased ventilation in buildings may require additional energy use, which may in turn cause air and water pollution. However, the additional need for energy can be mitigated by using heat-recovery ventilation and/or economizer strategies. Review the strategies in these credits:

- IEQ Prerequisite 1: Minimum Indoor Air Quality Performance
- IEQ Credit 1: Outdoor Air Delivery Monitoring
- IEQ Credit 2: Increased Ventilation
- IEQ Credit 6: Controllability of Systems
- IEQ Credit 7: Thermal Comfort
- IEQ Credit 8: Daylight and Views

Because water use, especially domestic hot water, requires significant energy use, water use reductions can lead to energy savings. Consider meeting the requirements for these credits:

- WE Credit 3: Water Use Reduction

3. SUMMARY OF REFERENCED STANDARDS

Model National Energy Code for Buildings (MNECB):
Canadian Commission on Building and Fire Codes, National Research Council of Canada.

The Model National Energy Code for Buildings (MNECB) is a model energy efficiency code published in September 1997 by the National Research Council Canada (NRCC).

The Model National Energy Code for Buildings (MNECB) was developed by the National Research Council of Canada, the organization that is responsible for the National Building Code of Canada, as a model code for adaptation or adoption by Canadian provinces and municipalities. The MNECB was developed with input from many committees and all provinces and was published in 1997, but there has been little adoption by authorities.

The code sets minimum energy efficiency standards for commercial building construction in Canada. The MNECB contains mandatory requirements for architectural, mechanical, and electrical design items. To evaluate energy efficiency, the proposed design is compared to a similar building that just meets the requirements of the MNECB. The energy savings can be achieved through improvements to the interior lighting systems, building envelope, HVAC systems, central plant equipment (e.g. boilers, chillers), and domestic hot water systems.

ANSI/ASHRAE/IESNA Standard 90.1–2007, Energy Standard for Buildings Except Low-Rise Residential, and Informative Appendix G, Performance Rating Method
American National Standards Institute
American Society of Heating, Refrigerating and Air-Conditioning Engineers Illuminating Engineering Society of North America
http://www.ashrae.org
ANSI/ASHRAE/IESNA Standard 90.1–2007 was formulated by ASHRAE under an ANSI consensus process. IESNA is a joint sponsor of the standard.

EA	
NC	Credit 1
CS	Credit 1

ANSI/ASHRAE/IESNA Standard 90.1–2007 establishes minimum requirements for the energy-efficient design of buildings, with these exceptions: single-family houses; multifamily structures of 3 habitable stories or fewer above grade; manufactured houses (mobile and modular homes); buildings that do not use either electricity or fossil fuel; and equipment and portions of buildings systems that use energy primarily for industrial, manufacturing, or commercial processes. Building envelope requirements are provided for semi-heated spaces, such as warehouses. Please refer to ASHRAE 90.1–2007, Section 2 for further details.

Option 1 of EA Prerequisite 2 and EA Credit 1 for *LEED Canada for New Construction* and *Core & Shell* requires documentation of a percentage savings in energy cost using the *LEED Canada Energy Modelling Rules* (see Interpretations under EA Prerequisite 2). The *LEED Canada Energy Modelling Rules* are informative documents for rating the energy efficiency of building designs, but they do not provide verification that the minimum requirements of the code have been met. Instead, they are used to quantify performance that substantially exceeds the requirements of MNECB or ASHRAE Standard 90.1.

For EA Credit 1, Option 1 Path 2, LEED relies extensively on the performance rating method explained in Appendix G. The method provides performance criteria for the components listed in Table 1 below.

The performance rating method uses an interactive model that enables project teams to compare the total energy cost for the proposed design with a baseline design. For modelling purposes, this method simplifies climate data and includes a mechanical system and process loads in both designs. See the Calculations section for more information on achieving compliance with the credit.

TABLE 1. ENERGY STANDARD REQUIREMENTS ADDRESSED BY ASHRAE 90.1–2007

ASHRAE 90.1–2007 COMPONENTS
Section 5. Building envelope (including semi-heated spaces, such as warehouses)
Section 6. Heating, ventilation, and air-conditioning (including parking garage ventilation, freeze protection, exhaust air recovery, and condenser heat recovery for service water heating)
Section 7. Service water heating (including swimming pools)
Section 8. Power (including all building power distribution systems)
Section 9. Lighting (including exit signs, building exterior, grounds, and parking garages)
Section 10. Other equipment (including all permanently wired electrical motors)

ASHRAE Advanced Energy Design Guide for Small Office Buildings, 2004
http://www.ashrae.org
The *Advanced Energy Design Guide* series provides a sensible approach to achieving advanced levels of energy savings without having to resort to detailed calculations or analysis. This guide is for office buildings up to 1,860 square metres (20,000 square feet); such buildings make up the bulk of office space in North America. The strategies provide benefits and savings for the building owner while maintaining the quality and functionality of the office space.

ASHRAE Advanced Energy Design Guide for Retail Buildings 2006
http://www.ashrae.org
The *Advanced Energy Design Guide* series provides a sensible and easy approach to achieving advanced levels of energy savings without having to resort to detailed calculations or analysis. This guide focuses on retail buildings up to 1,860 square metres (20,000 square feet) that use unitary heating and air-conditioning equipment; such buildings represent a significant amount of commercial retail space in North America.

EA	
NC	Credit 1
CS	Credit 1

ASHRAE Advanced Energy Design Guide for Small Warehouses and Self-Storage Buildings 2008
http://www.ashrae.org
The *Advanced Energy Design Guide* series provides a sensible and easy approach to achieving advanced levels of energy savings without having to resort to detailed calculations or analysis. This guide focuses on warehouses up to 4,645 square metres (50,000 square feet) and self-storage buildings that use unitary heating and air-conditioning equipment; such facilities represent a significant amount of commercial warehouse space in North America.

ASHRAE Advanced Energy Design Guide for K-12 School Buildings
http://www.ashrae.org
The *Advanced Energy Design Guide* series provides a sensible and easy approach to achieving advanced levels of energy savings without having to resort to detailed calculations or analysis. This guide focuses on elementary, middle, and high school buildings, which have a wide variety of heating and air-conditioning requirements. Options for daylighting, an important component in schools, are included.

New Buildings Institute, Advanced Buildings™ Core Performance™ Guide
The Advanced Building program provides a prescriptive plan for exceeding the energy performance requirements of ASHRAE 90.1–2004. The program was designed to provide a predictable alternative to energy performance modelling and a simple set of criteria for increasing building energy performance significantly. To use this option, projects cannot have a window-to-wall ratio greater than 40%.

The Advanced Building Core Performance program updates and replaces the Advanced Building Benchmarked program. Core Performance is calibrated to exceed the requirements of ASHRAE 90.1–2004 in all climate zones.

Information about the Core Performance program requirements and a range of additional reference material is available at www.advancedbuildings.net.

Several aspects of the Core Performance program overlap with other LEED credits and prerequisites. Following the Core Performance program is not an alternative path to achieving any LEED credits other than EA Credit 1, Optimize Energy Performance, but Core Performance may facilitate earning other LEED credits and prerequisites.

4. IMPLEMENTATION

OPTION 1. WHOLE BUILDING ENERGY SIMULATION

Energy modelling is an effective way to rate building energy performance and compare the costs and benefits of different energy efficiency strategies. All energy simulations must be done in accordance with the *LEED Canada Energy Modelling Rules*.

The terminology used by the performance rating method is used in this LEED credit. Proposed building performance is "the annual energy cost calculated for a proposed design." Baseline or Reference building performance is "the annual energy cost for a building design intended for use as a baseline for rating above standard design." *The LEED Canada Energy Modelling Rules* describe procedures for establishing the proposed building performance and the baseline building performance to evaluate the percentage improvement in energy cost for the project.

The performance rating method requires developing an energy simulation model for the proposed design, which is then used as the basis for generating the baseline design energy simulation model. As the design progresses, any updates made to the proposed design energy

EA	
NC	Credit 1
CS	Credit 1

simulation model (such as changes to the building orientation, wall area, fenestration area, space function, HVAC system type, and HVAC system sizing) should also be reflected in the baseline design energy simulation model.

The performance rating method enables the design team to identify the interactive effects of energy efficiency measures across all building systems. For example, a change to the proposed lighting power affects both heating and cooling energy consumption. When building lighting power density is decreased, the model will indicate how much additional summertime cooling energy is saved (because of lower internal loads) and how much the peak cooling equipment can be downsized (for first-cost savings). The greatest savings will accrue in the hottest climates and the least savings in the coldest climates, but in almost all cases, reducing lighting power density will achieve savings beyond the lighting alone.

The performance rating method requires that annual energy cost expressed in dollars be used to calculate the percentage improvement in energy usage. Annual energy costs are determined using rates for purchased energy, such as electricity, gas, oil, propane, steam, and chilled water, that are published by the local utility or fuel provider including demand, meter and billing costs (see the *LEED Canada Energy Modelling Rules*).

STRATEGIES

Four fundamental strategies can increase energy performance:

- Reduce demand by optimizing building form and orientation, reducing internal loads through shell and lighting improvements, and shifting load to off-peak periods.
- Harvest free energy by using site resources such as daylight, ventilation cooling, solar heating and power, and wind energy to satisfy needs for space conditioning, service water heating, and power generation.
- Increase efficiency with a more efficient building envelope, lighting system, and HVAC systems and by using appropriately sized HVAC systems. More efficient systems reduce energy demand and energy use.
- Recover waste energy through exhaust air energy recovery systems, greywater heat recovery systems, and cogeneration. When applying these strategies, establish and document energy goals and expectations and apply appropriate modelling techniques to assess achievement of the goals.

OPTION 2. PRESCRIPTIVE COMPLIANCE PATH, ASHRAE ADVANCED ENERGY DESIGN GUIDE

To comply with the prescriptive measures of the ASHRAE Advanced Energy Design Guide, first identify the climate zone where the building is located. Then, find the appropriate climate zone table that identifies the recommended roofs, walls, floors, slabs, doors, vertical glazing, skylights, interior lighting, ventilation, ducts, energy recovery, and service water heating.

EA	
NC	Credit 1
CS	Credit 1

CS

To apply for credit under this option, a Core & Shell project must comply with all requirements for the ASHRAE Advanced Energy Design Guidelines, including those that may be in the tenant's scope of work. A sales agreement or tenant lease may be necessary.

NC & CS

ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004
For office buildings smaller than 1860 square metres (20,000 square feet), the ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004 provides an effective means of limiting building energy usage and documenting improved building energy performance without using a building energy model. The climate-specific recommendations listed in the guide should be incorporated in the project early in the building design to optimize building performance and minimize costs.

ASHRAE Advanced Energy Design Guide for Small Retail Buildings 2006
The ASHRAE Advanced Energy Design Guide for Small Retail Buildings 2006 applies to retail buildings smaller than 1,860 square metres (20,000 square feet). Comply with all applicable criteria as established in this guide for the climate zone in which the building is located.

ASHRAE Advanced Energy Design Guide for Small Warehouses and Self-Storage Buildings 2008.
Warehouse and self-storage buildings smaller than 4,645 square metres (50,000 square feet) can use the ASHRAE Advanced Energy Design Guide for Small Warehouses and Self-Storage Buildings 2008. The climate-specific recommendations listed in this guide should be incorporated in the project early in the building design to optimize building performance and minimize capital costs.

ASHRAE Advanced Energy Design Guide for K–12 School Buildings
The ASHRAE Advanced Energy Design Guide for K–12 school buildings is applicable to school buildings smaller than 18,600 square metres (200,000 square feet).

OPTION 3. PRESCRIPTIVE COMPLIANCE PATH, ADVANCED BUILDINGS™ CORE PERFORMANCE GUIDE

Comply with the prescriptive measures identified in the Advanced Building Core Performance Guide developed by the New Building Institute. The following restrictions apply:

- The building must be less than 9,290 square metres (100,000 square feet).
- Health care, warehouse, laboratory projects or other building types that differ significantly from office or retail projects are not eligible.
- The building must have a window-to-wall ratio of less than 40%.

EA	
NC	Credit 1
CS	Credit 1

- Project teams must fully comply with Section 1, Design Process Strategies, and Section 2, Core Performance Requirements.

Option 3 (1 point)

This point is available for all office, school, public assembly, and retail projects smaller than 9,290 square metres (100,000 square feet) that comply with Section 1, Design Process Strategies, and Section 2, Core Performance Requirements, of the Core Performance Guide. The topics addressed in Sections 1 and 2 are as follows:

1.1. — Identify design intent

1.2. — Communicating design intent

1.3. — Building configuration

1.4. — Mechanical system design

1.5. — Construction certification (acceptance testing)

1.6. — Operator training and documentation

1.7. — Performance data review

2.1. — Energy code requirements

2.2. — Air barrier performance

2.3. — Minimum indoor air quality performance

2.4. — Below-grade exterior insulation

2.5. — Opaque envelope performance

2.6. — Fenestration performance

2.7. — Lighting controls

2.8. — Lighting power density

2.9. — Mechanical equipment efficiency requirements

2.10. — Dedicated mechanical systems

2.11. — Demand control ventilation

2.12. — Domestic hot water system efficiency

2.13. — Fundamental economizer performance

Option 3 (up to 2 additional points):

These points are available to projects that implement the performance strategies listed in Section 3, Enhanced Performance, of the Core Performance Guide. The strategies that can be implemented for credit under Option 3 are as follows:

3.2. — Daylighting and controls

3.3. — Additional lighting power reductions

3.4. — Plug loads, appliance efficiency

3.5. — Supply air temperature reset (VAV)

3.6. — Indirect evaporative cooling

3.7. — Heat recovery

3.9. — Premium economizer performance

3.10. — Variable speed control

3.11. — Demand-responsive buildings (peak power reduction)

3.12. — On-site supply of renewable energy

3.14. — Fault detection and diagnostics

For every 3 strategies implemented from this section, 1 point is available.

The following strategies are addressed by other aspects of the LEED program and are not eligible for additional points under EA Credit 1:

3.1. — Cool roofs

3.8. — Night venting

3.13. — Additional commissioning

COMBINED HEAT AND POWER (CHP)

Combined heat and power (CHP) systems capture the heat that would otherwise be wasted in traditional fossil fuel generation of electrical power; these integrated systems are therefore much more efficient than central station power plants and separate thermal systems. CHP systems also produce fewer emissions than traditional generators burning fossil fuels. Other benefits include reductions in peak demand, release of electrical grid system capacity, and reductions in overall electrical system transmission and distribution losses.

CHP systems that supply electricity and/or recovered thermal energy to LEED project buildings are treated in the *LEED Canada Interpretation Guide for District Energy Systems*.

CHP CASES AND CALCULATION OF BENEFIT

TABLE 2. CHP CASES

CASE	OWNERSHIP OF CHP VS. BUILDING	CHP LOCATION	ELECTRICITY	RECOVERED THERMAL
1	Same	Inside building	All in building and/or sold to the grid	All in building
2	Different (3rd party in building)	Inside building	All in building	All in building
3	Same (campus district energy plant)	District energy plant	Campus electrical supply and/or exported to grid	Campus thermal energy supply
4	Different (commercial district energy plant	District energy plant	Campus electrical supply and/or exported to grid	District thermal energy supply

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CASE 1. SAME OWNERSHIP, CHP INSIDE BUILDING

In accordance with the performance rating method, the parameters of the calculation of the CHP benefit are as follows:

The baseline building's heating and cooling plant utilizes the backup energy source of the design, or electricity if no backup source is present or specified.

When all electricity and thermal outputs (heating or cooling) of the CHP are used within the design building, the electricity produced is considered free, as is the produced thermal energy. The input fuel for the CHP and any additional purchased energy is charged to the design building.

In some cases, some electricity generated by the CHP is sold to the grid or an external customer. Thermal and electrical outputs of the CHP used within the design building are treated as above. All electricity sold externally is a "process," and both the design and the baseline buildings are charged with the input fuel associated with the generation of that electricity. (The sold electricity is irrelevant to the calculations other than for the purpose of determining the associated fuel input.) The thermal output generated from the process and used by the design is considered free.

CONSIDERATIONS FOR SIMULATION OR CALCULATION

The performance rating method requires hourly calculation of the CHP performance, either directly through simulation of the system or manual post-processing of the hourly simulation results. This captures hourly effects of load coincidence and electrical demand reduction, plus any declining block or time-of-day utility rate structures. The approach is used to determine the net design building hourly energy use after the CHP contribution and then apply the prevailing conventional utility rates. However, it may be possible to conduct the calculation on a net annual basis if hourly load, demand, or utility rate relationships are insignificant.

CASE 2. DIFFERENT OWNERSHIP, CHP INSIDE THE BUILDING

The rates charged to a building by a CHP developer or operator for electricity and thermal outputs typically include factors for capital recovery, maintenance, and other non-energy costs. Since these types of costs are not included in the performance rating method calculation for other energy efficiency equipment and measures within the design building, they are also excluded for the CHP calculation, regardless of who owns the system. Essentially, the CHP system in Case 2 is treated the same as in Case 1, with the input fuel charged to the design building (at the prevailing utility rate as it applies to the design building) for all CHP outputs used within the building, and charged to both the design and the baseline buildings for process electricity sold externally (again at the prevailing rate). As with Case 1, the design building realizes the benefit of thermal outputs resulting from the process electricity generation.

CASES 3 AND 4. DISTRICT CHP

Projects with district CHP must follow all the requirements in the *LEED Canada Interpretation Guide for District Energy Systems*. In principle, Cases 3 and 4 are analogous to Cases 1 and 2 except that a "virtual" CHP system within the design building uses the process electricity defined in the *LEED Canada Interpretation Guide for District Energy Systems*. As with Cases 1 and 2, the calculation of the CHP benefit considers only energy inputs and outputs and ignores all other non-energy cost factors. The parameters of the calculation are as follows:

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The baseline building's heating and cooling plant uses the backup energy source of the design building, or electricity if no backup source is present (as in Cases 1 and 2).

All electricity and thermal output obtained from the district CHP is considered free. Fuel input is charged as follows:

a. When the amount of virtual CHP electricity associated with the amount of thermal output used by the design building at a given point in time is equal to or less than the amount of electricity actually obtained from the district CHP, then the design building is charged with the input fuel associated with the generation of (all) the electricity obtained from the district CHP. The fuel is charged to the design building at the prevailing rate. Any additional energy used by the design building is also charged at market rates.

b. When the amount of virtual CHP electricity associated with the amount of thermal output used by the design building at a given time exceeds the amount of electricity actually obtained from the district CHP, then the excess virtual electricity generation is deemed to be a process (as in Case 1). The associated (excess) input fuel is charged to both the design and the baseline buildings at the prevailing rate.

CONSIDERATIONS FOR SIMULATION OR CALCULATION

Considerations are analogous to Cases 1 and 2. Although hourly calculation is necessary for most cases, either through simulation or manual post-processing of the hourly simulation results, for Cases 3 or 4 it may be possible to conduct the calculation on a net annual basis if hourly load, demand, and/or utility rate relationships are insignificant.

1. The design building must meet EA Prerequisite 2 without the benefit of CHP.
2. Additionally, to qualify for EA Credit 1 consideration under Case 4 (external ownership of the CHP plant with multiple customers), a project must meet the following criteria:
   a. Long-term commitment from the building owner. The project must have in place a long-term agreement (minimum 10 years) to purchase CHP thermal output from the district CHP system.
   b. Building reliance on district system. The project must be reliant on the district system for 90% of its thermal energy (heating, cooling, or both, depending on district service provided to the building), exclusive of any renewable energy (as defined in EA Credit 2).

DISTRICT ENERGY SYSTEMS

For projects with district energy systems, specific technical guidance can be found in the *LEED Canada Interpretation Guide for District Energy Systems* on CaGBC's website (http://www.cagbc.org). Follow the guidance in effect at the time of LEED project registration.

5. TIMELINE AND TEAM

By implementing energy analysis early in the design process, the design team can develop the most effective—and cost-effective—energy conservation strategies.

A simplified model analysis should be done at the end of the schematic design phase to understand the project's overall energy performance. This "shoe-box" analysis will help the architect and the mechanical engineer understand the current building performance and select the energy efficiency measures that can be implemented to achieve the target points.

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The next phase of the energy analysis phase is to develop a detailed energy model that can be submitted for review, as required for this credit. The construction documents must be used for performing a detailed energy model. This model must be revised to include all the modified details so that the final energy model reflects the 100% contract documents.

Team members engaged in energy analysis should work closely with other design team members from the early design phases through construction documentation, when the implemented strategies can be validated and revised. The team members involved during the entire process includes energy analyst (the modeller), architect, mechanical engineer, LEED consultant, and commissioning authority.

6. CALCULATIONS

Option 1 requires software energy simulation; Options 2 and 3 use a prescriptive approach and do not require modelling.

OPTION 1. WHOLE BUILDING SIMULATION

Option 1 relies entirely on building energy simulation and requires extensive calculations using an approved energy simulation program (see the CaGBC's website, http://www.cagbc.org). Refer to the *LEED Canada Energy Modelling Rules* for guidance.

Both the baseline building model and the proposed building model must cover all building energy components, including, but not limited to, office and general miscellaneous equipment, computers, elevators and escalators, kitchen cooking and refrigeration, laundry washing and drying, lighting exempt from the lighting power allowance (e.g., lighting integral to medical equipment), and other (e.g., waterfall pumps). Regulated (non-process) energy includes lighting (such as for the interior, parking garage, surface parking, façade, or building grounds, except as noted above), HVAC (such as for space heating, space cooling, fans, pumps, toilet exhaust, parking garage ventilation, and kitchen hood exhaust), humidification and service water heating for domestic or space heating purposes.

For EA Credit 1, process loads must be identical for both the baseline building performance rating and the proposed building performance rating. However, project teams may get credit for some reductions in process loads (see Interpretations under EA Prerequisite 2).

Design criteria, including both climate data and interior temperature and humidity setpoints, must be the same for the proposed and baseline building models. Furthermore, heating must be modelled in all conditioned spaces of both the proposed and the baseline building. Cooling systems may be undersized or not included provided consistent comfort conditions are maintained between the proposed and baseline building models (refer to the *LEED Canada Energy Modelling Rules* for guidance).

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MODELLING REQUIREMENTS FOR BASELINE AND PROPOSED CASE BUILDING

The following table summarizes the modelling requirements for typical projects. Project-specific information will vary; refer to the cited tables and sections of the referenced standard for all applicable details and modelling requirements.

BASELINE CASE	*LEED CANADA FOR NEW CONSTRUCTION* PROPOSED CASE	*LEED CANADA FOR CORE & SHELL* PROPOSED CASE
SCHEDULE OF OPERATION		
Same as proposed design. Exception: schedules may differ from proposed design if proposed design is implementing some nonstandard efficiency measures.	Use actual operating hours for schedule of operation in proposed design. Exception: schedules can be modified if schedule changes are necessary to model nonstandard efficiency measures such as lighting controls, natural ventilation, demand control ventilation, or service water heating load reductions. Describe any schedule of operation differences between baseline building model and proposed building.	Same as *LEED Canada for New Construction*.
ORIENTATION		
Baseline design simulations are required for generating baseline building performance. Models are identical except under the ASHRAE path the building orientation for each model is modified as described in Table G3.5.1(a), and window solar heat gain coefficients are revised to reflect minimum ASHRAE building envelope requirements for revised building orientation.	Proposed design models building as designed (with minor exceptions).	Same as *LEED Canada for New Construction*.

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BUILDING ENVELOPE		
Model building envelope for baseline design. **New buildings** Model above-grade walls, roof, and floor assemblies using lightweight assembly types (i.e., steel-framed walls, roofs with insulation entirely above deck, and steel-joist floors). Match values with appropriate assembly maximum U-factors in the standards. **Existing Buildings** Model building envelope using existing (preretrofit) building envelope thermal parameters rather than referenced standard's prescriptive building envelope requirements for specified climate.	Building components must be modelled as shown in architectural drawings. **Existing Buildings** Model must include any renovations in existing building envelope (such as replacing windows or increasing roof insulation).	Same as *LEED Canada for New Construction*.
Match percentage of vertical fenestration in baseline and proposed designs, or use 40% of gross wall area, whichever is less. Distribute windows on each face of building in same proportion as in proposed design. Fenestration U-factor must match appropriate requirements in the standards.	Model fenestration location and its properties (U-value, solar heat gain coefficient, and transmittance) as shown on architectural drawings.	Same as *LEED Canada for New Construction*.
Use fixed vertical glazing in baseline design, flush to exterior wall with no shading projections. Manually controlled interior shading devices, such as blinds or curtains can be included in the model provided they are included in both the baseline and proposed designs.	Shading projections in proposed design, which reduce solar gains on glazing, can also be modelled to demonstrate energy savings compared with baseline. Manually controlled interior shading devices such as blinds and curtains can be modelled provided they are included in both the baseline and proposed designs. Automatically controlled interior shading devices can be modelled.	Same as *LEED Canada for New Construction*.
Model all roof surfaces with reflectivity of 0.30.	"Cool roofs" (light-coloured roof finishes that have low heat absorption) can be modelled to show impact of reduced heat gains. Model proposed roof with solar reflectance greater than 0.70 and emittance greater than 0.75 with reflectivity of 0.45 (accounting for degradation in actual reflectivity) versus default reflectivity value of 0.30	Same as *LEED Canada for New Construction*.

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LIGHTING SYSTEMS		
LEED Canada for New Construction Model lighting using building area or space-by-space method depending on proposed design categorization. The baseline design model should also include exterior lighting power allowance . ***LEED Canada for Core & Shell*** Model lighting power in core and shell areas as determined by space type classification. **Tenant Spaces** Model separate electric meters for lighting in core building and tenant spaces. Use lighting power allowances for each space as indicated in the standards.	Model proposed design with installed lighting power density for each thermal block and account for all installed lighting on site including interior ambient and task lighting, parking garage lighting, and exterior lighting.	Model proposed design with installed lighting power density and account for all installed lighting on site including interior ambient and task lighting, parking garage lighting and exterior lighting. AND For core and shell project areas where no lighting system has been specified, model these spaces identically in both baseline and design cases as minimally code compliant according to building area method using appropriate space type classification in Table 9.6.1. **Tenant Spaces** Model separate electric meters for lighting in core building and tenant spaces. If tenant lighting is designed or installed, use as-designed values; otherwise classify space types for building spaces and use lighting power allowances for each space as indicated in the standards.
Do not take credit for automatic lighting controls such as daylight controls, occupancy controls, or programmable controls.	Model any daylight responsive lighting control systems directly in proposed design energy simulation. Credit can also be taken for occupant sensor lighting controls in spaces where they are not mandatory; however, note that such controls are mandatory under the ASHRAE path per Section 9.4.1.2 in classrooms, conference rooms and employee lunch and break rooms.	Same as *LEED Canada for New Construction*.
Excepted interior lighting power allowance is classified as process energy and must be identical to proposed case.	Lighting excepted from interior lighting power allowance should be modelled in proposed design; however, this lighting should be considered process energy.	Same as *LEED Canada for New Construction*.

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HVAC SYSTEM SELECTION		
Determine HVAC system type using actual building area, usage, quantity of floors, occupancy (residential or nonresidential), and heating fuel source per standard's requirements. Use same baseline HVAC system type for entire building except for, areas where occupancy, process loads or schedules differ significantly from rest of building or areas with varying pressurization, cross-contamination requirements.	Proposed design HVAC system type, quantities, should reflect actual design parameters except in cases where either heating system or cooling system has not been specified. If no cooling system has been specified, proposed design and baseline design shall be modelled to maintain equivalent comfort conditions (i.e., no more than a difference of 100 unmet load hours between the proposed and baseline). If no heating system has been specified, proposed design should assume electric heating. For areas of project without heating or cooling systems (such as parking garages), there is no need to model heating or cooling systems in either proposed or baseline designs.	Model building system as described in design documents. If HVAC system is not yet designed, use same HVAC system as baseline case.
HVAC equipment capacities for baseline system should be oversized according to standard's requirements.	Proposed design HVAC system should reflect actual design capacities and system efficiencies.	Same as *LEED Canada for New Construction*.
Unmet load hours (occupied periods where any zone is outside its temperature setpoints) may not be exceeded by more than 100 hours. Also, unmet load hours for proposed design may not exceed unmet load hours for baseline design by more than 50 (G3.1.2.2). It is acceptable to have unmet cooling hours in the Proposed and Baseline simulations if limited mechanical cooling capability is provided.	Same as baseline case.	Same as baseline case.
Outdoor ventilation rates should be identical to proposed case unless ventilation rate is 20% greater than ASHRAE 62-2007 requirement.	Proposed design should reflect actual outdoor ventilation rates. Exceptions are given for demand controlled systems.	Same as *LEED Canada for New Construction*.

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Operate fan continuously when spaces are occupied and cycle it during unoccupied hours. Except for spaces that have mandated minimum ventilation requirements, fan must remain on during occupied hours for health and safety reasons. Baseline system fan supply air volume should be based on a supply-air-to-room-air temperature difference of 9 C (20˚F) or required ventilation or makeup air, whichever is greater. Use this supply air volume to calculate total fan power for baseline system design. This value reflects sum of power modelled for supply, exhaust, return, and relief fans.	The proposed HVAC design should reflect actual fan operation, fan supply rate and fan motor horse power.	Same as *LEED Canada for New Construction*.
Fan energy must be separated from cooling system. Overall efficiency rating, such as an energy efficiency ratio, must be separated into component energy using coefficient of performance or other conversion.	Same as baseline case.	Same as baseline case.
Model economizers and exhaust air energy recovery systems in baseline HVAC systems when required for given climate zone and system parameters.	Include economizers if indicated in actual design parameters.	Same as *LEED Canada for New Construction*.
Follow HVAC system-specific requirements (chillers, boilers, heat pumps) as indicated in the standards.	System-specific requirements should reflect actual conditions.	System-specific requirements should reflect actual conditions. OR If system-specific requirements are not specified, HVAC system must be identical to baseline case system.

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PROCESS ENERGY		
LEED Canada for New Construction Process loads must be identical to proposed building. Occupancy and occupancy schedules may not be changed. However, variations of power requirements, schedules or control sequences are allowed based upon documentation that installed equipment in proposed design represents significant verifiable departure from documented conventional practice. ***LEED Canada for Core & Shell*** Model separate meters for tenant receptacle loads and process loads. Use same values for receptacle loads as used in proposed building.	Process energy includes office and general miscellaneous equipment, computers, elevators and escalators, kitchen cooking and refrigeration, laundry washing and drying, lighting exempt from lighting power allowance (e.g., lighting integral to medical equipment), and other (e.g., waterfall pumps). The standards provide acceptable receptacle power densities per occupancy type, which can be incorporated into building energy models. Other process energy inputs such as elevators, escalators, data center and telecom room computing equipment, refrigeration, process lighting, and non-HVAC motors should be modelled based on actual power requirements, and assuming reasonable schedules of operation. Include documentation substantiating that process energy inputs are appropriate.	Same as *LEED Canada for New Construction*. **Tenant spaces** Model separate meters for tenant plug loads and process loads. Use values indicated in the standards to model tenant plug loads or provide documentation for modelled loads.
ENERGY RATES		
Use same rates for both baseline and proposed building.	Rates from local utility schedules are default option to compute energy costs. However, intent is to encourage simulations that provide owners value and help them minimize their energy costs. Regardless of source of rate schedule used, same rate schedule must be used in both baseline and proposed simulations.	Same as *LEED Canada for New Construction*. **Tenant spaces** Energy-using components are metered and apportioned and/or billed to tenant. Tenant will pay for components.
SERVICE HOT WATER SYSTEM		
Service hot water must use same energy sources as proposed building. System-related specific parameters must be modelled as indicated in the standards.	Service hot water system type and its related performance parameters must be modelled to reflect actual system installed or designed in design documents.	Same as *LEED Canada for New Construction*.

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CREDIT FOR TENANT-IMPLEMENTED EFFICIENCY MEASURES

Under the *LEED Canada for Core & Shell* Rating System, project teams can claim efficiency improvements and therefore additional points under this credit for measures implemented by a tenant. The measures for which the project team is claiming credit must be included in the tenant's lease agreement and be enforceable by the owner through the lease agreement. The project team must provide a list of such measures, the level of performance expected to be met by the tenant, and a copy of the lease agreement. These credits are available only if the lease agreement is enforceable, not if it is simply a tenant guideline.

STRATEGIES WITH EXCEPTIONAL MODELLING REQUIREMENTS

1. Projects with natural ventilation may be able to take credit for natural ventilation in the energy modelling. However, projects demonstrating natural ventilation savings will be evaluated on a case-by-case basis. To adequately demonstrate the process and the results, provide the following:
   - Detailed project description.
   - Clear identification of the areas that qualify for natural ventilation credit.
   - Detailed description or references that document the modelling algorithms and/or methodology for the natural ventilation portion of the energy model.
   - All thermostat, fan, infiltration, and other appropriate schedules for naturally ventilated areas.

   Also demonstrate that the range of unmet load hours is similar for both the proposed and the baseline building, to ensure that savings are not claimed for hours outside the control parameters.

   Clearly demonstrate that the operational schedule for the natural ventilation system as modelled aligns with occupants' anticipated behaviour.

   Because manual control is not addressed by the modelling methodology, any manual control features must be submitted for case-by-case review. Be prepared to demonstrate convincingly that a manual control strategy is appropriate and workable.
2. On-site renewable energy and site-recovered energy costs are not included in the proposed case; therefore, these systems receive full credit using the performance rating method.

   Examples of on-site renewable energy systems include power generated by photovoltaics or wind turbines, and thermal energy collected by solar panels. Examples of site-recovered energy include heat recovered with chiller heat recovery systems or waste heat recovery units on distributed generation systems.

   When the actual building design incorporates on-site renewable or site-recovered energy, the baseline design should be modelled based on the backup energy source for the actual building design, or electricity if no backup energy source is specified. Proposed

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building performance can be determined using 1 of the following 2 methods when on-site renewable energy or site-recovered energy is incorporated into the building project:

1. Model the systems directly in the proposed design energy model. If the building simulation program is capable of modelling the on-site renewable or site-recovered energy systems, these systems can be modelled directly within the building energy model. The model should reflect the cost savings achieved through the on-site renewable or site-recovered energy systems.
2. Model the systems using the exceptional calculation method. If the building simulation program is not capable of modelling the on-site renewable or site-recovered energy systems, the energy saved by these systems can be calculated using the exceptional calculation method. The renewable or site-recovered energy cost can then be subtracted from the proposed building performance.

EXCEPTIONAL CALCULATION METHOD

Exceptional calculation methods must be used to document any measures that cannot be adequately modelled in a simulation program.

Examples of measures that may be modelled using the exceptional calculation method include improvements to laboratory or kitchen exhaust systems, improved appliance efficiencies in high-rise residential buildings, greywater heat recovery, flat-panel LCD computer monitors, improvements to refrigeration equipment efficiency, and zone variable air volume (VAV) occupant sensor controls.

Documentation of energy savings using the exceptional calculation method must include the following:

- Assumptions made for both the baseline and the proposed design.
- Theoretical or empirical information supporting these assumptions.
- Specific energy cost savings achieved based on the exceptional calculation.

COMMON MISTAKES MADE USING THE PERFORMANCE RATING METHOD

The following is a list of mistakes to avoid when using the performance rating method for EA Credit 1 calculations and submittals:

- Incorrect use of the ASHRAE energy cost budget method (Section 11) rather than the performance rating method (Appendix G).
- Opaque assembly (wall, roof, and slab) values are not correctly accounted for in the baseline case. ASHRAE requires using lightweight assembly type (i.e., steel-framed walls, roofs with insulation entirely above deck, and steel-joist floors). Proposed project values must account for thermal bridging (e.g., steel studs, spandrel panels).
- Center-of-glass performance is incorrectly used rather than fenestration assembly U-factor and solar heat gain coefficient (SHGC). The building envelope requirements listed for each climate zone refer to fenestration assembly maximum U-factors and SHGCs for glazing. The fenestration assembly performance accounts for the effects of both the frame and the glazing. To determine the fenestration assembly U-factor and SHGC, use ASHRAE Handbook of Fundamental or FRAMEplus On-line values. Alternatively, the fenestration U-factors, SHGCs, and visual light transmittance must be certified and labelled in accordance with NFRC 100, 200, and 300, or CSA A440.2.

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- Baseline design window area percentages are not calculated in accordance with the performance rating method.
- Baseline design fenestration is not uniformly distributed on each face of the building in the same proportion as in the proposed design.
- Models mistakenly include manually operated shading devices, which are ineligible under this credit; only automatically controlled shades or blinds should be modelled.
- The proposed design does not account for portable (task) lighting.
- Nontradable surfaces (such as building façades) are incorrectly treated as tradable surfaces for determining the exterior lighting power allowance.
- The baseline design is modelled with the automatic lighting controls (such as daylight sensors, occupancy sensor).
- The baseline HVAC system type is incorrectly determined.
- The baseline system capacities, design supply air volume, or total fan power are incorrectly calculated.
- The outdoor air ventilation volume for the baseline building is not adjusted for over-ventilation.
- The manufacturer's overall cooling energy efficiency ratings (EERs) are not separated into the component energy using the coefficient of performance or other conversion factors in accordance with ASHRAE 90.1-2007 requirements. Fan power is not deducted from the packaged equipment's EER values.
- The quantities and/or types of chillers and boilers are not determined in accordance with the performance rating method.
- The hot water and chilled water pump powers are not calculated in accordance with the performance rating method.
- Insufficient information is provided for energy measures incorporating the exceptional calculation methodology. Please refer the documentation required under exceptional calculations method above.
- Energy consumption is incorrectly used to calculate the percentage improvement rather than energy cost.
- The process loads in the proposed and the baseline designs are not identical. Further, no detailed explanation of the inputs is provided to assess the percentage change.
- Demand control ventilation is modelled as energy efficiency measures, and no information regarding the modelling process is provided.
- The number of unmet load hours for the proposed design exceeds that of the baseline design by more than 100 hours.

CALCULATING THE PERCENTAGE IMPROVEMENT

First, the whole-building simulations are used to produce reports that show the total cost for electricity, gas, and possibly other energy sources, such as steam and chilled water. The total annual energy cost calculated for the proposed design simulation is the proposed building performance. Under the ASHRAE path, the average total energy cost for the 4 orientations simulated for the baseline design is the baseline building performance. The MNECB uses the

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same orientation for proposed and reference or baseline buildings.

The total percentage improvement (energy savings) for the proposed case compared with the baseline case is calculated with this equation:

$$\text{Percentage Improvement} = 100 \times \left(1 - \frac{\text{Proposed Building Performance}}{\text{Baseline Building Performance}} \right)$$

Separate point scales are provided for new and existing buildings in recognition of the constraints inherent in renovating an existing shell compared with new construction.

OPTION 2. PRESCRIPTIVE COMPLIANCE PATH: ASHRAE ADVANCED ENERGY DESIGN GUIDE

There are no calculations required for Option 2.

OPTION 3. PRESCRIPTIVE COMPLIANCE PATH: ADVANCED BUILDINGS™ CORE PERFORMANCE™ GUIDE

There are no calculations required for Option 3.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED letter templates for the complete descriptions of all required documentation.

- For ASHRAE compliance, list any addenda used.
- Determine the climate zone for the project location.
- Calculate energy use by type.
- Maintain a list of energy end uses for the project building (for both the baseline case and the design case).
- If the project is using a computer energy simulation, adhere to the *LEED Canada Energy Modelling Rules* and retain the final report indicating the annual energy cost of the baseline and design cases as well as the simulation output files. Also prepare a modelling report describing the assumptions used in the model. Computer simulation files must be prepared by or reviewed by an individual on the CaGBC's Experienced Modeller List (refer to CaGBC's website, http://www.cagbc.org).
- If the project is using the prescriptive compliance path, assemble documentation demonstrating that the project meets all requirements applicable to the selected prescriptive path.

8. EXAMPLES

OPTION 1. WHOLE BUILDING SIMULATION, PATH 2: ASHRAE 90.1-2007

The project building is a 9,290 square metre (100,000-square-foot) office building, and the team is using the performance rating method. The design case uses a high-performance envelope

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with 23% glazing, "Super T8" direct and indirect ambient lighting with supplemental task lighting, a VAV system that receives chilled water from a 400-ton variable-speed electric chiller, and 20 kW of photovoltaic panels installed on the roof. Using the performance rating method system map, the budgeted HVAC system type is modelled as a packaged VAV system with hot water reheat, variable speed fan control, and direct expansion cooling.

To determine the proposed building performance, the energy modeller creates an energy simulation model for the design building using DOE-2, DOE EnergyPlus, EE4, eQUEST, or other CaGBC approved hourly load and energy modelling software tool (refer to CaGBC's website, http://www.cagbc.org). The model parameters for all loads, including receptacle and process loads and the expected building occupancy profile and schedule, are adjusted to determine central system capacities and energy use by system. Through parametric manipulation, the energy modeller, working with the design team, increases component efficiencies to exceed the referenced standard. The energy generated by the photovoltaic panels is calculated using RETScreen (or other suitable program).

The proposed building performance is calculated as the total projected energy cost for the design energy model minus the energy generated by the photovoltaic panels as calculated in RETScreen.

The baseline building performance is then calculated by adjusting the model parameters to meet the requirements listed in ASHRAE 90.1-2007, Appendix G. The baseline model includes the same plug and process loads and an identical building occupancy profile and schedule as the proposed design to determine central system capacities and energy use by system.

For the baseline model, the energy modeller redistributes the glazing uniformly across all 4 building orientations but otherwise models the baseline glazing percentage identically to the proposed design because the ratio of window-to-wall area for the proposed design is less than 40%. The energy modeller adjusts the construction assembly types in accordance with ASHRAE 90.1-2007, Table G3.1.5, and to meet minimal building envelope requirements for the building's climate zone. The baseline HVAC system type is modelled as a packaged VAV system with hot water reheat (ASHRAE 90.1-2007, Table G3.1.1.A). The energy modeller uses prescribed ASHRAE 90.1-2007 HVAC system component efficiencies and performs sizing runs to determine the fan supply air volume, and then uses this volume to calculate the total fan brake horsepower and the total fan power of the baseline case.

The energy modeller first performs the baseline design simulation with the actual building orientation, and then with the building rotated 90°, 180°, and 270°. (Note: this step is not required under the MNECB path.) The energy modeller takes the average of the total annual energy cost simulated for the 4 baseline simulations to establish the baseline building performance. The percentage improvement can be calculated according to Equation 1.

Equation 1

$$\text{Percentage Improvement} = 100 \text{ X } \left(1 - \frac{\text{Proposed Building Performance}}{\text{Baseline Building Performance}} \right)$$

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9. EXEMPLARY PERFORMANCE

OPTION 1. WHOLE BUILDING SIMULATION

Projects that use Option 1 and demonstrate a percentage improvement in the proposed building performance rating compared with the baseline building performance rating per MNECB or ASHRAE 90.1-2007 by the following minimum energy cost savings percentages will be considered for 1 additional point under the Innovation in Design category:

	MNECB	ASHRAE 90.1-2007
New Building	58%	50%
Existing Building Renovation	54%	46%

OPTION 2. PRESCRIPTIVE COMPLIANCE PATH: ASHRAE ADVANCED ENERGY DESIGN GUIDE

There is no exemplary performance point available for Option 2.

OPTION 3. PRESCRIPTIVE COMPLIANCE PATH: ADVANCED BUILDINGS™ CORE PERFORMANCE™ GUIDE

There is no exemplary performance point available for Option 3.

10. REGIONAL VARIATIONS

Regional variance is already represented in both MNECB and ASHRAE 90.1-2007, which account for the climate types and their minimum envelope and glazing property requirements.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Ensuring that the building systems are functioning properly and tracking energy use can save energy and operating costs. *LEED Canada for Existing Buildings: Operations & Maintenance* covers this topic in EA Credit 1, Optimizing Energy Efficiency Performance.

12. RESOURCES

WEBSITES

American Society of Heating, Refrigerating and Air-Conditioning Engineers
http://www.ashrae.org

ASHRAE has developed a number of publications on energy use in existing buildings, including Standard 100–1995, Energy Conservation in Existing Buildings. This standard defines methods for energy surveys, provides guidance for operation and maintenance, and describes building and equipment modifications that result in energy conservation. 2 publications referenced by this credit (ANSI/ASHRAE/IESNA 90.1–2007 and ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004) are available through ASHRAE.

EA	
NC	Credit 1
CS	Credit 1

Canadian Office of Energy Efficiency
http://oee.nrcan.gc.ca/english/index.cfm

The Office of Energy Efficiency (OEE), Canada's centre of excellence for energy conservation, energy efficiency and alternative fuels information, is playing a dynamic leadership role in helping Canadians save millions of dollars in energy costs while contributing to a healthier environment.

DOE-2, Building Energy Use and Cost Analysis Software
http://www.doe2.com

This website includes information from the developers of DOE-2 and DOE-2 products, such as eQUEST, PowerDOE, and COMcheck-Plus.

ecoENERGY Validation of New Building Designs
http://oee.nrcan.gc.ca/commercial/newbuildings/validation.cfm

As part of the ecoENERGY Efficiency Initiative, Natural Resources Canada (NRCan) offers a free service that validates the energy performance level of your building design. Energy-efficient buildings are better for the environment with increased comfort, lower operating costs and higher resale values.

Energy Information Agency, Commercial Building Energy Consumption Survey
http://www.eia.doe.gov

ENERGY STAR®
http://www.energystar.gov

ENERGY STAR is a government-industry partnership managed by the U.S. Environmental Protection Agency and the U.S. Department of Energy. The program's website offers energy management strategies, benchmarking software tools for buildings, product procurement guidelines, and lists of ENERGY STAR-labelled products and buildings.

ENERGY STAR® Building Upgrade Manual
http://www.energystar.gov/index.cfm?c=business.bus_upgrade_manual&layout=print

This document is a guide for ENERGY STAR Buildings Partners to use in planning and implementing energy efficiency upgrades in their facilities, and can be used as a comprehensive framework for an energy strategy.

International Energy Agency Solar Heating and Cooling Programme
http://www.iea-shc.org

New Buildings Institute
http://www.newbuildings.org

The New Buildings Institute is a nonprofit, public-benefits corporation dedicated to making buildings better for people and the environment. Its mission is to promote energy efficiency in buildings through technology research, guidelines, and codes.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy
http://www.eere.energy.gov/buildings

This extensive website for energy efficiency is linked to a number of DOE-funded sites that address buildings and energy. Of particular interest is the tools directory, which includes the Commercial Buildings Energy Consumption Tool for estimating end-use consumption in commercial buildings. The tool allows the user to define a set of buildings by principal activity, size, vintage, region, climate zone, and fuels (main heat, secondary heat, cooling and water heating) and to view the resulting energy consumption and expenditure estimates in tabular form.

EA	
NC	Credit 1
CS	Credit 1

PRINT MEDIA

ANSI/ASHRAE/IESNA Standard 90.1–2007 User's Manual (ASHRAE).

Advanced Lighting Guidelines, 2003 edition (New Building Institute, Inc., 2003). These guidelines are available as a free download or can purchased as a printed manual of 390 pages. http://www.newbuildings.org/lighting.htm

ANSI/IESNA RP-1-04, American National Standard Practice for Office Lighting (IESNA).

Daylight in Buildings: A Source Book on Daylighting Systems and Components, Chapter 5, Daylight-Responsive Controls (Lawrence Berkeley National Laboratory). http://gaia.lbl.gov/iea21/

Design Brief: Lighting Controls Energy Design Resources (Southern California Edison). http://www.energydesignresources.com

Electricity Used by Office Equipment and Network Equipment in the United States: Detailed Report and Appendices, by Kawamoto, et al. (Lawrence Berkeley National Laboratory, February 2001). http://enduse.lbl.gov/Projects/InfoTech.html

Illuminating Engineering Society of North America Lighting Handbook, ninth edition (IESNA, 2000).

Mechanical and Electrical Equipment for Buildings, ninth edition, by Benjamin Stein and John S. Reynolds (John Wiley & Sons, 2000).

Sustainable Building Technical Manual (Public Technology Institute, 1996). http://www.pti.org/index.php/ptiee1/inside/C84

13. DEFINITIONS

Baseline building performance is the annual energy cost for a building design intended for use as a baseline for rating above standard design, as defined in ASHRAE 90.1-2007, Appendix G.

Building Floor Area is the sum of the floor areas of the spaces within the building including basements, mezzanine and intermediate-floored tiers, and penthouses with headroom height of 7.5 ft (2.2 meters) or greater. It is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features. (ASHRAE 90.1 – 2007)

Daylighting is the controlled admission of natural light into a space, used to reduce or eliminate electric lighting.

A district energy system (DES) is a central plant and distribution system that provides energy (heat, cooling and/or electricity) to a group of buildings in a small district. Examples include central plants on university campuses or those that serve the downtown cores of cities. Large-scale utilities that supply energy to large regions, provinces or municipalities, are not considered DESs. Refer to the *LEED Canada Interpretation Guide for District Energy Systems* for further information.

Downstream equipment consists of all heating or cooling systems, equipment, and controls located within the project building and site associated with transporting thermal energy into heated or cooled spaces. This includes the thermal connection or interface with the district energy system, secondary distribution systems in the building, and terminal units.

An **energy simulation model**, or **energy model**, is a computer-generated representation of the anticipated energy consumption of a building. It permits a comparison of energy performance, given proposed energy efficiency measures, with the baseline.

EA	
NC	Credit 1
CS	Credit 1

An **ENERGY STAR** rating is a measure of a building's energy performance compared with that of similar buildings, as determined by the ENERGY STAR Portfolio Manager. A score of 50 represents average building performance.

Lighting power density is the installed lighting power, per unit area.

Model National Energy Code for Buildings (MNECB) 1997 contains cost-effective minimum requirements for energy efficiency in new buildings. The MNECB applies to all buildings, other than houses of three storeys or less, and to additions of more than 10 m^2 to such buildings. The MNECB is prepared under the auspices of the Canadian Commission on Building and Fire Codes (CCBFC) and was first published in 1997 by the National Research Council Canada (NRC).

Percentage improvement measures the energy cost savings for the proposed building performance compared with the baseline building performance.

Plug load is synonymous with **receptacle load**.

Proposed building performance is the annual energy cost calculated for a proposed design, as defined in MNECB and ASHRAE 90.1-2007, Appendix G.

Receptacle (or plug) load is the current drawn by all equipment that is plugged into the electrical system.

Upstream equipment consists of all heating or cooling systems, equipment, and controls that are associated with a district energy system but are not part of the project building's thermal connection or do not interface with the district energy system. It includes the central energy plant and all transmission and distribution equipment associated with transporting the thermal energy to the project building and site.

EA	
NC	Credit 1
CS	Credit 1

14. CASE STUDY

CHILD DEVELOPMENT CENTRE AT THE UNIVERSITY OF CALGARY

LEED Canada-NC 1.0 LEED Platinum, 15 October 2007

Location:	Calgary, Alberta
Building Type:	Office building
Owner Type:	University/College
Building Size:	$11,800m^2$
Owner Name:	University of Calgary
LEED Consultant:	Green Building Services
Responsible Firm:	Kasian Architecture
Photo Credit:	Lemermeyer Photography

The significant energy savings realized at the CDC required a comprehensive approach to building orientation and the planning and design of the program, systems, and envelope. This resulted in efficient equipment and focused on low internal gains, low envelope exchanges, heat recycling, and double-duty systems and a responsive system for lighting, heating, cooling, and ventilation. The project saw substantial energy cost savings of 66% over the Model National Energy Code, which resulted in the building achieving all 10 LEED energy credits.

A high-performance building envelope is essential to the energy performance equation. A continuous 100mm layer of semi-rigid insulation provides RSI 0.76 per 25mm and eliminates thermal breaks between the structure and the various assemblies to maintain a continuous thermal resistance throughout the assembly. On average, the effective thermal resistance of the exterior wall assemblies is 0.43 $W/m^2{}^\circ C$. The roof is a mechanically fastened PVC membrane over 100mm of isocyanurite rigid insulation and the assembly provides an average U-Value of 0.71 $W/m^2{}^\circ C$. The membrane is reflective and not only contributes to mitigating the urban heat island effect, it also helps to reduce peak loading. The glazing, both curtainwall and windows, are thermally broken aluminum frames with double-glazed sealed units. An insulating "super-spacer," argon gas and a low-emissivity coating on the third surface create an insulating unit with an average U-value of 2.1

EA	
NC	Credit 1
CS	Credit 1

W/m²°C and a solar heat gain coefficient of 0.32. The average window-to-wall ratio of 21% provides an effective balance between thermal performance and glazing to allow daylight and view.

The lighting strategy at the CDC effectively harvests daylight where possible and optimizes lighting levels. The average power density is very low in comparison to a typical reference building, being 7.3 W/m^2 throughout the designed spaces compared to a reference of 17.9 W/m^2. Daylight controls are used on the south-side perimeter corridors and the public spaces on the main floor due to the large glazing areas and building orientation. Occupancy controls are utilized throughout to ensure that lighting is only used when a space is occupied. In the designed areas, T8 bulbs with high-efficiency electronic ballasts are housed in custom fixtures that provide a more effective distribution of light to reduce the number of fixtures required.

The ventilation system uses a displacement design. Air is provided primarily through a raised floor system, or in some cases a low sidewall discharge system, at a very effective range of 2 – 2.7 L/s m^2. Using the natural buoyancy of hot air to move air through a space, it provides superior air quality and temperature control while at the same time being a significant reduction in electricity use for driving fans; in some cases as much as 50%. Operable windows and a high number of lighting and temperature controls provide users with a high level of individual controllability.

The HVAC system is a comprehensive design involving CO_2 sensors, occupancy controls, VAV boxes in smaller mechanical zones to reflect building orientation and occupancy patterns, and variable speed motor drivers for heating and cooling. This controllable and responsive system serves to condition areas as required as opposed to maintaining the comfort conditions at all times. Furthermore, radiant cooling panels on the south perimeter efficiently handle the higher peak loads created by the south sun. 96% efficient boilers, high efficiency chillers with variable speed or modulating capacities drive the systems.

Besides optimizing the energy used of the facility, 11.2% of the energy required is supplied by one of the largest solar panel installations integrated into a building network in Canada. The solar panels also shade the south glazing to reduce peak cooling loads. The remainder of the power is supplied from wind farm energy under a two year contract with the energy utility provider.

EA	
NC	Credit 1
CS	Credit 1

GULF ISLANDS NATIONAL PARK RESERVE OPERATIONS CENTRE

LEED Canada-NC 1.0 Platinum, 12 July 2006

Location: Sidney, BC
Building Type: Office Building
Owner Type: Government - Federal
Building Size: 1,100m^2
Owner Name: Parks Canada
LEED Consultant: Larry McFarland Architects Ltd.
Responsible Firm (for this credit): EnerSys Analytics Inc. (energy analysis), Stantec (mechanical)
Photo Credit: Derek Lopper

Islands National Park Reserve Operations Centre was the first project in Canada to achieve the LEED Platinum certification level. The sustainable design of this project is based upon the notion that in the isolated environment prevalent in the island ecology of this National Park, a sustainable building must respond to its site and environment to minimize its dependence on outside sources of energy and services. The design of the project was guided by this principle and is a demonstration of how this can be achieved using off-the-shelf technologies.

The lowest level of the three-storey facility is oriented to the waterfront and is primarily a support facility for the field operations. The upper two floors accommodate the administrative functions of the park. The main entry/lobby also serves an interpretive function.

The integrated design process included an "energy performance workshop" (EPW), a form of live modelling session held at a critical juncture in the design process to investigate a range of energy efficiency strategies and to optimize building energy performance.

Building Design

A cooling system was not installed, but the heat pump system can be programmed to provide cooling if needed. The form of the building and motorized louvers at roof level encourage natural ventilation and the design of the exterior sunshades minimizes the amount of summer solar radiation entering the building. The building is also designed to be automatically flushed out at night when daytime temperatures cause uncomfortable indoor conditions.

EA	
NC	Credit 1
CS	Credit 1

Heating system

An ocean-based geoexchange system provides for all the heat requirements of the building. Ocean water is pumped into the building and passes through a titanium heat exchanger. Heat pumps are used to upgrade the available heat energy and are coupled with a low temperature in-floor hydronic radiant distribution system. Domestic hot water needs are also supplied by the heat pump system.

Lighting

The building, which is equipped with occupancy sensors, has been designed to enable all workstations to be located adjacent to windows, minimizing the need for artificial lighting during daytime hours. Lights adjacent to windows are furnished with photosensors.

Building Envelope

The building envelope and cladding system has been engineered to minimize heat loss through thermal bridging, with performance levels significantly higher than Code.

Other aspects that contribute to the energy efficient design and operations included:

- Heat recovery on exhaust air to preheat incoming fresh air.
- Variable speed drives installed on all fans and pumps.
- Roof-mounted photovoltaic system.
- The building systems were fully commissioned.
- Post-occupancy follow up and model calibration to verify energy performance and identify any potential problems.

The energy model developed for this building predicted a reduction of over 75% in comparison to the Model National Energy Code Reference building. The Owner is committed to understanding the performance of this project, and has involved the design team in a post-occupancy energy evaluation to track actual performance over the next several years.

Lessons Learned

Energy consumption has been remarkably similar to that predicted during the summer and shoulder months, but deviated somewhat during much of the heating season due to operational problems.

- Even with the heating system problems in the first year, the annual energy use was well under half that of a typical office for the region; with corrections on the few operational issues, the energy use should drop further to about a third of a typical office building.
- Additional sensors are being installed to further refine the monitoring capabilities of the building control system which will facilitate a detailed analysis of how actual performance differs from the design case.

EA	
NC	Credit 2
CS	Credit 2

ON-SITE RENEWABLE ENERGY

	NC	CS
Credit	EA Credit 2	EA Credit 2
Points	1-7 points	2, 4 points

INTENT

To encourage and recognize increasing levels of on-site renewable energy self-supply to reduce environmental and economic impacts associated with fossil fuel energy use.

REQUIREMENTS: NC & CS

Use on-site renewable energy systems to offset building energy cost. Calculate project performance by expressing the energy produced by the renewable systems as a percentage of the building's annual energy cost and use the table below to determine the number of points achieved.

For projects pursuing Option 1 in EA Credit 1; Optimize Energy Performance, use the building annual energy cost calculated in EA Credit 1. For projects pursuing EA Credit 1 prescriptive paths use the U.S. Department of Energy's (DOE) Commercial Buildings Energy Consumption Survey (CBECS) database to determine the estimated electricity use.

The minimum renewable energy percentage for each point threshold is as follows:

NEW CONSTRUCTION:

PERCENTAGE RENEWABLE ENERGY	POINTS
1%	1
3%	2
5%	3
7%	4
9%	5
11%	6
13%	7

CORE AND SHELL:

PERCENTAGE RENEWABLE ENERGY	POINTS
0.5%	2
1%	4

INTERPRETATIONS

There are no interpretations for this credit.

EA	
NC	Credit 2
CS	Credit 2

1. BENEFITS AND ISSUES TO CONSIDER

Use of renewable energy instead of fossil fuel–based energy can dramatically improve outdoor environmental quality. Use of renewable energy means reductions in air and water pollution, benefiting all community members.

Renewable energy has a positive impact on rural communities in particular; siting and operating wind farms and biomass conversion facilities in rural areas enhances economic development. Rural wind generation is providing new sources of income for Canadian farmers and other rural landowners while meeting the growing demand for clean sources of electricity. However, care must be taken to minimize undesirable noise from wind farms and emissions from combustion at biomass conversion facilities.

ENVIRONMENTAL ISSUES

Energy production from traditional, fossil fuel–based sources is a significant contributor to air pollution in the United States, releasing such pollutants as sulphur dioxide, nitrogen oxide, and carbon dioxide, which have widespread and adverse effects on human health, especially respiratory health, and contribute to acid precipitation, smog, and concentrations of greenhouse gases.

The overall environmental benefit of renewable energy depends on the source of energy and the process by which it is extracted. Although renewably generated electricity is not entirely benign, it greatly lessens the negative environmental impacts of power generation. Generating renewable energy on-site is an excellent way for owners to reduce the negative environmental impacts associated with a building's energy use.

ECONOMIC ISSUES

Using on-site renewable energy technologies can result in cost savings. Utility rebates are often available to reduce first costs of renewable energy equipment. The initial costs of installing or providing renewable energy sources on-site can be offset by future savings. A life-cycle cost analysis of the potential savings can help project teams in their decision-making process. In some provinces, initial costs can also be offset by net metering, in which excess energy is sold back to the utility, and through programs that provide incentives for using renewable energy. Project teams should ascertain whether these options are available locally, particularly for the type of renewable energy they plan to use.

Research on the available technologies is essential; consider climatic, geographical, and other regional factors that influence the appropriateness of an on-site renewable source for the building's energy use.

EA	
NC	Credit 2
CS	Credit 2

2. RELATED CREDITS

The installation of renewable energy generation equipment usually has only a small effect on the achievement of other credits. Renewable energy equipment will change the energy performance of the building and require commissioning as well as measurement and verification. Achievement of EA Credit 2 is determined by the percentage of the building's energy use that is provided by on-site renewable energy generation systems, and therefore is directly tied to the building's energy performance. Additionally, there are synergies with purchasing green power for the project, since on-site energy generation reduces the quantity of green power that must be purchased to offset the building's energy use. Refer to the following prerequisites and credits:

- EA Prerequisite 1: Fundamental Commissioning
- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance
- EA Credit 5: Measurement and Verification
- EA Credit 6: Green Power

3. SUMMARY OF REFERENCED STANDARD

ANSIASHRAE/IESNA Standard 90.1–2007, Energy Standard for Buildings Except Low-Rise Residential

American Society of Heating, Refrigerating and Air-Conditioning Engineers
http://www.ashrae.org
ANSI/ASHRAE/IESNA 90.1–2007 establishes minimum requirements for the energy-efficient design of buildings, with these exceptions: single-family houses; multifamily structures of 3 habitable stories or fewer above grade; manufactured houses (mobile and modular homes); buildings that do not use either electricity or fossil fuel; and equipment and portions of buildings systems that use energy primarily for industrial, manufacturing, or commercial processes. Building envelope requirements are provided for semiheated spaces such as warehouses.

On-site renewable or site-recovered energy that might be used to earn EA Credit 2 is handled as a special case in the modelling process. Renewable and recovered energy produced on-site are considered free energy in the performance rating method and not included in the design energy cost. See the Calculation section for details.

4. IMPLEMENTATION

Renewable energy systems include technologies designed to capture solar, wind, geothermal, water, or bio-based energy to satisfy on-site electric power demand or to directly offset space heating, space cooling, or water heating energy consumption.

Consider photovoltaics, solar thermal, geothermal, wind, biomass, and biogas energy. Eligible systems produce electric power or thermal energy for use on-site and should, where possible, deliver power to the grid when their output exceeds the site demand. Contact local utilities or electric service providers to determine whether net metering is available.

Energy savings from the use of on-site renewable energy should be based on either the metered renewable energy produced and used on-site, or the metered renewable energy produced and used on-site or sent to the grid. Energy produced on-site that is not captured and used, whether on-site or via the grid, cannot be included in the credit calculations. For example, if a project building uses photovoltaic panels to generate electricity on-site but does not store energy when output exceeds demand or use net metering, only the portion of renewable electricity actually consumed on-site counts. Renewable energy produced on-site and then sold to the grid is not eligible.

EA	
NC	Credit 2
CS	Credit 2

ELIGIBLE ON-SITE SYSTEMS

On-site renewable energy technologies eligible for EA Credit 2 include the following:

- Photovoltaic systems
- Wind energy systems
- Solar thermal systems
- Biofuel-based electrical and thermal systems (see list of eligible biofuels, below)
- Geothermal heating systems
- Geothermal electric systems
- Low-impact hydroelectric power systems
- Wave and tidal power systems

There are some restrictions for geothermal energy systems, solar thermal energy systems, and biofuel-based electrical and thermal systems. Geothermal energy systems using deep-earth water or steam sources (but not vapour compression systems for heat transfer) may be eligible for this credit. These systems may either produce electric power or provide thermal energy for primary use at the building.

Active solar thermal energy systems that employ collection panels, heat transfer mechanical components (such as pumps or fans), and defined heat storage systems (such as hot water tanks) are eligible for this credit. Thermo-siphon solar and storage tank "batch heaters" are also eligible.

The following biofuels are considered renewable energy under this credit:

- Untreated wood waste, including mill residues
- Agricultural crops or waste
- Animal waste and other organic waste
- Landfill gas

INELIGIBLE ON-SITE SYSTEMS

These types of on-site systems are not eligible for this credit:

- Architectural features
- Passive solar strategies
- Daylighting strategies
- Geo-exchange systems (ground-source heat pumps)

Architectural passive solar and daylighting strategies provide significant energy savings. Their contributions are reflected in project-wide energy efficiency levels and facilitate the achievement of EA Prerequisite 2 and EA Credit 1.

Geo-exchange systems (geothermal or ground-source heat pumps) are earth-coupled HVAC applications use vapour-compression systems for heat transfer and do not obtain significant quantities of deep-earth heat. These systems are not eligible as renewable energy systems. The contributions of these systems are reflected in project-wide energy efficiency levels and facilitate the achievement of EA Prerequisite 2 and EA Credit 1.

EA	
NC	Credit 2
CS	Credit 2

Energy production based on the following biofuels are not eligible for this credit:

- Combustion of municipal solid waste,
- Forestry biomass waste other than mill residue,
- Wood coated with paints, plastics, or formica,
- Wood treated for preservation with materials containing halogens, chlorine compounds, halide compounds, chromated copper arsenate, or arsenic. If more than 1% of the wood fuel has been treated with these compounds, the energy system is ineligible.

RETENTION OF RENEWABLE ENERGY ENVIRONMENTAL ATTRIBUTES

If the renewable energy system is installed on the building or on-site and is on the building side of the utility billing meter, it qualifies for EA credits 1 and 2 regardless of the funding arrangement or financial incentives provided by third parties. Selling the environmental attributes does not affect the quantity of renewable energy used for the calculations of EA Credit 2 but does impact the EA Credit 6 calculations (see EA Credit 6 for more information).

DISTRICT ENERGY SYSTEMS

For projects with district energy systems, specific technical guidance can be found in the *LEED Canada Interpretation Guide for District Energy Systems* on CaGBC's website (http://www.cagbc.org). Follow the guidance in effect at the time of LEED project registration.

5. TIMELINE AND TEAM

The project team, with the owner, architect, and engineer, should first estimate the potential energy use of the building so that renewable technologies with adequate capacity can be identified. Systems producing on-site renewable electrical power should be designed to facilitate net metering back to the grid for periods when the renewable energy system output exceeds the site demand. Ask local utilities and electric service providers about incentive and rebate programs.

6. CALCULATIONS

Calculate the amount of energy cost offset by using the energy calculated in EA Credit 1 or based on the Commercial Buildings Energy Consumption Survey database for the building type. Calculations are based on energy use before the credit for renewable energy is taken. Calculate renewable energy production using a suitable program (e.g. RETScreen International).

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED letter templates for the complete descriptions of all required documentation.

- Document on-site renewable energy source types, total annual energy generation, and backup energy sources.
- Calculate the energy generated from each on-site renewable energy source.

EA	
NC	Credit 2
CS	Credit 2

8. EXAMPLE

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

NC

Projects can earn credit for exemplary performance by showing that on-site renewable energy accounts for 15% or more of the annual building energy cost.

CS

Projects can earn credit for exemplary performance by showing that on-site renewable energy accounts for 5% or more of the annual building energy cost.

10. REGIONAL VARIATIONS

The availability and appropriateness of renewable energy technologies for a building varies by region. Factors like climate, geography, and location can greatly affect the choice of the best renewable source. For example, although solar energy is available across Canada, it is most abundant in locations such as southern Alberta, Saskatchewan and Manitoba and southwestern Ontario.

Similarly, biomass is likely to be more cost-effective in agricultural regions, and wind power in coastal regions and southwestern Alberta.

Although energy efficiency is universally important, it is crucial in regions where coal is used to generate electricity. It is also particularly important to reduce peak energy use because units brought online to meet peak demand tend to be the greatest contributors to greenhouse gas emissions. Replacing fossil fuel with renewable energy for generating electricity during peak periods delivers the greatest benefits in reducing the marginal emissions.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Confirm that the renewable energy systems have been correctly and appropriately implemented as designed and that the building owner, maintenance personnel, and occupants are given the information they need to understand, maintain, and use systems that may be unfamiliar to them. Provide building operators with the manufacturer's recommendations for operating and maintenance procedures. Operators may need guidance on how to maximize efficiency, including information about the cleaning method and frequency for solar panels.

Specify a way to track energy production from the renewable energy source over the lifespan of the building, to help the facility manager maximize use of the system and accurately determine the savings. Ensure that the renewable energy system is submetered so that energy production and use can be monitored.

EA	
NC	Credit 2
CS	Credit 2

12. RESOURCES

WEBSITES

Canadian Solar Industries Association (CanSIA)
http://www.cansia.ca

CanSIA is the primary Canadian solar energy industry association, fostering research, information exchange and lobbying on behalf of manufacturers and distributors.

Canadian Wind Energy Association (CanWEA)
www.canwea.ca

The Canadian Wind Energy Association (CanWEA) is a nonprofit trade association that promotes the appropriate development and application of all aspects of wind energy in Canada, including the creation of a suitable policy environment.

ENERGY Guide
http://www.energyguide.com

This website provides information on different power types, including green power, as well as general information on energy efficiency and tools for selecting power providers based on economic, environmental, and other criteria.

National Center for Photovoltaics
http://www.nrel.gov/ncpv/

NCPV provides clearinghouse information on all aspects of photovoltaic systems.

Natural Resources Canada's ecoENERGY for Renewable Heat
http://ecoaction.gc.ca/ecoenergy-ecoenergie/heat-chauffage/index-eng.cfm

The federal government's ecoENERGY for Renewable Heat program offers incentives up to $80,000 per installation to help the industrial/commercial/institutional sector cover the cost of installing active energy-efficient solar air and/or water heating systems.

Natural Resources Canada's ecoENERGY for Renewable Power
http://ecoaction.gc.ca/ecoenergy-ecoenergie/power-electricite/index-eng.cfm

The federal government's ecoENERGY for Renewable Power program offers an incentive of one cent per kilowatt-hour for up to 10 years for to low-impact, renewable electricity projects. Projects must have a total rated capacity of 1 MW or greater in order to qualify.

Natural Resources Canada's Renewable Energy Deployment Initiative
http://www.nrcan.gc.ca/eneene/renren/index-eng.php

Find current research and investment initiatives supporting Canada's commitment to increase its supply of clean, renewable energy.

Pollution Probe Consumer Guide to Green Power in Canada
http://www.pollutionprobe.org/whatwedo/greenpower/consumerguide/c2_1.htm

This website provides some information on the availability of green power in each province of Canada.

RETScreen International
http://www.retscreen.net/

EA	
NC	Credit 2
CS	Credit 2

The **RETScreen Clean Energy Project Analysis Software** is a unique decision support tool developed with the contribution of numerous experts from government, industry, and academia. The software, provided free-of-charge, can be used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of Renewable-energy and Energy-efficient Technologies (RETs). The software (available in multiple languages) also includes product, project, hydrology and climate databases, a detailed user manual, and a case study based college/university-level training course, including an engineering e-textbook.

U.S. Department of Energy, National Renewable Energy Laboratory
http://www.nrel.gov

NREL is a leader in the U.S. Department of Energy's effort to secure for the nation an energy future that is environmentally and economically sustainable.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy
http://www.eere.energy.gov

This website is a comprehensive resource for U.S. Department of Energy information on energy efficiency and renewable energy and provides access to energy links and downloadable documents.

U.S. EPA Green Power Partnership
http://www.epa.gov/greenpower/index.htm

EPA's Green Power Partnership provides assistance and recognition to organizations that demonstrate environmental leadership by choosing green power. It includes a buyer's guide with lists of green power providers in each state.

PRINT MEDIA

Wind and Solar Power Systems, by Mukund Patel (CRC Press, 1999). This text offers information about the fundamental elements of wind and solar power generation, conversion, and storage and detailed information about the design, operation, and control methods of stand-alone and grid-connected systems.

Wind Energy Comes of Age, by Paul Gipe (John Wiley & Sons, 1995). This book provides extensive information on the wind power industry, and is among several books by the author covering general and technical information about wind power.

13. DEFINITIONS

Biofuel-based systems are power systems that run on renewable fuels derived from organic materials, such as wood by-products and agricultural waste. Examples of biofuels include untreated wood waste, agricultural crops and residues, animal waste, other organic waste, and landfill gas.

Biomass is plant material from trees, grasses, or crops that can be converted to heat energy to produce electricity.

A **district energy system** is a central plant and distribution system that provides energy (heat, cooling and/or electricity) to a group of buildings in a small district. Examples include central plants on university campuses or those that serve the downtown cores of cities. Large-scale utilities that supply energy to large regions, provinces or municipalities, are not considered DESs. Refer to *LEED Canada Interpretation Guide for District Energy Systems* for further information.

EA	
NC	Credit 2
CS	Credit 2

Downstream equipment consists of all heating or cooling systems, equipment, and controls located within the project building and site associated with transporting thermal energy into heated or cooled spaces. This includes the thermal connection or interface with the district energy system, secondary distribution systems in the building, and terminal units.

Geothermal energy is electricity generated by converting hot water or steam from within the earth into electrical power.

Geothermal heating systems use pipes to transfer heat from underground steam or hot water for heating, cooling, and hot water. The system retrieves heat during cool months and returns heat in summer months.

Green-e is a program established by the Center for Resource Solutions to both promote green electricity products and provide consumers with a rigorous and nationally recognized method to identify those products.

Life-cycle cost analysis calculates expected future operating, maintenance, and replacement costs of designs and features used to assist owners in developing a realistic design and budget estimate.

Low-impact hydro power is electricity produced from the downhill flow of water and operates such that reduced water flows are not detrimental to indigenous inhabiting species, in-stream flows downstream are adequate to support indigenous inhabiting species, and water quality is comparable to unaltered bodies within the local watershed, as well as ensuring water temperature changes are not detrimental to indigenous inhabiting species. Also provide measures to minimize fish mortality that would result from impingement and entrainment and ensure fish passage exists where man-made structures are replaced where no natural barriers exist.

Net metering is a metering and billing arrangement that allows on-site generators to send excess electricity flows to the regional power grid; these flows offset a portion of the energy drawn from the grid.

On-site renewable energy is energy derived from renewable sources located within the project site perimeter.

Renewable energy comes from sources that are not depleted by use (renewable sources). Examples include energy from the sun, wind, and small (low-impact) hydropower, plus geothermal energy and wave and tidal systems. Ways to capture energy from the sun include photovoltaic, solar thermal, and bioenergy systems based on wood waste, agricultural crops or residue, animal and other organic waste, or landfill gas.

Renewable Sources are energy sources as defined and/or excluded in EA Credit 2 Section 4 Implementation.

Upstream equipment consists of all heating or cooling systems, equipment, and controls that are associated with a district energy system but are not part of the project building's thermal connection or do not interface with the district energy system. It includes the central energy plant and all transmission and distribution equipment associated with transporting the thermal energy to the project building and site.

EA	
NC	Credit 2
CS	Credit 2

14. CASE STUDY

DEPARTMENT OF NATURAL RESOURCES – FLORENCEVILLE DISTRICT OFFICE
LEED Canada-NC 1.0 Gold, 4 January 2007

Location: Florenceville, New Brunswick
Building Type: Office building
Owner Type: Government (provincial)
Building Size: $540m^2$
Owner Name: New Brunswick Department of Natural Resources
LEED Consultant: New Brunswick Department of Supply Services
Responsible Firm (for this credit): New Brunswick Department of Supply Services
Photo Credit: Keith Minchin

The district office of the provincial Department of Natural Resources in Florenceville, New Brunswick supports the staff with sustainable forestry management, protection and management of fish and wildlife populations, and management of Crown land activities as well fire protection for both Crown and Private lands.

During the design stage, the site was assessed for the incorporation of a renewable energy system. The goal was to supply approximately 20% of the building's total energy use through renewables. In the end, though, the system provided 28% of the electricity needed for the building and achieved a LEED Innovation in Design credit for exemplary renewable energy performance.

To determine whether systems were feasible, a wind system was considered. Wind data was available for the region from a DNR wind monitoring station approximately 10km away and situated at the same altitude. Based on the monitored information, the wind system was found to be feasible and a 10kW wind turbine with a 208V, three phase voltage output was chosen to match the building's voltage characteristics. The wind turbine was located on the highest possible elevation on the site and a 24m lattice type galvanized steel tower was selected to ensure that the wind turbine's performance is not effected by nearby buildings or tree lines.

The generated energy by the wind turbine is monitored by the local building management system and is occasionally verified. The wind turbine has been connected to the utility grid and is currently generating energy as expected.

EA	
NC	Credit 3
CS	Credit 3

ENHANCED COMMISSIONING

	NC	CS
Credit	EA Credit 3	EA Credit 3
Points	2 points	2 points

INTENT

To begin the commissioning process early during the design process and execute additional activities after systems performance verification is completed.

REQUIREMENTS: NC & CS

Implement, or have a contract in place to implement, the following additional commissioning process activities in addition to the requirements of EA Prerequisite 1: Fundamental Commissioning of Building Energy System:

1. Prior to the start of the construction documents phase, designate an independent Commissioning Authority (CxA) to lead, review, and oversee the completion of all commissioning process activities.
   a. The CxA must have documented commissioning authority experience in at least 2 building projects.
   b. The individual serving as the CxA:
      i. Must be independent of the work of design and construction.
      ii. Must not be an employee of, or contracted through the design firm (engineering firm of record).
      iii. Must not be an employee of, or contracted through a contractor or construction manager holding construction contracts.
      iv. May be a qualified employee or consultant of the owner.
   c. The CxA must report results, findings and recommendations directly to the owner.
2. The CxA must conduct, at a minimum, 1 commissioning design review of the owner's project requirements basis of design, and design documents prior to mid-construction documents phase and back-check the review comments in the subsequent design submission.
3. The CxA must review contractor submittals applicable to systems being commissioned for compliance with the owner's project requirements and basis of design. This review must be concurrent with the review of the architect or engineer of record and submitted to the design team and the owner.

	EA
NC	Credit 3
CS	Credit 3

4. The CxA or other project team members must develop a systems manual that provides future operating staff the information needed to understand and optimally operate the commissioned systems.
5. The CxA or other project team members must verify that the requirements for training operating personnel and building occupants are completed.
6. The CxA must be involved in reviewing the operation of the building with operations and maintenance (O&M) staff and occupants within 10 months after substantial completion. A plan for resolving outstanding commissioning-related issues must be included.

INTERPRETATIONS

For Public-Private-Partnerships (P3) the intent of EA Credit 3 can be met for this particular contract structure when the commissioning authority functions independently (as defined in EA Prerequisite 1, Table 2) and maintains a strict communication protocol directly to the operator or financier and not through the design or construction firms. The commissioning reports must also be circulated to the tenant/owner. Since there is a financial relationship between the commissioning authority and both the design and construction firms within the P3 contract structure, the conflict of interest must be declared in writing with a (brief) description of the process for dealing with commissioning conflicts.

LEASED TENANT SPACE (NC & CS)

Base building systems and owner fit-up spaces must meet the requirements of this credit, however future fit-up of leased tenant spaces not included in LEED project application are excluded from the credit requirement for both NC and CS certification.

EA	
NC	Credit 3
CS	Credit 3

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Facilities that do not perform as intended may consume significantly more resources over their lifetimes. Commissioning can minimize the negative impacts buildings have on the environment by helping verify that buildings are designed, constructed, and operated as intended and in accordance with the owner's project requirements.

ECONOMIC ISSUES

An effective commissioning process typically increases soft costs and may require additional scheduling for commissioning activities. This investment is generally recouped in improved design and construction coordination, fewer change orders, and reduced operating costs.

Indoor air quality and building occupants' comfort may have tremendous impact on their productivity, health, and well-being, as well as the cost of ownership. Commissioning can significantly reduce repairs, construction change orders, energy costs, and maintenance and operation costs.

2. RELATED CREDITS

The commissioning effort can affect many performance-based features encouraged in the LEED Rating System. Consider including in commissioning the energy-using systems addressed by the following credits:

- SS Credit 8: Light Pollution Reduction
- WE Credit 1: Water Efficient Landscaping
- WE Credit 2: Innovative Wastewater Technologies
- WE Credit 3: Water Use Reduction
- EA Credit 1: Optimize Energy Performance
- EA Credit 2: On-site Renewable Energy
- EA Credit 5: Measurement and Verification
- IEQ Prerequisite 1: Minimum Indoor Air Quality Performance
- IEQ Credit 1: Outdoor Air Delivery Monitoring
- IEQ Credit 2: Increased Ventilation
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control
- IEQ Credit 6: Controllability of Systems
- IEQ Credit 7: Thermal Comfort

EA Credit 3, Enhanced Commissioning, goes beyond the minimum threshold for commissioning activities, as defined by the related prerequisite:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

EA	
NC	Credit 3
CS	Credit 3

4. IMPLEMENTATION

RELATIONSHIP BETWEEN FUNDAMENTAL AND ENHANCED COMMISSIONING

LEED Canada for New Construction and *LEED Canada for Core & Shell* address building commissioning in 2 places, EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems, and EA Credit 3, Enhanced Commissioning.

For LEED design and construction projects, the scope of services for the commissioning authority (CxA) and project team should be based on the owner's project requirements. The commissioning process activities must address the commissioned systems noted in the EA Prerequisite 1 requirements. Other systems, such as the building envelope, stormwater management systems, water treatment systems, and information technology systems, may also be included in the commissioning process at the owner's discretion. EA Credit 3 requires that the commissioning authority be involved early in the process to help facilitate a commissioning design review and a commissioning documentation review. As the project nears completion, enhanced commissioning requires oversight of staff training, a walkthrough 10 months after completion, and the completion of a systems manual.

5. TIMELINE AND TEAM

Refer to the Timeline and Team section in EA Prerequisite 1.

6. CALCULATIONS

There are no calculations required for this credit.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED letter templates for the complete descriptions of all required documentation.

- Update the commissioning plan at milestones throughout the project. This should happen, at a minimum, during the design development phase, the construction documents phase, and just prior to the kick-off meeting with the general contractor.
- Prepare a systems list that indicates which systems have been included within the scope of enhanced commissioning.
- Request confirmation that the commissioning authority has documented experience on at least 2 building projects.
- Create a written schedule of building operator training sessions.
- Retain a copy of the commissioning authority's design review, any designer responses to this review, and confirmation of the back-check.
- Retain copies of the owner's project requirements, basis of design, commissioning specifications, commissioning report, and systems manual.

EA	
NC	Credit 3
CS	Credit 3

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

LEED Canada for New Construction and *LEED Canada for Core & Shell* projects that conduct comprehensive envelope commissioning may be considered for an innovation credit. These projects will need to demonstrate the standards and protocol by which the envelope was commissioned.

CS

LEED Canada for Core & Shell projects that require the full scope of commissioning (both fundamental and enhanced) for all the tenant spaces may be considered for an innovation point.

10. REGIONAL VARIATIONS

Refer to EA Prerequisite 1, Regional Variations.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Refer to the Operations and Maintenance section in EA Prerequisite 1.

12. RESOURCES

See also the Resources section of EA Prerequisite 1 for a list of specific commissioning resources.

13. DEFINITIONS

Basis of design includes design information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations, and guidelines.

Commissioning (Cx) is the process of verifying and documenting that a building and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements.

The **commissioning authority (CxA)** is the individual designated to organize, lead, and review the completion of commissioning process activities. The CxA facilitates communication among the owner, designer, and contractor to ensure that complex systems are installed and function in accordance with the owner's project requirements.

The **commissioning plan** is a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

The **commissioning process** is a systematic quality-focused effort to ensure that building systems are designed, specified, procured, installed, and functioning in accordance with the owner's intent. The process uses planning, documentation, and verification of testing to review and oversee the activities of both designer and constructor.

EA	
NC	Credit 3
CS	Credit 3

The **commissioning report** documents the commissioning process, including a commissioning program overview, identification of the commissioning team, and description of the commissioning process activities.

Commissioning specification is the contract language used in the construction documents to detail the objective, scope, and implementation of the construction and acceptance phases of the commissioning process as developed in the design phase of the commissioning plan. This allows the construction contractor to ensure that these activities are considered in proposals for the construction work.

The **commissioning team** includes those people responsible for working together to carry out the commissioning process.

A **district energy system (DES)** is a central plant and distribution system that provides energy (heat, cooling and/or electricity) to a group of buildings in a small district. Examples include central plants on university campuses or those that serve the downtown cores of cities. Large-scale utilities that supply energy to large regions, provinces or municipalities, are not considered DESs. Refer to *LEED Canada Interpretation Guide for District Energy Systems* for further information.

Downstream equipment consists of all heating or cooling systems, equipment, and controls located within the project building and site associated with transporting thermal energy into heated or cooled spaces. This includes the thermal connection or interface with the district energy system, secondary distribution systems in the building, and terminal units.

Enhanced commissioning is a set of best practices that go beyond fundamental commissioning to ensure that building systems perform as intended by the owner. These practices include designating a commissioning authority prior to the construction documents phase, conducting commissioning design reviews, reviewing contractor submittals, developing a systems manual, verifying operator training, and performing a post-occupancy operations review.

Fundamental commissioning is a set of essential best practices used to ensure that building performance requirements have been identified early in the project's development and to verify that the designed systems have been installed in compliance with those requirements. These practices include designating a commissioning authority, documenting the owner's project requirements and basis of design, incorporating commissioning requirements into the construction documents, establishing a commissioning plan, verifying installation and performance of specified building systems, and completing a summary commissioning report.

An **installation inspection** examines components of the building systems to determine whether they are installed properly and ready for systems performance testing.

Owner's project requirements is a written document that details the ideas, concepts, and criteria that are determined by the owner to be important to the success of the project.

Systems performance testing is the process of determining the ability of commissioned systems to perform in accordance with the owner's project requirements, the basis of design, and construction documents.

Upstream equipment consists of all heating or cooling systems, equipment, and controls that are associated with a district energy system but are not part of the project building's thermal connection or do not interface with the district energy system. It includes the central energy plant and all transmission and distribution equipment associated with transporting the thermal energy to the project building and site.

Verification is the range of checks and tests carried out to determine whether components, subsystems, systems, and interfaces between systems operate in accordance with the contract documents.

EA	
NC	Credit 4
CS	Credit 4

ENHANCED REFRIGERANT MANAGEMENT

	NC	CS
Credit	EA Credit 4	EA Credit 4
Points	2 points	2 points

INTENT

To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change.

REQUIREMENTS: NC & CS

OPTION 1

Do not use refrigerants.

OR

OPTION 2

Select refrigerants and heating, ventilating, air conditioning and refrigeration (HVAC&R) that minimize or eliminate the emission of compounds that contribute to ozone depletion and global climate change. The base building HVAC&R equipment must comply with the following formula, which sets a maximum threshold for the combined contributions to ozone depletion and global warming potential:

$LCGWP + LCODP \times 10^5 \leq 100$

CALCULATION FOR DEFINITITIONS FOR LCGWP + LCODP X $10^5 \leq 100$
LCODP = [ODPr x (Lr x Life + Mr) x Rc]/Life
LCGWP = [GWPr x (Lr x Life + Mr) x Rc]/Life
LCODP: Lifecycle Ozone Depletion Potential (lb CFC11/Ton-Year)
LCGWP: Lifecycle Direct Global Warming Potential (lb CO_2/Ton-Year)
GWPr: Global Warming Potential of Refrigerant (0 to 12,000 lb CO_2/lbr)
ODPr: Ozone Depletion Potential of Refrigerant (0 to 0.2 lb CFC11/lbr)
Lr: Refrigerant Leakage Rate (0.5% to 2.0%; default of 2% unless otherwise demonstrated)
Mr: End of life Refrigerant Loss (2% to 10%; default of 10% unless otherwise demonstrated)
Rc: Refrigerant Charge (0.5 to 5.0 lbs of refrigerant per ton of gross ARI rated cooling capacity)
Life: Equipment of Life (10 years; default based on equipment type, unless otherwise demonstrated)

EA	
NC	Credit 4
CS	Credit 4

For multiple types of equipment, a weighted average of all base building level HVAC&R equipment must be calculated using the following formula:

$[\sum (LCGWP + LCODP \times 10^5) \times Qunit]/Qtotal \leq 100$

CALCULATION DEFINITIONS FOR [∑ (LCGWP + LCODP X 10^5) X Qunit] / Qtotal ≤ 100
Qunit = Gross ARI rated cooling capacity of an individual HVAC or refrigeration unit (Tons)
Qtotal = Total gross ARI rated cooling capacity of all HVAC or refrigeration units (Tons)

ALL OPTIONS

Small HVAC units (defined as containing less than 0.23 kg (0.5 lbs) of refrigerant), and other equipment such as standard refrigerators, small water coolers, and any other cooling equipment that contains less than 0.23 kg (0.5 lbs) of refrigerant, are not considered part of the "base building" system and are not subject to the requirements of this credit.

Do not operate or install fire suppression systems that contain ozone-depleting substances such as CFCs, hydrochlorofluorocarbons (HCFCs) or halons.

INTERPRETATIONS

There are no interpretations for this credit.

EA	
NC	Credit 4
CS	Credit 4

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Some refrigerants used in heating, ventilating, air conditioning, and refrigeration (HVAC&R) systems cause significant damage to Earth's protective ozone layer if they are released into the atmosphere. Others contribute to greenhouse gas emissions, causing global climate change. According to a report issued by the USGBC's LEED Technical and Scientific Advisory Committee, an objective, scientific analysis of trade-offs between global climate change and ozone depletion is extremely complex and will come only from a full understanding of all interacting pathways and effects on economic activities, human health, and terrestrial and oceanic ecosystems.[16] Refrigerant management to minimize the negative impacts on ozone depletion and climate change requires all of the following strategies to reduce dangerous refrigerant leakage to the environment:

- Designing buildings that do not rely on chemical refrigerants.
- Designing HVAC&R equipment that uses energy efficiently.
- Selecting refrigerants with zero or low ozone depleting potential (ODP) and minimal direct global warming potential (GWP).
- Maintaining HVAC&R equipment to reduce refrigerant leakage to the environment.

Under the Montreal Protocol, an international treaty ratified in 1989, refrigerants with non-zero ODP will be phased out by 2030 in developed countries. This includes the chlorinated refrigerants chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs).

ECONOMIC ISSUES

Passive cooling strategies can greatly decrease the costs associated with mechanical equipment by reducing or eliminating the need for active cooling systems.

Although environmentally preferable refrigerants are becoming standard or available as an option on new air-conditioning equipment, approximately 50% of the water chillers in existing buildings still use CFC-11 as refrigerant. As environmental impacts are factored into the costs of replacement refrigerant, operational cost savings will be realized through installation of HVAC&R equipment with environmentally preferable refrigerants.

2. RELATED CREDITS

This credit encourages either the use of no refrigerants or the use of environmentally preferable refrigerants. Because cooling equipment is often a significant percentage of the overall building energy use, the selection of a HVAC&R system has a large effect on the overall energy performance of the building. Additionally, the systems addressed by this credit can help meet the thermal comfort needs of the building occupants. It is important to balance refrigerant impact, energy use, and occupants' comfort when selecting HVAC&R systems. Refer to these prerequisites and credits:

- EA Prerequisite 3: Fundamental Refrigerant Management
- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance
- IEQ Credit 7.1 (CS IEQ Credit 7): Thermal Comfort—Design
- IEQ Credit 7.2: Thermal Comfort—Verification

EA	
NC	Credit 4
CS	Credit 4

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

Most refrigerants used in building HVAC and refrigeration equipment are stable chemical compounds until they are released to the atmosphere, where they become greenhouse gases that deplete Earth's protective ozone layer and contribute to climate change.

HVAC&R systems also contribute to climate change through their energy consumption and the greenhouse gas emissions associated with the production of energy at power plants. Over the life of the equipment, the indirect global warming impact of HVAC&R equipment may be much greater than the direct impact of releasing the refrigerant into the atmosphere. The indirect impact of running HVAC&R equipment is addressed by EA Credit 1, Optimize Energy Performance, which accounts for the energy savings associated with more energy-efficient equipment. The direct impact of refrigerant selection is addressed in EA Prerequisite 3, Fundamental Refrigerant Management, which requires zero use of CFC-based refrigerants in base building systems, or a reduction in refrigerant leakage if system conversion is not economically feasible. This credit encourages significantly reducing or even eliminating a building's use of refrigerants.

The credit covers base building HVAC&R equipment—any equipment permanently installed in the building that contains more than 0.23 kilograms (0.5 pounds) of refrigerant. This includes chillers, unitary (split and packaged) HVAC equipment, room or window air-conditioners, computer room air-conditioning units, data and telecommunications room cooling units, and commercial refrigeration equipment. Portable cooling equipment (such as standard refrigerators), temporary cooling equipment, and equipment with less than 0.23 kilograms (0.5 pounds) of refrigerant (such as small water coolers) may be excluded from the calculations for this credit. For buildings connected to an existing chilled water system, the chilled water supplier must perform the required calculation and submit a letter showing compliance with the requirements.

DO NOT USE REFRIGERANTS

Eliminating the use of vapour-compression HVAC&R equipment can help prevent atmospheric damage from refrigerant emissions. LEED projects that use no refrigerants—for example, a naturally ventilated building with no active cooling systems—are awarded this LEED credit without having to submit any calculations or analyses.

USE ONLY NATURAL REFRIGERANTS

Some HVAC&R systems use natural refrigerants, including water, carbon dioxide, and ammonia. These naturally occurring compounds generally have much lower potential for atmospheric damage than manufactured chemical refrigerants. Projects that employ natural refrigerants are eligible for this credit.

SELECT REFRIGERANTS WITH LOW OZONE-DEPLETION AND GLOBAL-WARMING POTENTIALS

Selection of the appropriate refrigerant for any given project and HVAC system may be affected by available equipment, energy efficiency, budget, and other factors. If possible, use refrigerants with zero or very little ozone depletion potential (ODP) and global warming potential (GWP). Table 1 shows the ODPs and direct GWPs of many common refrigerants.

EA	
NC	Credit 4
CS	Credit 4

TABLE 1. OZONE DEPLETION AND GLOBAL WARMING POTENTIALS OF REFRIGERANTS (100-YEAR VALUES)

REFRIGERANT	ODP	GWP	COMMON BUILDING APPLICATIONS
CHLOROFLUOROCARBONS			
CFC-11	1.0	4,680	Centrifugal chillers
CFC-12	1.0	10,720	Refrigerators, chillers
CFC-114	0.94	9,800	Centrifugal chillers
CFC-500	0.605	7,900	Centrifugal chillers, humidifiers
CFC-502	0.221	4,600	Low-temperature refrigeration
HYDROCHLOROFLUOROCARBONS			
HCFC-22	0.04	1,780	Air-conditioning, chillers
HCFC-123	0.02	76	CFC-11 replacement
HYDROFLUOROCARBONS			
HFC-23	~ 0	12,240	Ultra-low-temperature refrigeration
HFC-134a	~ 0	1,320	CFC-12 or HCFC-22 replacement
HFC-245fa	~ 0	1,020	Insulation agent, centrifugal chillers
HFC-404A	~ 0	3,900	Low-temperature refrigeration
HFC-407C	~ 0	1,700	HCFC-22 replacement
HFC-410A	~ 0	1,890	Air-conditioning
HFC-507A	~ 0	3,900	Low-temperature refrigeration
NATURAL REFRIGERANTS			
Carbon dioxide (CO_2)	0	1.0	
Ammonia (NH_3)	0	0	
Propane	0	3	

The USGBC LEED Technical and Scientific Advisory Committee report that provides the basis of this credit notes the following: The ozone-depletion potential (ODP) of the HCFCs (e.g., HCFC-123, HCFC-22) is much smaller than the ODP of the CFCs, but is not negligible. In contrast, the HFCs (e.g., HFC-134a, HFC-410a) have an ODP that is essentially zero, but their global warming potential (GWP) is substantially greater than some of the HCFCs, leading to a direct mechanism when the compound leaks into the atmosphere. Moreover, thermodynamic properties make the HFCs slightly less efficient refrigerants than the HCFCs, given idealized equipment design, so the same amount of cooling may require more electricity and thereby causes the indirect release of more CO_2 in generating that electricity. The dilemma, therefore, is that some refrigerants cause more ozone depletion than others, but the most ozone-friendly refrigerants cause more climate change.

MINIMIZE REFRIGERANT LEAKAGE

The refrigerant leakage rate can magnify or minimize the harmful effects of refrigerant use. See EA Prerequisite 3, Fundamental Refrigerant Management, for information about minimizing leakage rates through compliance with refrigerant management regulations and best practices.

In general, refrigerants that operate at low or negative pressure are likely to leak less.

SELECT EQUIPMENT WITH EFFICIENT REFRIGERANT CHARGE

Refrigerant charge is the ratio of refrigerant required (pounds) to gross cooling capacity provided (tons) for a given piece of HVAC&R equipment. Equipment that uses refrigerants efficiently has low refrigerant charge and therefore less potential to contribute to atmospheric damage.

Table 2 shows the maximum refrigerant charge for a single unit of equipment that would comply with this credit, based on default values. Most projects have multiple units of base building HVAC&R equipment, but if each unit is compliant, the project as a whole meets the requirement. The values in the table assume average refrigerant leak rates of 2% per year and 10% end-of-life losses; if a unit has a higher leakage rates, the maximum allowable refrigerant charge for that equipment would decrease accordingly. For equipment that has a service life greater than 23 years, the allowable refrigerant charge is 1–2% higher.

TABLE 2. MAXIMUM REFRIGERANT CHARGE

REFRIGERANT	10-YEAR LIFE (ROOM OR WINDOW AC, HEAT PUMPS)	15-YEAR LIFE (UNITARY, SPLIT, PACKAGED AC, HEAT PUMPS)	20-YEAR LIFE (RECIPROCATING OR SCROLL COMPRESSORS, CHILLERS)	23-YEAR LIFE (SCREW, ABSORPTION CHILLERS)
R-22	0.57	0.64	0.69	0.71
R-123	1.60	1.80	1.92	1.97
R-134a	2.52	2.80	3.03	3.10
R-245fa	3.26	3.60	3.92	4.02
R-407c	1.95	2.20	2.35	2.41
R-410a	1.76	1.98	2.11	2.17

SELECT EQUIPMENT WITH LONG SERVICE LIFE

HVAC&R service equipment with a long service life will generally reduce the potential amount of refrigerant leaked to the environment, because most refrigerant loss occurs during installation and decommissioning of equipment. The 2007 ASHRAE Applications Handbook provides data on the service life of different types of HVAC equipment; see the Calculations section of this credit for the ASHRAE equipment life list.

SELECT ALTERNATIVE FIRE-SUPPRESSION SYSTEMS

Halons were widely used in fire-suppression systems prior to their phase-out, which began in 1994 under the Montreal Protocol because of their strong ozone-depleting potential. EPA maintains a list of acceptable alternatives to halon-based fire suppression, but facility managers must determine the suitability of these alternatives for the situation. To achieve this credit, replacement systems must avoid halons, CFCs, and HCFCs.

EA	
NC	Credit 4
CS	Credit 4

DISTRICT ENERGY SYSTEMS

For projects with district energy systems, specific technical guidance can be found in the *LEED Canada Interpretation Guide for District Energy Systems* on CaGBC's website (http://www.cagbc.org). Follow the guidance in effect at the time of LEED project registration.

5. TIMELINE AND TEAM

Consult with a mechanical engineer or HVAC&R systems specialist during the design phase to identify refrigerant issues and leakage rates.

6. CALCULATIONS

The following information is required for each unit of base building HVAC&R equipment:

- Refrigerant charge (Rc) in pounds of refrigerant per ton of gross cooling capacity.
- Refrigerant type (used to determine ODP and GWP).
- Equipment type (used to determine Life).

Table 1 lists ODP and GWP values for many common refrigerants. These values should be used in the calculations.

Assume equipment life as follows (from ASHRAE Applications Handbook 2007):

- Window air-conditioning units and heat pumps, 10 years.
- Unitary, split, and packaged air-conditioning units and heat pumps, 15 years.
- Reciprocating compressors, scroll compressors, and reciprocating chillers, 20 years.
- Absorption chillers, 23 years.
- Water-cooled packaged air-conditioners, 24 years.
- Centrifugal chillers, 25 years.

Use any updated equipment life assumptions from Abramson (see the ASHRAE Applications Handbook). All other HVAC&R equipment is assumed to have a life of 15 years. Applicants may use alternative values for equipment life if they submit supporting documentation, such as a manufacturer's 30-year guarantee and equivalent long-term service contract for a chiller installation.

Refrigerant leakage rate (Lr) is assumed to be 2%/yr for all equipment types. End-of-life refrigerant loss (Mr) is assumed to be 10% for all equipment types.

EA	
NC	Credit 4
CS	Credit 4

For each piece of HVAC&R equipment, calculate the following values:

$$\text{Life-Cycle Ozone Depletion Potential (LCODP)} = \frac{\text{ODPr X (Lr X Life + Mr) X Rc}}{\text{Life}}$$

$$\text{Life-Cycle Direct Global Warming Potential (LCGWP)} = \frac{\text{GWPr X (Lr X Life + Mr) X Rc}}{\text{Life}}$$

If there is only 1 piece of base building HVAC&R equipment, use the following equation to demonstrate compliance:

Refrigerant Atmospheric Impact = LCGWP + LCODP X $10^5 \leq 100$

If there are multiple pieces of base building HVAC&R equipment, use a weighted average of all equipment, based on cooling capacity:

$$\text{Average Refrigerant Atmospheric Impact} = \frac{\Sigma\ (\text{LCGWP} + \text{LCODP} \times 10^5) \times \text{Qunit}}{\text{Qtotal}} \leq 100$$

Where:

- Qunit = Cooling capacity of an individual HVAC or refrigeration unit (tons)
- Qtotal = Total cooling capacity of all HVAC or refrigeration (tons)

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED letter templates for the complete descriptions of all required documentation.

- List base building systems containing refrigerants and the associated type of refrigerant. Include ODP and GWP in the list.
- Retain manufacturer's documentation, indicating the type and quantity of refrigerant used.
- Compile engineer's or manufacturer's information indicating that halons, CFCs, and HCFCs are not in fire-suppression systems.

EA	
NC	Credit 4
CS	Credit 4

8. EXAMPLES

Sample calculations are shown below. In the first sample, the school building does not comply with EA Credit 4, Enhanced Refrigerant Management. In the second example, the hotel meets the requirements even though individual units of HVAC&R equipment have refrigerant atmospheric impacts greater than 100.

Sample Calculation 1. School Building

- (12) 5-ton packaged HVAC units with HFC-410A for classrooms
- (1) 2-ton split system HVAC units with HCFC-22 for a data room
- (1) 1-ton window HVAC unit with HCFC-22 for an office

INPUTS								CALCULATIONS					
N (# of Units)	Qunit (tons)	Refrigerant	GWPr	ODPr	Rc (lb/ton)	Life (yrs)	Lr (%)	Mr (%)	Tr Total Leakage (Lr x Life +Mr)	LCGWP (GWPr x Tr x Rc)/ Life	LCODP x 10^5 100,000 x (ODPr x Tr x Rc)/Life	Refrigerant atmospheric impact = LCGWP + LCODP x 10^5	LCGWP + LCODP x 10^5) x N x Qunit
12	5	R410A	1,890	0	1.8	15	2	10	40%	90.72	0	90.7	5,443
1	2	R22	1,780	0.04	3.3	15	2	10	40%	156.6	352.0	508.6	1,017
1	1	R22	1,780	0.04	2.1	10	2	10	30%	112.1	252.0	364.1	364
Qtotal	63											Subtotal	6,825
Average refrigerant atmospheric impact = [∑ (LCGWP + LCODP x 10^5) x Qunit] / Qtotal													108.33
Result: Average refrigerant atmospheric impact has a value greater than 100; therefore this project does not earn EA credit 4.													

Sample Calculation 2. Hotel

- (3) 400-ton absorption chillers with HCFC-123
- (1) 40-ton commercial refrigeration compressor rack with HCFC-22
- (12) 2-ton telephone and data room split-system cooling units with HCFC-22

INPUTS								CALCULATIONS					
N (# of Units)	Qunit (tons)	Refrigerant	GWPr	ODPr	Rc (lb/ton)	Life (yrs)	Lr (%)	Mr (%)	Tr Total Leakage (Lr x Life +Mr)	LCGWP (GWPr x Tr x Rc)/ Life	LCODP x 10^5 100,000 x (ODPr x Tr x Rc)/Life	Refrigerant atmospheric impact = LCGWP + LCODP x 10^5	LCGWP + LCODP x 10^5) x N x Qunit
3	400	R-123	76	0.02	1.63	23	2	10	56%	3.016209	79.37391	82.4	98,868.1
1	40	R-22	1,780	0.04	2.1	20	2	10	50%	93.45	210	303.5	12,138.0
12	2	R-22	1,780	0.04	3.1	15	2	10	40%	147.1467	330.6667	477.8	11,467.5
Qtotal	1264											Subtotal	122,473
Average refrigerant atmospheric impact = [∑ (LCGWP + LCODP x 10^5) x Qunit] / Qtotal													96.9
Result: Average refrigerant atmospheric impact has a value ≤ 100; therefore this project earns EA credit 4.													

EA	
NC	Credit 4
CS	Credit 4

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations associated with this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATION

Provide facility operators with complete records (such as LEED application materials) for all refrigerant-containing systems, including fire suppression. Ensure that equipment labels are in place and accessible to building operators.

12. RESOURCES

WEBSITES

U.S. EPA Significant New Alternatives Policy
http://www.epa.gov/ozone/strathome.html

SNAP is an EPA program to identify alternatives to ozone-depleting substances. The program maintains up-to-date lists of environmentally-friendly substitutes for refrigeration and air conditioning equipment, solvents, fire suppression systems, adhesives, coatings, and other substances.

The Treatment by LEED of the Environmental Impact of HVAC Refrigerants (U.S. Green Building Council, 2004)
http://www.usgbc.org/DisplayPage.aspx?CMSPageID=154

This report was prepared under the auspices of the U.S. Green Building Council's LEED Technical and Scientific Advisory Committee. It was created in response to the LEED Steering Committee's charge to the committee to review the atmospheric environmental impacts of the use of halocarbons as refrigerants in building HVAC equipment.

PRINT MEDIA

2009 ASHRAE Handbook – Fundamentals
2008 ASHRAE Handbook – HVAC Systems and Equipment
2007 ASHRAE Handbook – HVAC Applications
2006 ASHRAE Handbook – Refrigeration
(American Society of Heating, Refrigeration and Air Conditioning Engineers, 2007)
http://www.ashrae.org/publications/

The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) is the primary professional association in North America on heating, ventilation, air conditioning and refrigeration engineering and operational practice. The ASHRAE Handbooks are written to help engineers design and use HVACR equipment and systems. Of particular interest on the topic of refrigerant management are Fundamentals Chapters 19-Refrigerants and 20 – Thermophysical Properties of Refrigerants; and Refrigeration Chapter 2 – System Practices for Halocarbon Refrigerants and Chapter 5 – Refrigerant System Chemistry.

EA	
NC	Credit 4
CS	Credit 4

CFCs, HCFC and Halons: Professional and Practical Guidance on Substances That Deplete the Ozone Layer (CIBSE, 2000).
This booklet provides background information on the environmental issues associated with CFCs, HCFCs, and halons, plus design guidance and strategies for refrigerant containment and leak detection.

The Refrigerant Manual: Managing the Phase-Out of CFCs (BOMA International, 1993).
This manual gives an overview of the phase-out of CFCs, including information on retaining or retrofitting existing equipment and replacing equipment.

13. DEFINITIONS

Chlorofluorocarbons (CFCs) are hydrocarbons that are used as refrigerants and cause depletion of the stratospheric ozone layer.

Greenhouse gases (GHG) absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by Earth's surface, clouds, and the atmosphere itself. Increased concentrations of greenhouse gases are a root cause of global climate change.

Halons are substances, used in fire-suppression systems and fire extinguishers, that deplete the stratospheric ozone layer.

Hydrochlorofluorocarbons (HCFCs) are refrigerants that cause significantly less depletion of the stratospheric ozone layer than chlorofluorocarbons.

Hydrofluorocarbons (HFCs) are refrigerants that do not deplete the stratospheric ozone layer but may have high global warming potential. HFCs are not considered environmentally benign.

The **leakage rate** is the speed at which an appliance loses refrigerant, measured between refrigerant charges or over 12 months, whichever is shorter. The leakage rate is expressed in terms of the percentage of the appliance's full charge that would be lost over a 12-month period if the rate stabilized. (EPA Clean Air Act, Title VI, Rule 608)

Refrigerants are the working fluids of refrigeration cycles that absorb heat from a reservoir at low temperatures and reject heat at higher temperatures.

EA	
NC	Credit 5
CS	NA

MEASUREMENT AND VERIFICATION

	NC	CS
Credit	EA Credit 5	NA
Points	3 points	NA

INTENT

To provide for the ongoing accountability of building energy consumption over time.

REQUIREMENTS: NC

OPTION 1

Develop and implement a measurement & verification (M&V) Plan consistent with Option D: Calibrated Simulation (Savings Estimation Method 2) as specified in the International Performance Measurement & Verification Protocol (IPMVP) Volume III: Concepts and Options for Determining Energy Savings in New Construction, April, 2003.

The M&V period must cover at least 1 year of post-construction occupancy.

Provide a process for corrective action if the results of the M&V plan indicate that energy savings are not being achieved.

OR

OPTION 2

Develop and implement a measurement & verification (M&V) Plan consistent with Option B: Energy Conservation Measure Isolation, as specified in the International Performance Measurement & Verification Protocol (IPMVP) Volume III: Concepts and Options for Determining Energy Savings in New Construction, April, 2003.

The M&V period must cover at least 1 year of post-construction occupancy.

Provide a process for corrective action if the results of the M&V plan indicate that energy savings are not being achieved.

EA	
NC	Credit 5
CS	NA

INTERPRETATIONS

Option D of the IPMVP protocol requires that calculations be calibrated against hourly or monthly end-use metering or data. A comparison of the calibrated energy model to monthly utility meter bills does not provide for an appropriate level of detailed information to give the building operator the ability to assess the performance of individual end uses. A combination of utility meters and trend logs from a DDC system or BAS would be acceptable provided that all significant energy end-uses and equipment performance parameters are isolated in some manner, either by direct monitoring or by deductive exclusion.

MURB

For MURBs it is acceptable to only meter central equipment and common utilities, recognizing that suite level information will not be available for privately owned or rental dwelling units with separate utility billing.

EA	
NC	NA
CS	Credit 5.1

MEASUREMENT AND VERIFICATION: BASE BUILDING

	NC	CS
Credit	NA	EA Credit 5.1
Points	NA	3 points

INTENT

To provide for the ongoing accountability of building energy consumption over time.

REQUIREMENTS: CS

OPTION 1

Develop and implement a measurement and verification (M&V) plan consistent with Option D: Calibrated Simulation (Savings Estimation Method 2) as specified by the International Performance Measurement & Verification Protocol (IPMVP), Volume III: Concepts and Options for Determining Energy Savings in New Construction, April 2003.

The documentation must include the following:

- A description of the infrastructure design.
- Existing meter locations.
- Existing meter specifications.
- 1-line electrical schematics identifying end-use circuits.
- Guidelines for carrying out tenant submetering.

The M&V period must cover at least 1 year of post-construction occupancy.

Provide a process for corrective action to ensure energy savings are realized if the results of the M&V plan indicate that energy savings are not being achieved.

OR

OPTION 2

Develop and implement a measurement and verification (M&V) plan consistent with Option B: Energy Conservation Measure Isolation, as specified by the International Performance Measurement & Verification Protocol (IPMVP), Volume III: Concepts and Options for Determining Energy Savings in New Construction, April 2003.

EA	
NC	NA
CS	Credit 5.1

The documentation must include the following:

- A description of the infrastructure design.
- Existing meter locations.
- Existing meter specifications.
- 1-line electrical schematics identifying end-use circuits.
- Guidelines for carrying out tenant submetering.

The M&V period must cover at least 1 year of post-construction occupancy.

Provide a process for corrective action to ensure energy savings are realized if the results of the M&V plan indicate that energy savings are not being achieved.

INTERPRETATIONS

Option D of the IPMVP protocol requires that calculations be calibrated against hourly or monthly end-use metering or data. A comparison of the calibrated energy model to monthly utility meter bills does not provide for an appropriate level of detailed information to give the building operator the ability to assess the performance of individual end uses. A combination of utility meters and trend logs from a DDC system or BAS would be acceptable provided that all significant energy end-uses and equipment performance parameters are isolated in some manner, either by direct monitoring or by deductive exclusion.

EA	
NC	NA
CS	Credit 5.2

MEASUREMENT AND VERIFICATION: TENANT SUBMETERING

	NC	CS
Credit	NA	EA Credit 5.2
Points	NA	3 points

INTENT

To provide for the ongoing accountability of building electricity consumption performance over time.

REQUIREMENTS: CS

Include a centrally monitored electronic metering network in the base building design that is capable of being expanded to accommodate the future tenant submetering as required by *LEED Canada for Commercial Interiors* Rating System EA Credit 3: Energy Use, Measurement & Payment Accountability.

Develop a tenant measurement and verification (M&V) plan that documents and advises future tenants of this opportunity and the means of achievement.

Provide a process for corrective action if the results of the M&V plan indicate that energy savings are not being achieved.

INTERPRETATIONS

There are no interpretations for this credit.

EA	
NC	Credit 5
CS	Credit 5.1-5.2

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Measurement and verification of a building's ongoing energy use optimize performance and minimize the economic and environmental impacts associated with its energy-using systems.

ECONOMIC ISSUES

The benefits of optimal building operation, especially in terms of energy performance, are substantial. The lifetime of many buildings is longer than 50 years, and so even minor energy savings are significant when considered in aggregate. Potential long-term benefits often go unrealized because of maintenance personnel changes, aging of building equipment, and changing utility rate structures. Therefore, it is important to institute M&V procedures and continuous monitoring to achieve and maintain optimal performance over the lifetime of the building. The goal of M&V activities is to provide building owners with the tools and data necessary to identify systems that are not functioning as expected and thus optimize building system performance.

The cost to institute an M&V program in a new construction project varies with the complexity of the building's systems and instrumentation and controls in the baseline design. The additional instrumentation and metering equipment, programming of controls, and labour associated with monitoring and processing data can all add to costs. Projects with sophisticated digital controls can often support an effective M&V program without incurring significant additional costs. On the other hand, projects with a series of chillers, air handlers, and simple controls may need to install a significant amount of equipment to generate the necessary data for an effective M&V program. Smaller buildings with packaged HVAC equipment and fewer pieces of equipment overall may have lower costs for instrumentation and metering because there are fewer systems to measure and verify. The cost of an M&V program must be balanced against the potential performance risk. A simple method of estimating performance risk can be based on the project value and technical uncertainty, as illustrated in Table 1.

TABLE 1. SAMPLE CALCULATION OF PERFORMANCE RISK

PROJECT	ANTICIPATED ANNUAL ENERGY COSTS	ESTIMATED SAVINGS	ESTIMATED UNCERTAINTY	PERFORMANCE RISK
Small	$250,000	$50,000	20%	$10,000
Large	$2,000,000	$500,000	30%	$150,000

A capital and operational budget for M&V can be a percentage of the project's performance risk over a suitable time period. A smaller project with predictable technologies has less performance risk (and thus a lower M&V budget) than a larger project that includes less predictable technologies.

EA	
NC	Credit 5
CS	Credit 5.1-5.2

In general, higher M&V intensity and rigor mean higher costs, both upfront and over time. The following factors (many of which are interrelated) typically affect M&V accuracy and costs:

- Level of detail and effort associated with verifying post-construction conditions.
- Number and types of metering points.
- Duration and accuracy of metering activities.
- Number and complexity of dependent and independent variables that must be measured or determined on an ongoing basis.
- Availability of existing data collection systems (e.g., energy management systems).
- Confidence and precision levels specified for the analyses.

CREDIT 5.2: CS

The goal of submetering is to give tenants an incentive to save energy. Submetering accounts for their energy consumption so that they can see a return on any conservation investments they make. Enabling tenants to track their electricity use gives them the opportunity to realize savings by reducing energy use or implementing energy efficiency measures.

Submeters are not a major expense. Some municipalities and utilities, however, do not allow a second party to charge for electricity based on submetering. In this case, providing separate utility meters for each tenant may be the best option. Or, for buildings that submeter, electricity cost can be apportioned to the tenants based on usage. The design team should confirm its strategies with both the municipality and the utility provider.

2. RELATED CREDITS

Implementation of a measurement and verification plan can help ensure accountability and contribute to realizing optimal energy performance. If system performance is the basis for the funding of the project (as with energy performance contracts), the International Performance Measurement and Verification Protocol (see the Referenced Standards section) will likely be used for verification. Renewable energy generation systems are considered within an M&V plan, and performance of these systems is often tracked to identify any operational issues. Refer to the requirements in the following:

- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance
- EA Credit 2: On-site Renewable Energy

Commissioning often employs measurement devices and capabilities to track building performance. These same devices can serve as the basis for a measurement and verification plan, especially if ongoing commissioning programs have been adopted by the owner. See the following:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Credit 3: Enhanced Commissioning

EA	
NC	Credit 5
CS	Credit 5.1-5.2

3. SUMMARY OF REFERENCED STANDARDS

International Performance Measurement and Verification Protocol, Volume III, Concepts and Options for Determining Energy Savings in New Construction, 2003

http://www.evo-world.org

The Efficiency Valuation Organization is a nonprofit organization whose vision is a global marketplace that properly values energy and water efficiency.

IPMVP Volume III provides a concise description of best practice techniques for verifying the energy performance of new construction projects. Chapter 2 describes the process for developing the theoretical baseline for new construction projects and provides examples of relevant applications. Chapter 3 describes the basic concepts and structure of the measurement and verification plan. Chapter 4 describes specific measurement and verification methods for energy conservation measure isolation (Option B) and whole-building calibrated simulation (Option D). Volume III pertains to new construction projects; Volume I relates to retrofit projects in existing facilities.

4. IMPLEMENTATION

IPMVP Volume III presents 4 options for new construction M&V. Of these, Options B and D are appropriate for LEED Canada M&V (Table 2).

TABLE 2. MEASUREMENT AND VERIFICATION FOR NEW CONSTRUCTION

M&V OPTION	BASELINE ENERGY USE	TYPICAL APPLICATIONS
OPTION B, ENERGY CONSERVATION MEASURE ISOLATION		
Determine savings by measuring energy use and operating parameters of system to which measure was applied, separate from rest of facility.	Calculate hypothetical energy performance of baseline system under measured post-construction operating conditions.	Variable speed control of fan motor; electricity use is measured on continuous basis throughout M&V period.
OPTION D, WHOLE-BUILDING SIMULATION		
Determine savings at whole-building or system level by measuring energy use and comparing it with baseline.	Estimate through whole-building simulation, then subtract energy efficiency measures from measured building performance.	Savings determination for new building performance contract, with baseline defined by local energy code.

IPMVP is not prescriptive about the application of M&V options but instead defers to the professional judgment of the implementer to apply the options in an appropriate manner while still meeting the M&V objective (see Economic Issues). The M&V plan should be based on the owner's needs and described in the owner's project requirements. Other implementation issues are the availability of a building automation system and whether the local utility uses meters that provide hourly or minute-by-minute power consumption data.

Option B addresses M&V at the system or energy conservation measure level. This approach is suitable for small and/or simple buildings that can be monitored by isolating the main energy systems and applying Option B to each system on an individual basis. The savings associated with most types of energy conservation measures can be determined using Option B. However, since each measure may require a meter, the limiting consideration may be cost associated with increased metering complexity. Greater certainty in determining savings, particularly with variable loads, often warrants the higher cost.

EA	
NC	Credit 5
CS	Credit 5.1-5.2

The energy savings may be determined from simple spreadsheet calculations using metered data. Deficiencies and operation errors can often be identified at this time. Usually, the ongoing cost of implementation for this option tends to be lower, because once the meters are installed, they provide continuous performance monitoring. Once the system or tracking is in place, monitoring requires minimal effort.

Option B is best applied in these circumstances:

- Interactive effects between energy conservation measures or with other building equipment can be measured or assumed to be insignificant.
- The parameters that affect energy use are not complex or excessively difficult or expensive to monitor.
- If measurement is limited to a few parameters, this option is less costly and is preferable to simulating operation under Option D.
- Meters can serve a dual purpose; for example, submetering is used for both operational feedback and tenant billing.
- Projected baseline energy use can be readily and reliably calculated.

Option D addresses M&V at the whole-building level. This approach is most suitable for buildings with a large number of energy conservation measures or interacting systems, such as those related to the building envelope. The performance of triple-glazed windows, air infiltration control, and highly insulated or mass wall systems is difficult to measure and requires computer simulation. An owner or institution wishing to analyze the effectiveness of such conservation measures should choose this option. Whole-building calibration compares the actual energy use of the building and its systems with the performance predicted by a calibrated computer model (like that developed for the energy simulation model used for EA Credit 1, Option 1). Calibration is achieved by adjusting the energy simulation model to reflect actual operating conditions and parameters. Next, the conservation measures are removed from the model to define the baseline. The energy savings are determined by subtracting the baseline energy simulation from the actual energy use.

Option D is useful in these circumstances:

- Calibration of the as-built energy simulation model shows how interactive energy conservation measures affect building energy use.
- Calibration of the as-built energy simulation model develops a breakdown of energy use. The breakdown of specific systems and equipment depends on the simulation software used. The advantages to this breakdown are discussed in the Performance Measurement credit of *LEED Canada for Existing Buildings: Operations & Maintenance 2009 Reference Guide*.
- A breakdown of energy end uses can help determine the most effective areas for energy conservation, such as electrical lighting versus gas water heating.
- The comparison of the calibrated as-built model with the calibrated baseline can show the payback of the capital costs of multiple, interactive conservation measures, such as a continuously insulated wall plus triple-glazed windows.

The M&V plan identifies the options to be applied, defines the baseline (or how it will be determined), identifies metering requirements, and outlines specific methodologies associated with implementing the plan. Responsibility for the design, coordination, and implementation of the M&V plan should reside with 1 entity of the design team. The person(s) responsible for energy

EA	
NC	Credit 5
CS	Credit 5.1-5.2

engineering and analysis is usually best suited for this role, although third-party verification may be appropriate in some cases. Since the pursuit of this credit is largely affected by the option selected to achieve EA Credit 1, Optimize Energy Performance, the baseline definition will vary. For EA Credit 1, Option 1, ASHRAE 90.1-2007, Appendix G or Model National Energy Code for Buildings 1997defines the baseline. The baselines for EA Credit 1, Options 2 and 3, are defined by the respective prescriptive standards, which (in some cases) may be effectively the same as the design. In that case, the M&V plan addresses design performance only. However, it is necessary in all cases to predict the energy performance of the design and/or its systems. For Option B, this prediction can be accomplished through either computer modelling or engineering analysis, depending on the complexity of the systems.

DISTRICT ENERGY SYSTEMS

For projects with district energy systems, specific technical guidance can be found in the *LEED Canada Interpretation Guide for District Energy Systems* on CaGBC's website (http://www.cagbc.org). Follow the guidance in effect at the time of LEED project registration.

CREDIT 5.1: CS

This credit focuses on the energy-using systems (and primarily the electricity-using systems) of the core and shell building. This may include measuring electricity use in the tenant spaces. However, for the purposes of this credit, the electricity use of the tenant spaces does not have to be itemized by the tenant. The submetering of tenant spaces is addressed in EA Credit 5.2.

To achieve this credit, the electricity-using systems in the core and shell building should be addressed in the M&V plan. Decide which electricity uses to focus on and how electricity use will be measured. Infrastructure, such as meters or a building management system, must be provided. If the building does not have any electricity-using equipment, the project is ineligible for this credit. Consider measuring other energy use (i.e., natural gas) to get a complete picture of the energy use of the building.

CREDIT 5.2: CS

This credit is designed to create the infrastructure that will enable any tenant in the building to earn EA Credit 3, Energy Use, Measurement & Payment Accountability, in *LEED Canada for Commercial Interiors*.

Either the project building or the local utility can install submeters so that tenants can monitor the energy consumption in their leased spaces. In a commercial office building that has a master electric meter, submeters track the actual consumption of individual tenants. In tests of commercial and residential situations, individual tenant responsibility for utility charges has resulted in conservation. For electrical service, the equipment and installation of submeters is not a major expense.

To satisfy the credit requirement, only electricity needs to be submetered. The electricity used for lighting and plug loads and to run HVAC equipment may be measured on a single meter and reported together.

EA	
NC	Credit 5
CS	Credit 5.1-5.2

5. TIMELINE AND TEAM

TABLE 3. M&V ACTIVITIES, BY PROJECT PHASE

PHASE	M&V ACTIVITIES
Design Development	Develop an energy model of the design.
	Specify number and types of meters.
	Provide trending parameters for controls specifications.
	Design document review.
Construction Documents	Review meter placement in drawings.
Construction Phase	Verify controls; contractor sets up required trends.
Post-Construction	Begin logging data.
	Re-calibrate base model or estimate base energy use.
	Report on energy savings.
	Provide suggestions for continuous improvement.

Introducing M&V early can alter the design of the mechanical system. Cross-discipline coordination of M&V system implementation can help the design team think about how the building will be operated. The operators of the building should be involved in M&V development, since they will be expected to execute the plan either directly or in partnership with a third party.

M&V begins after occupancy and only once a reasonable degree of operational stability has been achieved. The first phase of M&V lasts 1 year. The information recorded during the first phase helps to establish a protocol for the following:

- Determining the energy use in the building systems or system.
- Verifying the performance of energy conservation measures.
- Determining the energy conservation and associated cost savings over the baseline.

Continuation of M&V after the first year will enable the following:

- Continued performance improvements of the building energy systems.
- Tracking of systems to determine whether the long-term performance goals of the building are being achieved.

The M&V plan may identify additional monitoring opportunities to track and analyze energy use and permit continuous improvement, such as installation of specific diagnostic alerts within the control system for the following:

- Leaking valves in the cooling and heating coils within air-handling units.
- Missed economizer opportunities (e.g., faulty economizer damper controls).
- Software and manual overrides allowing equipment to operate 24/7.
- Equipment operation during unusual circumstances [e.g., boiler on when outside air temperature is above 18 ºC (65°F)].

In addition to bringing in control diagnostics specialists, consider employing retrocommissioning services or dedicating staff (usually a resource conservation manager) to investigate increases in energy use.

EA	
NC	Credit 5
CS	Credit 5.1-5.2

6. CALCULATIONS

IPMVP Volume III provides basic formulas as well as quantitative guidelines for error estimation and tolerance for various M&V options (not applicable to Core & Shell EA Credit 5.2, for which there are no calculations).

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED letter templates for the complete descriptions of all required documentation.

CREDIT 5: NC & CREDIT 5.1: CS

- Develop an IPMVP-compliant measurement and verification plan.
- Diagram the locations of any meters needed for measurement and update as necessary.

CREDIT 5.2: CS

- Decide how the tenants will be accountable for their energy use; include specific indication of how the energy use will be determined and how costs will be incurred.
- Develop a tenant measurement and verification plan.
- Develop a process for corrective action if the results of the M&V plan indicate that energy savings are not being achieved.

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations in the M&V methods, but the type of energy conservation measures employed does depend on climate. Various M&V techniques may become more popular in a given region because of the typical projects employing them. However, IPMVP is based on industry best practices, and the fundamentals of M&V apply to all projects.

EA	
NC	Credit 5
CS	Credit 5.1-5.2

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Consider submetering major energy end uses to help operators identify any deviations from expected consumption. Ensure that building operators are given the original and recalibrated energy use models so that they can identify unusual or unexpected consumption patterns.

12. RESOURCES

WEBSITES

Direct Digital Controls (DDC) Online
http://www.ddc-online.org

The DDC-Online website provides information on direct digital controls and a searchable database of DDC manufacturers.

Energy Management Systems: A Practical Guide
http://www.peci.org/documents/PECI_PracticalGuide1_0302.pdf

This aid, developed by Portland Energy Conservation Inc., provides information on commissioning BAS as well as sample control specification language. It is available on the organization's website and in print.

ENERGY STAR® Portfolio Manager
http://www.energystar.gov/benchmark

ENERGY STAR is a government-industry partnership managed by the U.S. Environmental Protection Agency and the U.S. Department of Energy. The program's website offers energy management strategies, benchmarking software tools for buildings, product procurement guidelines, and lists of ENERGY STAR–qualified products and buildings.

Portfolio Manager is an online tool to help track the energy use of commercial buildings. It provides a benchmark number that can be used to assess future energy improvements.

International Performance Measurement and Verification Protocol
http://www.evo-world.org

IPMVP Inc. is a nonprofit organization whose vision is a global marketplace that properly values energy and water efficiency.

13. DEFINITIONS

A district energy system (DES) is a central plant and distribution system that provides energy (heat, cooling and/or electricity) to a group of buildings in a small district. Examples include central plants on university campuses or those that serve the downtown cores of cities. Large-scale utilities that supply energy to large regions, provinces or municipalities, are not considered DESs. Refer to *LEED Canada Interpretation Guide for District Energy Systems* for further information.

Downstream equipment consists of all heating or cooling systems, equipment, and controls located within the project building and site associated with transporting thermal energy into heated or cooled spaces. This includes the thermal connection or interface with the district energy system, secondary distribution systems in the building, and terminal units.

Energy conservation measures are installations or modifications of equipment or systems intended to reduce energy use and costs.

EA	
NC	Credit 5
CS	Credit 5.1-5.2

Measurement and Verification (M&V) Plan is a document specific to a building project that outlines measures and procedures to record and analyze building performance through metering.

Upstream equipment consists of all heating or cooling systems, equipment, and controls that are associated with a district energy system but are not part of the project building's thermal connection or do not interface with the district energy system. It includes the central energy plant and all transmission and distribution equipment associated with transporting the thermal energy to the project building and site.

Verification is the range of checks and tests carried out to determine whether components, subsystems, systems, and interfaces between systems operate in accordance with the contract documents.

EA	
NC	Credit 5
CS	Credit 5.1-5.2

14. CASE STUDY

MINTO ROEHAMPTON

LEED Canada-NC 1.0 Gold, 30 January 2008

Location: Toronto, Ontario
Building Type: Multi-Unit Residential
Owner Type: Property Manager
Building Size: 9,700 m^2
Owner Name: Minto Apartments Limited
LEED Consultant: The Minto Green Team
Responsible Firm (for this credit): The Minto Green Team
Photo Credit: The Minto Group

MintoRoehampton is a multi-unit residential building located in midtown Toronto. Like most buildings, effective control of utility expenses is essential. The project was built with many green features to differentiate it from the surrounding rental buildings including the Minto QuickFlick™ (an "all-off" suite light switch), in-suite heat recovery ventilation, condensing boilers, free cooling, variable speed fan and pumps, a rainwater harvesting system, dual-flush toilets, solar air preheat, and many other energy and water conservation measures. A Measurement Canada approved sub-metering system was installed to empower residents to conserve natural resources by providing feedback on electricity and hot and cold water consumption patterns in the form of monthly bills for water and energy use. MintoRoehampton also features an extensive building automation system including networked suite thermostats with occupancy control in additional to monitoring and control for all central mechanical systems.

MintoRoehampton used the International Performance Measurements and Verification Protocol to provide guidance for their measurement and verification plan. Expected energy consumption values are based upon an energy model that was verified by Natural Resources Canada. Loads that are not considered by the Natural Resources Canada energy model such as the elevators, domestic cold-water booster pumps, and the solar wall were added to the results. Base year water consumption is based on the typical water consumption witnessed across Minto's portfolio of

EA	
NC	Credit 5
CS	Credit 5.1-5.2

rental buildings adjusted to account for the higher efficiency water fixtures and sub-metering that is installed at MintoRoehampton.

The Minto Green Team uses a utility database management tool to manage utility bill cost, consumption and demand data. Actual utility consumption and costs are compared to weather adjusted utility budgets. At the end of each month, a Monthly Property Savings Report is reviewed to ensure that the actual consumption is similar to the expected consumption. If an unexpected gap exists between the actual and expected consumption, the energy analysts, engineers and technicians investigate the issue to find the source of the discrepancy. The sub-metering system and building automation system are also utilized to provide very detailed utility audits to better understand variances in system performance and to help identify opportunities for improvement in future developments.

In addition to ensuring the maintenance of the natural resource conservation objectives, the measurement, verification, and commissioning process provides feedback on the success of each energy conservation measure to help Minto build better buildings in the future.

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POWERSTREAM CORPORATE HEAD OFFICE

LEED Canada-NC 1.0 Gold, 24 September 2008

Location: Vaughan, Ontario
Building Type: Office
Owner Type: Government - Local
Building Size: 9,800m^2
Owner Name: Powerstream
LEED Consultant: Enermodal Engineering Ltd.
Responsible Firm (for this credit): Enermodal Engineering Ltd.
Photo Credit: Enermodal Engineering Ltd.

The PowerStream Head Office is a three-storey, LEED Canada Gold certified office building that houses executive, administrative, and engineering functions, a customer service centre, and a power control centre for the fourth largest electricity distribution company in Ontario. This corporate headquarters illustrates PowerStream's vision for a sustainable future and commitment to leading by example. The key guiding features of the building design include improved workplace quality, energy conservation and monitoring; exceptional provision for grid-connected renewable energy technologies; and a reduction in environmental impact.

This project required electrical and gas meters to be installed to provide sufficient information to produce a representative calibrated simulation of the building. This simulation was then used to determine the potential performance of the building, which was compared to the actual performance. Non-regulated loads were removed from the meter readings to allow regulated loads to be compared to the calibrated simulation.

Over its first year of operation the building's energy consumption was well within its expected range. Overall the total yearly energy consumption of the Powerstream Headquarters was 274 ekWh/m^2. This represents around a 30% savings over the energy consumption of typical office buildings in Canada (394 ekWh/m^2). The building has the potential to save even more energy. Now that the M&V infrastructure has been installed and a baseline year has been completed, the stage has been set for the owner to take further action to reach the full potential of the building.

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Lessons learned:

- Non-regulated building loads can represent large energy uses that are not typically modeled. Quantifying these loads is critical in evaluating the true performance of the building.
- Measurement & Verification can detect and quantify operational issues that contribute to excessive energy use.
- Measurement & Verification can verify whether the energy conservation measures and the building control system are operating as intended and that the building has achieved expected energy savings.

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CS	Credit 6

GREEN POWER

	NC	CS
Credit	EA Credit 6	EA Credit 6
Points	2 points	2 points

INTENT

To encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.

REQUIREMENTS: NC & CS

Engage in at least a 2-year renewable energy contract to provide at least 35% of the building's electricity from renewable sources. Renewable sources are those that meet the Environmental Choice EcoLogo Program requirements for renewable, low-impact generation.

All purchases of green power shall be based on the quantity of energy consumed, not the cost.

CS ADDITIONAL REQUIREMENT:

The core and shell building's electricity is defined as the electricity usage of the core and shell floor area, but not less than 15% of the total proposed building electricity consumption.

OPTION 1. DETERMINE BASELINE ELECTRICITY USE

Use the annual electricity consumption from the results of EA Credit 1: Optimize Energy Performance.

OR

OPTION 2. ESTIMATE BASELINE ELECTRICITY USE

Use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey database to determine the estimated electricity use.

INTERPRETATIONS

Green-e is an acceptable alternative to EcoLogo. The Green-e program was established by the Center for Resource Solutions to promote green electricity and provide consumers with a rigorous method to identify green electricity products.

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CS	Credit 6

CAMPUS

This credit can be achieved on either a project or Campus basis. To meet the requirements on a Campus-wide basis, sufficient green power must be purchased to meet the total Campus Requirements, for all buildings.

For project compliance where green power is purchased for several LEED projects, provide a table of all the Campus LEED buildings including each building's total electrical use.

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NC	Credit 6
CS	Credit 6

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Energy production from traditional sources (such as coal, natural gas, and other fossil fuels) is a significant contributor to air pollution in Canada, releasing such pollutants as sulphur dioxide, nitrogen oxide, and carbon dioxide. These pollutants are primary contributors to acid rain, smog, and climate change. Along with other associated pollutants, they have widespread and adverse effects on human health, especially respiratory health.

The EcoLogo Program was established by Environment Canada to promote green electricity products and provide consumers with a rigorous and nationally recognized method to identify green electricity products. These products reduce the air pollution impacts of electricity generation by relying on renewable energy sources such as solar, water, wind, biomass, and geothermal sources. In addition, the use of ecologically responsive energy sources avoids reliance on nuclear power and large-scale hydropower, which have their own drawbacks—security and environmental issues related to nuclear waste reprocessing, transportation, and storage, and alteration of aquatic habitats in the case of hydroelectric dams. Deregulated energy markets have enabled hydroelectric generators to market their electricity in areas unaffected by the dams' regional impacts.

The overall environmental benefit of renewable energy depends on the source of energy and the process by which it is extracted. For example, using biomass can reduce the estimated 136 million tons of woody construction, demolition, and land-clearing waste sent annually to landfills,[17] but if these wastes are not processed properly, their combustion could degrade air quality. Although green electricity is not entirely benign, it significantly lessens the negative environmental impacts of power generation. Using renewable energy generated either on-site or off-site is an excellent way for owners to reduce the negative environmental impacts on air and water associated with a building's energy requirements.

Renewable energy has a positive impact on rural communities in particular; siting and operating wind farms and biomass conversion facilities in rural areas enhances economic development. Rural wind generation is providing new sources of income for Canadian farmers and other rural landowners while meeting the growing demand for clean sources of electricity. However, care must be taken to minimize undesirable noise from wind farms and emissions from combustion at biomass conversion facilities.

While acknowledging the difficulty of identifying the exact source of green energy in every region, this credit requires that the renewable energy used for the building and its site be certified as green by the EcoLogo Program or its equivalent.

ECONOMIC ISSUES

Green power products may cost somewhat more than conventional energy products but are derived, in part, from renewable energy sources with stable energy costs. As the green power market matures and the effects of other power sources on the environment and human health are factored into power costs, renewable energy is expected to become less expensive than conventional power products. Typically, programs are structured such that utility customers can choose the portion of their electricity delivered from renewable sources. In these cases, a premium may be added to the monthly utility bill. Although the source of the green power is different from traditional sources, it reaches end users via the established grid distribution system, and thus project teams can implement green power programs, even in the postdesign phase, with no design changes. Find out whether the local government sponsors any incentive program or tax benefit for using renewable energy, particularly for the type of renewable energy planned for a

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CS	Credit 6

project. The Pembina Institute website (http://re.pembina.org/canada/policies) provides a list of federal and provincial initiatives designed to support the growth of renewable energy in Canada.

2. RELATED CREDITS

Replacing conventional energy sources with renewable energy sources works synergistically with efforts to reduce energy costs. Refer to the following credit:

- EA Credit 1: Optimize Energy Performance
- EA Credit 2: On-Site Renewable Energy

3. SUMMARY OF REFERENCED STANDARDS

EcoLogo Electricity
http://www.ecologo.org/en/

The Environmental Choice EcoLogo Program certifies a wide range of environmentally preferred products. The program was initiated by Environment Canada and is now run by TerraChoice Environmental Marketing. To be eligible for the EcoLogo, electricity must be generated from solar, wind, small-scale hydro, biomass and/or biogas, and must meet certain threshold criteria.

4. IMPLEMENTATION

THERE ARE 3 APPROACHES FOR ACHIEVING THIS CREDIT.

1. In a province with an open electricity market, building owners may be able to select an Ecologo–certified power provider. Investigate green power and power markets licensed to provide power in the province and secure a 2-year contract for a minimum of 35% of the annual electrical power consumption from an Ecologo–certified provider.
2. In a province with a closed electricity market, the governing utility company may have an Ecologo–accredited utility program. In this case, building owners can enrol the building in the renewable power program for at least 35% of the provided electrical energy. Typically, programs are structured such that utility customers can choose how much of their electricity will be delivered from renewable sources; a premium may be added to the monthly utility bill. Commit to a 2-year enrolment period or use other strategies to accumulate 2 years' worth of renewable energy for the desired portion of total annual energy use. If the utility does not offer 2-year enrolment options, submit a letter of commitment to stay enrolled in the program for the required period.
3. As a third option, the owner and project team can purchase EcoLogo–accredited renewable energy certificates (RECs) from any company regardless of proximity to project. Investigate green power and power markets licensed to provide power and purchase a quantity of RECs equal to 35% of the predicted annual electricity consumption over a 2-year period. The RECs may be purchased either all at once (which is equivalent to 70% of predicted annual electricity consumption if all the RECs are purchased at 1 time) or in contracted instalments. These RECs, or "green-tags," compensate EcoLogo generators for the premium of production over the market rate they sell to the grid. Purchasing EcoLogo RECs will not affect the cost or procurement of the electricity from the local electrical utility. Although there is no impact on achievement of the credit, teams are encouraged to use local suppliers. See the Calculations section below for information on calculating electrical power consumption and determining the 35% threshold.

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CS	Credit 6

ESTABLISHING ECOLOGO EQUIVALENCY

If renewable energy is not EcoLogo certified, establish that it is equivalent for the 2 major criteria for EcoLogo certification: (1) the energy source meets the requirements for renewable resources detailed in the current version of the EcoLogo standard, and (2) the renewable energy supplier has undergone an independent, third-party verification that the standard has been met. The current version of the standard is available on the EcoLogo website (http://www.ecologo.org/en/). The third-party verification process must be as rigorous as that used in the EcoLogo certification process, and it must be performed annually.

RETENTION OF RENEWABLE ENERGY ENVIRONMENTAL ATTRIBUTES

For renewable energy coming from both on-site and off-site sources, the associated environmental attributes must be retained or retired; they cannot be sold. If the associated environmental benefits of on-site renewable energy (i.e., those used in EA Credit 2) are sold, then the green power purchases must also replace this energy.

DISTRICT ENERGY SYSTEMS

For projects with district energy systems, specific technical guidance can be found in the Interpretation Guide for District Energy Systems on CaGBC's website (http://www.cagbc.org). Follow the guidance in effect at the time of LEED project registration.

5. TIMELINE AND TEAM

The project team should estimate the potential energy use of the building during the design phase so that appropriate renewable technologies and potential benefits can be identified.

6. CALCULATIONS

Use either of 2 compliance paths to calculate the amount of electrical energy that must be obtained from qualifying providers to achieve compliance with EA Credit 6.

1. DESIGN ENERGY COST (OPTION 1)

The first compliance path is based on the design case annual electricity consumption, which the project team may have calculated as part of compliance with EA Credit 1. The project owner should contract with an EcoLogo-certified power producer for that amount.

SAMPLE CALCULATION BASED ON DESIGN ENERGY COST

The building's annual electricity use is 151,816 kWh based on the performance path method for EA Credit 1, Option 1.

REQUIRED GREEN POWER QUANTITY

151,816 (kWh/yr) x 35% x 2 yrs = 106,271 (kWh)

This project needs to purchase EcoLogo–certified green power or RECs equal to 106,271 kWh.

If, for example, the project obtained a quote from a REC provider of $0.02/kWh, the total cost to the project to earn EA Credit 6 would be $2,125.

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2. DEFAULT ELECTRICITY CONSUMPTION (OPTION 2)

If an energy model was not performed in EA Credit 1, use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey database to determine the estimated electricity use. This database provides electricity intensity factors (kWh/sf/yr) for various building types in the United States.

Table 1 summarizes median annual electrical intensities in kWh/m^2/yr and kWh/sf/yr for different building types, based on data from the latest survey. The energy intensity multiplied by the floor area (square metres) of the project represents the total amount of electricity consumption. Total electricity consumption X 35% X 2 years represents the total green power (in kWh) that would need to be purchased over a 2-year period to qualify for EA Credit 6 using this option.

TABLE 1: COMMERCIAL BUILDINGS ENERGY CONSUMPTION SURVEY (CBECS) DATA, FROM U.S. DOE ENERGY INFORMATION ADMINISTRATION

BUILDING TYPE	MEDIAN ELECTRICAL INTENSITY(kWh/m^2-yr)	MEDIAN ELECTRICAL INTENSITY(kWh/ft^2-yr)
Education	71.0	6.6
Food Sales	634.0	58.9
Food Service	308.9	28.7
Health Care Inpatient	231.4	21.5
Health Care Outpatient	104.4	9.7
Lodging	135.6	12.6
Retail (Other than Mall)	86.1	8.0
Enclosed and Strip Malls	156.1	14.5
Office	125.9	11.7
Public Assembly	73.2	6.8
Public Order and Safety	44.1	4.1
Religious Worship	26.9	2.5
Service	65.7	6.1
Warehouse and Storage	32.3	3.0
Other	148.5	13.8

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CS

AREA CALCULATION

The building's core and shell floor area is the area of all common spaces and common systems.

The percentage of the building that is core and shell floor area is as follows:

$$\frac{\text{Core \& Shell Floor area}}{\text{Building Floor Area}} \times 100$$

If the result is less than 15%, use 15% for the calculations.

SAMPLE CALCULATION BASED ON DEPARTMENT OF ENERGY DATA

The project is a 18,000 square metre speculative office building. According to the CS area calculation, the core and shell is 20% of the building total area, or 3,600 square metres. The calculation for the renewable energy required is based on this figure. To determine how much renewable energy is needed to meet the requirements of EA Credit 6, use Table 1 and the median electricity consumption intensity for offices.

DEFAULT ANNUAL ELECTRICITY CONSUMPTION

$$3{,}600\ (m^2) \times 125.9\ (kWh/m^2/yr) = 453{,}240\ (kWh/yr)$$

REQUIRED GREEN POWER

$$453{,}240\ (kWh/yr) \times 35\% \times 2\ yrs = 317{,}268\ (kWh)$$

This project needs to purchase EcoLogo–certified green power or RECs equal to 317,268 kWh. If the project obtained a quote from a RECs provider of $0.02/kWh, the total cost to the project to earn EA Credit 6 would be $6,346.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED letter templates for the complete descriptions of all required documentation.

- Sign a 2-year contract for the purchase of renewable energy certified by EcoLogo (or equivalent) and maintain contractual documentation.
- For a campus project, where the certified renewable energy is purchased for the project by others, maintain documentation indicating that the renewable energy was retained on behalf of the project.

8. EXAMPLES

There are no examples for this credit.

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CS	Credit 6

9. EXEMPLARY PERFORMANCE

Exemplary performance is available to projects that purchase 70% of their electricity from renewable sources for 2 years.

10. REGIONAL VARIATIONS

Renewable energy certificates (RECs) are now available in nearly all the provinces. Customers can buy green certificates whether or not they have access to green power through their local utility or a competitive electricity marketer.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

To facilitate the continued purchase of green power beyond the 2-year contract period, give building operators details of the original green power contract.

12. RESOURCES

WEBSITES

Canadian Solar Industries Association (CanSIA)
http://www.cansia.ca

CanSIA is the primary Canadian solar energy industry association, fostering research, information exchange and lobbying on behalf of manufacturers and distributors.

Canadian Wind Energy Association (CanWEA)
http://www.canwea.ca

The Canadian Wind Energy Association (CanWEA) is a nonprofit trade association that promotes the appropriate development and application of all aspects of wind energy in Canada, including the creation of a suitable policy environment.

Center for Resource Solutions, Green-e Product Certification Requirements
http://www.green-e.org

Green-e Energy is a voluntary certification and verification program for renewable energy products. Green-e certifies products that meet environmental and consumer protection standards developed in conjunction with environmental, energy, and policy organizations. Sellers of Green-e–certified energy must disclose clear and useful information to customers. Three types of renewable energy options are eligible for Green-e certification: renewable energy certificates, utility green-pricing programs, and competitive electricity products. The Green-e standard that went into effect on January 1, 2007, supersedes previous regional and product specific criteria.

Products exhibiting the Green-e logo are greener and cleaner than the average retail electricity product sold in that particular region. To be eligible for the Green-e logo, companies must meet certain criteria. The first criterion is the inclusion of qualified sources of renewable energy content such as solar electric, wind, geothermal, biomass, and small or certified low-impact hydro facilities. Other criteria are the inclusion of new renewable energy content (to support new generation capacity); compliance with emissions regulations for the non-renewable portion of the energy product; and the absence of nuclear power. Companies must also meet other criteria regarding renewable portfolio standards. Refer to the standard for more details.

EcoLogo Program
http://www.ecologo.org/en

EA	
NC	Credit 6
CS	Credit 6

This website provides information on the Environmental Choice EcoLogo Program which certifies a wide range of environmentally preferred products. The program was initiated by Environment Canada and is now run by TerraChoice Environmental Marketing. To be eligible for the EcoLogo, electricity must be generated from solar, wind, small-scale hydro, biomass and/or biogas, and must meet certain threshold criteria.

ENERGY Guide
http://www.energyguide.com

This website provides information on different power types, including green power, as well as general information on energy efficiency and tools for selecting power providers based on economic, environmental, and other criteria.

Office of Energy Efficiency and Renewable Energy
http://www.eere.energy.gov

This website includes information on all types of renewable energy technologies and energy efficiency.

Pembina Institute
http://re.pembina.org/canada/policies

This database provides a list of federal and provincial initiatives designed to support the growth of renewable energy in Canada.

Pollution Probe, Consumer Guide to Green Power in Canada (published in 2006)
http://www.pollutionprobe.org/whatwedo/greenpower/consumerguide/c2_1.htm

This publication provides information on the availability of green power in each province of Canada.

Union of Concerned Scientists, Clean Energy
http://www.ucsusa.org/clean_energy

This independent nonprofit analyzes and advocates energy solutions that are environmentally and economically sustainable. The site provides news and information on research and public policy.

U.S. Department of Energy, Green Power Network
http://www.eere.energy.gov/greenpower

The Green Power Network provides news and information on green power markets and related activities. It contains up-to-date information on green power providers, product offerings, consumer issues, and in-depth analyses of issues and policies affecting green power markets. The website is maintained by the National Renewable Energy Laboratory for the Department of Energy.

U.S. EPA, Green Power Partnership
http://www.epa.gov/greenpower

The Green Power Partnership provides news and information on green power markets and related activities. It contains up-to-date information on green power providers, product offerings, consumer issues, and in-depth analyses of issues and policies affecting green power markets. The website is maintained by the National Renewable Energy Laboratory for the Department of Energy.

13. DEFINITIONS

Biofuel-based systems are power systems that run on renewable fuels derived from organic materials, such as wood by-products and agricultural waste. Examples of biofuels include untreated wood waste, agricultural crops and residues, animal waste, other organic waste, and landfill gas.

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Biomass is plant material from trees, grasses, or crops that can be converted to heat energy to produce electricity.

Biomass power is electrical or thermal energy that is generated through the combustion of biomass (e.g., plant material such as trees, grasses, and crops).

Building Floor Area is the sum of the floor areas of the spaces within the building including basements, mezzanine and intermediate-floored tiers, and penthouses with headroom height of 2.2 metres (7.5 ft) or greater. It is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features. (ASHRAE 90.1 – 2007)

The building's **Core and Shell floor area** is the area of all common spaces and common systems.

Geothermal heating systems use pipes to transfer heat from underground steam or hot water for heating, cooling, and hot water. The system retrieves heat during cool months and returns heat in summer months.

Geothermal power is heat or electricity generated from steam or high temperature hot water released from the Earth. Ground-source heat pumps, which typically operate at moderate temperatures, are considered an energy efficiency technology similar to efficient air-source heat pumps, and are recognized under EACredit 1, rather than a renewable energy source recognized by EA Credit 2.

Green power is synonymous with renewable energy.

Green power contract certifies that a unit of electricity was generated from a renewable source. This contract may be separate from the sale of the electricity itself, allowing the purchase of green power by any electricity customer.

Hydropower is electricity produced from the downhill flow of water from rivers or lakes.

Photovoltaic (PV) energy is electricity from photovoltaic cells that convert the energy in sunlight into electricity.

Renewable energy comes from sources that are not depleted by use (renewable sources). Examples include energy from the sun, wind, and small (low-impact) hydropower, plus geothermal energy and wave and tidal systems. Ways to capture energy from the sun include photovoltaic, solar thermal, and bioenergy systems based on wood waste, agricultural crops or residue, animal and other organic waste, or landfill gas.

Renewable energy certificates (RECs) are tradable commodities representing proof that a unit of electricity was generated from a renewable energy resource. RECs are sold separately from electricity itself and thus allow the purchase of green power by a user of conventionally generated electricity.

Solar thermal systems collect or absorb sunlight via solar collectors to heat water that is then circulated to the building's hot water tank. Solar thermal systems can be used to warm swimming pools or heat water for residential and commercial use.

Wave and tidal power systems capture energy from waves and the diurnal flux of tidal power, respectively. The captured energy is commonly used for desalination, water pumping, and electricity generation.

Wind energy is electrical production generated from a wind turbine that converts the kinetic energy of the wind into electricity.

ENERGY AND ATMOSPHERE ENDNOTES

[1] Natural Resources Canada Office of Energy Efficiency, Energy Use Data Handbook, 1990 to 2006, January 2009, Retrieved February 2009, http://oee.nrcan.gc.ca/publications/statistics/handbook08/index.cfm?attr=0 (From Chapter 1 – Total End-Use Sector: The Data Simulation (2006): Energy Use Data Handbook. Table 2 and 3 and includes Residential sector, Commercial/Institutional sector, and Construction sub sector. Available at: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_totalsectors_ca.cfm?attr=0

[2] Natural Resources Canada Office of Energy Efficiency, Energy Use Data Handbook, 1990 to 2006, January 2009, Retrieved February 2009, http://oee.nrcan.gc.ca/publications/statistics/handbook08/index.cfm?attr=0 (From Chapter 1 – Total End-Use Sector: The Data Simulation (2006): Energy Use Data Handbook. Table 2 and 3 and includes Residential sector and Commercial/Institutional sector. Available at: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_totalsectors_ca.cfm?attr=0

[3] Natural Resources Canada Office of Energy Efficiency, "Energy Use Data Handbook Tables (Canada)", Retrieved February 2009, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_totalsectors_ca.cfm?attr=0 (Select "Download all of the Handbook Tables" to view the Electricity Generation sector data and the breakdown of secondary energy use in each sector by energy source)

[4] Natural Resources Canada Office of Energy Efficiency, "Energy Use Data Handbook Tables (Canada) – Electricity Generation Sector", Retrieved February 2009, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_totalsectors_ca.cfm?attr=0 (Select "Download all of the Handbook Tables" to view the Electricity Generation sector data)

[5] Natural Resources Canada Office of Energy Efficiency, "Energy Use Data Handbook Tables (Canada) - Total End-Use Sector (Table 3)", Retrieved February 2009, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_totalsectors_ca.cfm?attr=0

[6] Natural Resources Canada Office of Energy Efficiency, "Energy Use Data Handbook Tables (Canada) – Total End-Use Sector (Table 1)", Retrieved February 2009, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_totalsectors_ca.cfm?attr=0

[7] U.S. Environmental Protection Agency. "ENERGY STAR Home Improvement Tips", http://www.energystar.gov/index.cfm?c=cfls.pr_cfls (accessed November 2008).

[8] Canadian Council of Ministers of the Environment. "Canada's Strategy to Accelerate the Phase-Out of CFC and Halon Uses and to Dispose of the Surplus Stocks". May 2001. Retrieved January 2009. http://www.ccme.ca/assets/pdf/cfc_halons_dspslstrtgy_e.pdf.

[9] Ibid.

[10] BOMA Canada. "Canada's Federal Halocarbon Regulations: Update". December 2003. Retireved January 2009. http://www.bomacanada.ca/news/200312_Halocarbon.pdf.

[11] Ibid.

[12] Canadian Council of Ministers of the Environment. "Canada's Strategy to Accelerate the Phase-Out of CFC and Halon Uses and to Dispose of the Surplus Stocks". May 2001. Retrieved January 2009. http://www.ccme.ca/assets/pdf/cfc_halons_dspslstrtgy_e.pdf.

[13] Natural Resources Canada Office of Energy Efficiency, "Energy Use Data Handbook Tables (Canada) – Total End-Use Sector (Table 3)", Retrieved February 2009, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_totalsectors_ca.cfm?attr=0

[14] Natural Resources Canada Office of Energy Efficiency, "Energy Use Data Handbook Tables (Canada) – Total End-Use Sector (Table 1)", Retrieved February 2009, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_totalsectors_ca.cfm?attr=0

[15] U.S. Environmental Protection Agency. "ENERGY STAR Home Improvement Tips", http://www.energystar.gov/index.cfm?c=cfls.pr_cfls (accessed November 2008).

[16] U.S. Green Building Council LEED Steering Committee. "The Treatment by LEED® of the Environmental Impact of HVAC Refrigerants". October 2004. https://www.usgbc.org/Docs/LEED_tsac/TSAC_Refrig_Report_Final-Approved.pdf

[17] United States. Department of Energy, Energy Information Administration. Renewable Energy Trends 2003 August 2004. 24 February 2005. http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table1.html

MATERIALS AND RESOURCES (MR)

OVERVIEW

Building operations generate a large amount of waste on a daily basis. Meeting the LEED Materials and Resources (MR) credits can reduce the quantity of waste while improving the building environment through responsible waste management and materials selection. The credits in this section focus on 2 main issues: the environmental impact of materials brought into the project building, and the minimization of landfill and incinerator disposal for materials that leave the project building.

This credit category addresses the environmental concerns relating to materials selection, waste disposal, and waste reduction. The *LEED® Canada for New Construction* and *LEED Canada for Core & Shell* Materials and Resources prerequisites and credits promote the following measures:

SELECTING SUSTAINABLE MATERIALS

Materials selection plays a significant role in sustainable building operations. During the life cycle of a material, its extraction, processing, transportation, use, and disposal can have negative health and environmental consequences, polluting water and air, destroying native habitats, and depleting natural resources. Environmentally responsible procurement policies can significantly reduce these impacts. Consider the relative environmental, social, and health benefits of the available choices when purchasing materials and supplies. For example, the purchase of products containing recycled content expands markets for recycled materials, slows the consumption of raw materials, and reduces the amount of waste entering landfills. Use of materials from local sources supports local economies while reducing transportation impacts.

PRACTICING WASTE REDUCTION

Maintaining occupancy rates in existing buildings reduces redundant development and the associated environmental impact of producing and delivering new materials. Construction waste disposal through landfilling or incineration contributes significantly to the negative environmental impacts of a building. Construction and demolition wastes constitute about 12% of the total solid waste stream in the Canada.[1] In its solid waste management hierarchy, the U.S. Environmental Protection Agency (EPA) ranks source reduction, reuse, and recycling as the 3 preferred strategies for reducing waste.[2] Source reduction appears at the top of EPA's hierarchy because it minimizes environmental impacts throughout the material's life cycle, from the supply chain and use to recycling and waste disposal. Reuse of materials is ranked second because reused materials are diverted from the waste stream and substitute for other materials with greater environmental impacts. Recycling does not have all the same benefits as source reduction and reuse, but it diverts waste from landfills and incinerators and lessens the demand for virgin materials.

REDUCING WASTE AT ITS SOURCE

Source reduction, which includes reducing the overall demand for products, is the most economical way to reduce waste. In 2006, Canadians produced 35 million tonnes of waste (over 1,000 kg of waste per person); of which 27 million tonnes ended up in landfills or were incinerated.[3] The total amount of waste generated and ending up in landfills or incinerated in 2006 (27 million tonnes) represents a 31% increase over the 20.6 million tonnes sent to landfills or incinerated in 1996.[4] Waste generation raises building costs in 2 ways. First, unnecessary materials (such as packaging) add to the cost of products purchased, and second, fees for waste collection and disposal rise as the amount of waste increases.

Reducing the amount of waste is an important component of sustainable construction practices. A construction waste management plan is the first step in managing construction waste because it requires contractors to establish a system for tracking waste generation and disposal during construction.

REUSING AND RECYCLING

Reuse of existing buildings, versus building new structures, is one of the most effective strategies for minimizing environmental impacts. By reusing existing building components, waste can be reduced and diverted from landfills. Reuse of an existing building results in less habitat disturbance and, typically, less new infrastructure, such as utilities and roads. An effective way to reuse interior components is to specify them in construction documents. By reusing or recycling these materials, an increasing number of public and private waste management operations have reduced the volume of construction debris. Recovery typically begins on the jobsite with separation of debris into bins or disposal areas. Some regions have access to mixed waste processing facilities. When selecting materials, it is important to evaluate new and alternative sources. Salvaged materials can be substituted for new materials, saving costs and adding character to the building. Recycled-content materials reuse waste that would otherwise be disposed in landfills or incinerators. Use of local materials supports the local economy and reduces transportation impacts. Using rapidly renewable materials may minimize natural resource consumption with the harvest cycle of the resource potentially matching the life of the material in buildings. Use of third-party certified wood improves the stewardship of forests and related ecosystems.

Recycling construction, demolition, and land-clearing debris reduces demand for virgin resources and has the potential to lessen the environmental and health burdens associated with resource extraction, processing, and transportation. Debris recycling also reduces dependence on landfills, which may contaminate groundwater and encroach upon valuable open space. In addition, it lessens disposal in incinerators, which may contaminate groundwater and pollute the air. Effective construction waste management can extend the life of existing landfills, which in turn reduces the need for expansion or development of new landfills.

Over the past decade, although the total mass of materials diverted from landfills or incineration either through recycling or composting has increased from 6 million tonnes in 1996[5] to 7.7 million tonnes in 2006[6], the percentage of waste diverted from landfills over this decade has remained fairly constant at around 22%. Curbside recycling is now standard in many communities, and recycling facilities are available in almost all municipalities. In addition, many businesses, non-profit organizations, and manufacturers have successful recycling programs that divert a wide range of materials from the waste stream.

Recycling provides materials for new products that would otherwise be manufactured from virgin materials. It avoids the extraction of raw materials and preserves landfill space. Recycling certain products, such as batteries and fluorescent light bulbs, prevents toxic materials from polluting the air and ground water.

Reuse and recycling can also save money. Effective waste management benefits organizations by reducing the cost of waste disposal and generating revenue from recycling or resale proceeds.

SUMMARY

A sustainable building requires policies for responsible construction and materials selection as well as effective waste management. The Materials and Resources prerequisites and credits establish the foundation for developing, implementing, and documenting these policies.

Operations and building management can effectively reduce a building's overall impact on the environment with waste management programs and purchasing policies that reduce waste and specify less harmful materials and supplies.

MATERIALS AND RESOURCES CREDIT CHARACTERISTICS

Table 1 shows the metrics used to determine compliance with each credit, such as area, weight, and cost, and materials that should be included and excluded in the calculations. Materials that are blacked out in the table are excluded from the corresponding credit calculations.

CALCULATING MATERIALS COSTS TO ACHIEVE MR CREDITS

Project construction materials are those included in Construction Specification Institute (CSI) MasterFormat™ 2004 Divisions 03–10, 31 (Section 31.60.00 Foundations) and 32 (Sections 32.10.00 Paving, 32.30.00 Site Improvements, and 32.90.00 Planting). For projects using CSI MasterFormat™ 1995, the construction materials are those in Divisions 02-10. These divisions are referred to as the "LEED Materials Divisions."

Project teams are encouraged to determine the actual total materials cost (excluding labour and equipment) from the LEED Materials Divisions. However, *LEED Canada for New Construction* and *LEED Canada for Core & Shell* allow project teams to apply a 45% factor to total construction costs (including labour and equipment) from the LEED Materials Divisions to establish a default total materials cost for the project. Table 2 contains guidance regarding specification sections included in the cost calculation. The approach selected by the project team (actual materials cost or LEED default materials cost) must be consistent across all credits based on total materials cost. A project team may include materials costs from CSI MasterFormat™ Division 12—Furniture and Furnishings as long as this is done consistently across all MR credits. *LEED Canada for Core & Shell* project teams that use tenant sales or lease agreements to assist with credit compliance must also do so consistently across all MR credits.

Materials calculated toward materials reuse cannot be applied to MR credits for building reuse, construction waste management, recycled content, rapidly renewable materials, or certified wood.

TABLE 1. MR CREDIT METRICS

<table>
<tr><th>Material</th><th>MRc1: BUILDING REUSE</th><th>MRc2: CONSTRUCTION WASTE MANAGEMENT</th><th>MRc3: MATERIALS REUSE</th><th>MRc4: RECYCLED CONTENT</th><th>MRc5: REGIONAL MATERIALS</th><th>MRc6: RAPIDLY RENEWABLE MATERIALS</th><th>MRc7: CERTIFIED WOOD</th></tr>
<tr><td>LEED Materials Divisions</td><td>Based on Area</td><td rowspan="5">Based on weight or volume. Include demolition and construction waste</td><td>Based on replacement value ($)</td><td colspan="3">Based on cost of qualifying materials as a percent of overall materials cost for the LEED Materials Divisions ($)</td><td>Based on cost of FSC wood as a percentage of all new wood ($)</td></tr>
<tr><td>Mechanical</td><td rowspan="4"></td><td colspan="5" rowspan="3"></td></tr>
<tr><td>Electrical</td></tr>
<tr><td>Plumbing</td></tr>
<tr><td>Furniture & Furnishings (CSI Division 12)</td><td colspan="5">May be added to the LEED Materials Divisions, if done consistently for Credits 3-7</td></tr>
</table>

CREDIT	TITLE	NC	CS
MR Prerequisite 1	Storage and Collection of Recyclables	Required	Required
MR Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1-3 points	NA
MR Credit 1	Building Reuse—Maintain Existing Walls, Floors, and Roof	NA	1-5 points
MR Credit 1.2	Building Reuse—Maintain Interior Non-structural Elements	1 point	NA
MR Credit 2	Construction Waste Management	1-2 points	1-2 points
MR Credit 3	Materials Reuse	1-2 points	1 point
MR Credit 4	Recycled Content	1-2 points	1-2 points
MR Credit 5	Regional Materials	1-2 points	1-2 points
MR Credit 6	Rapidly Renewable Materials	1 point	NA
MR Credit 6/7	Certified Wood	1 point	1 point

STORAGE AND COLLECTION OF RECYCLABLES

	NC	CS
Prerequisite	MR Prerequisite 1	MR Prerequisite 1
Points	Required	Required

INTENT

To facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.

REQUIREMENTS: NC & CS

Provide an easily-accessible dedicated area or areas for the collection and storage of materials for recycling for the entire building. Materials must include, at a minimum, paper, corrugated cardboard, glass, plastics, metals, and, if a municipal collection program is available, organic wastes (including landscaping waste).

INTERPRETATIONS

There are no interpretations for this prerequisite.

MR	
NC	Prerequisite 1
CS	Prerequisite 1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

By creating convenient recycling opportunities for all building occupants, a significant portion of the solid waste stream can be diverted from landfills. Recycling of paper, metals, glass, cardboard, and plastics reduces the need to extract virgin natural resources. For example, recycling 1 tonne of paper prevents the processing of 17 trees and saves 3 cubic yards of landfill space.[7] Recycled aluminum requires only 5% of the energy required to produce virgin aluminum from bauxite, its raw material form.[8] Diverting waste from landfills can help minimize land, water, and air pollution. An occupant education program that addresses the environmental and financial benefits of recycling can encourage occupants to participate in preserving the environment.

ECONOMIC ISSUES

Many communities sponsor and promote recycling programs to reduce the amount of waste sent to landfills. Community recycling efforts return valuable resources to local production processes and may spur increases in employment in the recycling industry. Community-wide participation results in higher recycling rates and, in turn, more stable markets for recycled materials.

Recycling infrastructure, such as storage areas and bins, may add to project costs and take up floor area that could be used for other purposes. However, recycling offers significant savings through reduced landfill disposal costs or tipping fees. In larger projects, processing equipment (can crushers, cardboard balers) can minimize the space required for recycling activities. Some recyclables can generate revenue that offsets collection and processing costs.

2. RELATED CREDITS

Project teams seeking an Innovation in Design credit for educational outreach can create signage and displays to inform building occupants and visitors about on-site recycling.

CS

Core & Shell project teams should address recycling within tenant guidelines. The tenant guidelines should include information regarding the building's recycling policy and procedures. The project team should encourage activities to reduce and reuse materials before recycling to decrease the volume of recyclables handled.

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

Building owners and designers must determine the best way to create a dedicated recycling collection and storage area that is easily accessible within the building and encourages recycling yet is accessible to the waste hauler. Recyclable material collection and storage space might increase the project footprint in some instances. Consider how recycling activities might affect a building's indoor environmental quality. Activities that create odours, noise, and air contaminants should be isolated or performed during non-occupant hours. The requirements of this prerequisite do not regulate the size of the recycling area. However, Table 1 provides guidelines for the recycling

MR	
NC	Prerequisite 1
CS	Prerequisite 1

storage area based on overall building floor area, including corridors, elevators, stairwells, and shaft spaces. These guidelines will help the design team determine the appropriate size for recycling facilities according to specific building operations.

TABLE 1. RECYCLING AREA GUIDELINES

Commercial Building (m^2)	Minimum Recycling Area (m^2)
0 to 465	7.6
466 to 1400	11.6
1,401 to 4,650	16.3
4,651 to 9,300	20.9
9,300 to 18,600	25.6
18,600 or greater	46.5

In places where the materials specified in this prerequisite are not recycled, a building should still have designated space to collect and store those materials in anticipation of recycling infrastructure for the materials becoming available in the future.

Designate and visibly mark central collection and storage areas for recyclables, including paper, cardboard, glass, plastic, metals, and organic waste (if applicable). The central collection and storage area should provide easy access for both maintenance staff and collection vehicles. A central collection area designed to consolidate a building's recyclables meets the credit requirements as long as the intent of the credit and the recycling needs of the occupants are met. For projects with larger site areas, it may be possible to create a central collection area that is outside the building footprint or project site boundary. In this case, document how the recyclable materials will be transported to the separate collection area. For projects with landscaping, consider designating an area for collecting plant debris.

Establish recycling collection points within common areas, such as classrooms, break rooms, open offices, and any location where occupants may need to recycle.

Design considerations for recycling areas should include signage to discourage contamination, protection from the elements, and security for high-value materials. Design security for the recyclable collection areas to discourage illegal disposal.

If possible, teach occupants, maintenance personnel, and other building users about recycling procedures. Consider using a recycling manual or educational program. Activities to reduce and reuse materials before recycling will reduce the volume of recyclables. For instance, building occupants can reduce the solid waste stream by using reusable bottles, bags, and other containers. Maintenance personnel can reduce waste by purchasing cleaners in bulk or concentrated form. Consider employing cardboard balers, aluminum can crushers, recycling chutes, and other waste management technologies to further improve the recycling program.

MR	
NC	Prerequisite 1
CS	Prerequisite 1

CS

Core & Shell project teams need to consider the maintenance and waste management practices for the entire building, including tenant spaces. Depending on the region, market, business practices, and customs, core and shell building owners may approach waste management differently. Building owners who provide cleaning services for all tenants can control both the space needs and the procedures for removing, storing, and hauling recyclables. In these instances, the space needs should be evaluated based on how frequently waste and recyclables are collected from tenant spaces. In buildings where tenants contract their own cleaning services, provide adequate space for recyclable storage and include specific instructions for use within tenant guidelines.

If cleaning services are contracted directly by the tenants, consider providing several recycling collection points within the building. For example, building owners with multiple tenant floors or large floor plates may want to provide collection points in the building core areas that tenants can easily access. Recyclables can then be collected and removed as needed by the building owner's contracted recycling service.

5. TIMELINE AND TEAM

Early in the design phase, to ensure that proper space is allocated for a centralized collection point, seek input from the local hauler who will be providing waste management services to the site. Attention should be given to the accessibility and convenience of the waste and recycling collection locations. Prior to occupancy, the owner or owner's representative should ensure that sufficient recycling bins are in place. Post-occupancy, the project team should educate occupants on the benefits of recycling, as well as the location of facilities. Most importantly, the project team should educate the facilities staff on the proper recycling procedures. This is critical to ongoing success and improvements in waste management.

6. CALCULATIONS

There are no calculations required for this credit. However, project teams should refer to Table 1 for sizing recycling areas. The values in this table were developed by the City of Seattle in support of an ordinance requiring minimum areas for recycling and storage of recyclables in commercial buildings. The ordinance is based on the total floor area of the building. Minimum areas for residential buildings are also specified. The requirements of this prerequisite do not regulate the size of the recycling area; the intent is for the design team to size the facilities appropriately for the specific building operations.

Another source of guidelines for sizing recycling areas is the California Integrated Waste Management Board's (CIWMB) 2004 Statewide Waste Characterization Study,[9] which gives quantity and composition estimates for commercial, residential, and self-hauled waste streams. The study examines material disposal rates of rigid plastic packaging containers and California redemption value containers in more detail beyond the 1999 report (see the References section).

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the

MR	
NC	Prerequisite 1
CS	Prerequisite 1

following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

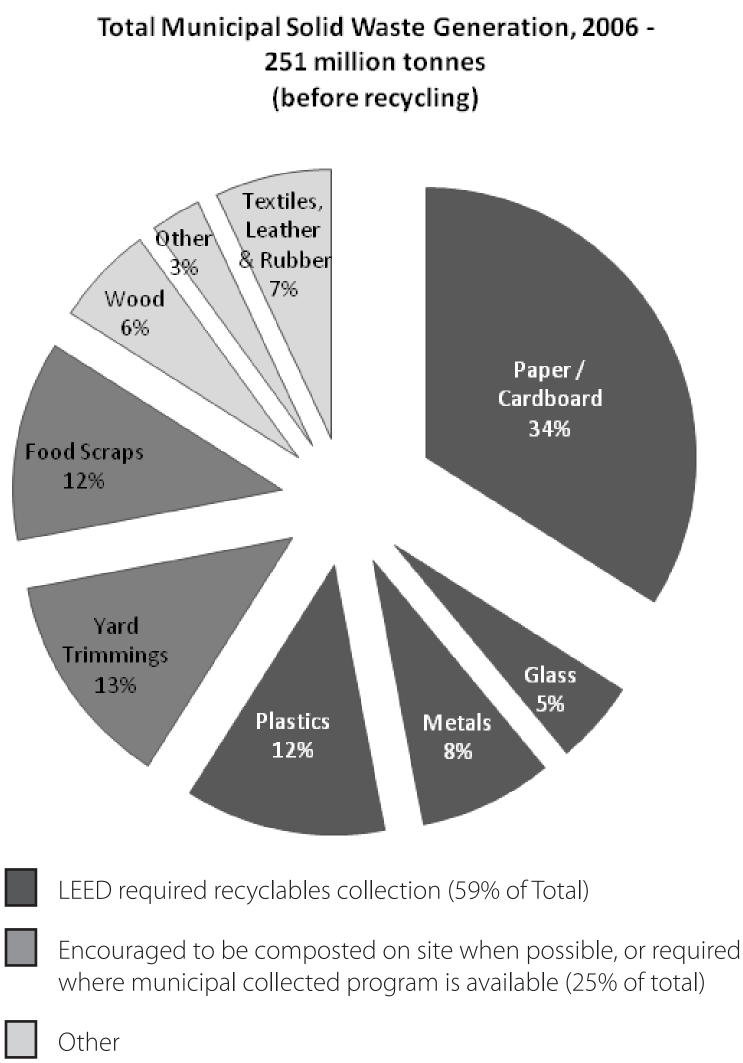
- Keep a record of the recycling plan's size and accessibility to occupants and facility staff; based on expected volume for the entire building (pickup frequency of commingling, etc.), consider whether the planned approach will be adequate.
- Prepare documentation such as floor plans and site plans that highlight all recycling storage areas.

8. EXAMPLES

Figure 1 shows a typical breakdown of waste stream materials. The 5 materials required for collection— paper, glass, plastics, cardboard, and metals—make up 59% of the waste stream.

FIGURE 1. MUNICIPAL SOLID WASTE GENERATION

Data from U.S. Environmental Protection Agency, 2006.



MR	
NC	Prerequisite 1
CS	Prerequisite 1

9. EXEMPLARY PERFORMANCE

This prerequisite is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Dense urban areas typically have public or private recycling infrastructure in place, but some less populated areas may not. Research local recycling programs to find the best method of diverting recyclable materials from the waste stream. Space needs can vary depending on collection strategies used by the hauler, and whether recyclables are commingled or separated at the source. For example, if the local hauler accepts commingled recyclables, it may be possible to reduce the area needed for separate collection bins.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Consider developing a commercial waste and recycling policy and education program for occupants. The policy should outline the protocol for collection and processing that the facility staff will follow and detail the signage for collection areas. The education component should explain the environmental and financial benefits of recycling to all building occupants.

Post-occupancy, the recycling program should be reviewed as needed and any problems addressed. Conduct periodic reviews of building waste collection points and adjust the number and size of recycling bins. Provide additional on-site recycling resources and occupant training if needed. Owners should consider a waste stream audit to identify the types and amounts of building waste.

12. RESOURCES

WEBSITES

California Integrated Waste Management Board
http://www.ciwmb.ca.gov

The California Integrated Waste Management Board (CIWMB) offers information about waste reduction, recycling and solid waste characterization, as well as generation rates for offices, schools, and residences.

Environment Canada – Extended Producer Responsibility & Stewardship
http://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=FB8E9973-1

This website provides an inventory of waste diversion programs in Canada funded in whole or in part by industry and consumers.

Recycling Council of Alberta (RCA)
http://www.recycle.ab.ca/

The website of Alberta's Recycling Council provides information on recycling and waste reduction, and provides resources for Alberta projects.

Recycling Council of British Columbia (RCBC)
http://www.rcbc.bc.ca/

The website of Canada's oldest Recycling Council provides information on recycling and waste reduction, and provides resources for B.C. projects.

MR	
NC	Prerequisite 1
CS	Prerequisite 1

Recycling Council of Ontario (RCO)
http://www.rco.on.ca/

The website of Ontario's Recycling Council provides information on recycling and waste reduction, and provides resources for Ontario projects.

Waste Management Guide for Small and Medium Enterprises – Canadian version
http://www.ec.gc.ca/cppic/En/refView.cfm?refId=1691

This guide is a management tool designed to assist in the development of customized waste management programs. The guide provides waste management case studies, a directory of resources, and an operation guide to a five-step implementation of a waste management program.

PRINT MEDIA

Composting and Recycling Municipal Solid Waste, by Luis Diaz et al. (CRC Press, 1993).

McGraw-Hill Recycling Handbook, by Herbert F. Lund (McGraw-Hill, 2000).

13. DEFINITIONS

Landfills are waste disposal sites for solid waste from human activities.

Occupants in a commercial building are workers who either have a permanent office or workstation in the building or typically spend a minimum of 10 hours per week in the building. In a residential building, occupants also include all persons who live in the building. In schools, occupants also include students, faculty, support staff, administration, and maintenance employees.

Recycling is the collection, reprocessing, marketing, and use of materials that were diverted or recovered from the solid waste stream.

A **recycling collection** area is located in regularly occupied space in the building for the collection of occupants' recyclables. A building may have numerous collection areas from which recyclable materials are typically removed to a central collection and storage area.

Reuse returns materials to active use in the same or a related capacity as their original use, thus extending the lifetime of materials that would otherwise be discarded.

Source reduction reduces the amount of unnecessary material brought into a building. Examples include purchasing products with less packaging.

Tipping fees are charged by a landfill for disposal of waste, typically quoted per tonne.

Waste comprises all materials that flow from the building to final disposal. Examples include paper, grass trimmings, food scraps, and plastics. In LEED, waste refers to all materials that are capable of being diverted from the building's waste stream through waste reduction.

Waste disposal eliminates waste by means of burial in a landfill, combustion in an incinerator, dumping at sea, or any other way that is not recycling or reuse.

Waste diversion is a management activity that disposes of waste other than through incineration or the use of landfills. Examples include reuse and recycling.

Waste reduction includes both source reduction and waste diversion through reuse or recycling.

The **waste stream** is the overall flow of waste from the building to a landfill, incinerator, or other disposal site.

MR	
NC	Credit 1.1
CS	Credit 1

BUILDING REUSE: MAINTAIN EXISTING WALLS, FLOORS, AND ROOF

	NC	CS
Credit	MR Credit 1.1	MR Credit 1
Points	1-3 points	1-5 points

INTENT

To extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.

REQUIREMENTS: NC & CS

Maintain the existing building structure (including structural floor and roof decking) and envelope (the exterior skin and framing, excluding window assemblies and non-structural roofing material).

Hazardous materials remediated as a part of the project scope must be excluded from the calculation of the percentage maintained.

The table below describes the minimum % building structure reuse requirements for credit achievement, as measured by surface area:

NC:

% BUILDING REUSE	POINTS
55%	1
75%	2
95%	3

MR	
NC	Credit 1.1
CS	Credit 1

CS:

% BUILDING REUSE	POINTS
25%	1
33%	2
42%	3
50%	4
75%	5

If the project includes an addition that is more than 6 times (for Core and Shell) and 2 times (for New Construction) the total floor area of the existing building, this credit is not applicable. Government registered or designated heritage building projects are exempted from this floor area requirement.

INTERPRETATIONS

There are no interpretations for this credit.

MR	
NC	Credit 1.1
CS	Credit 1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Building reuse is a very effective strategy for reducing the overall environmental impact of construction. Reusing existing buildings significantly reduces the energy use associated with the demolition process as well as construction waste. Reuse strategies also reduce environmental impacts associated with raw material extraction, manufacturing, and transportation.

ECONOMIC ISSUES

Although retrofitting an existing building to accommodate new programmatic and LEED requirements can add to the complexity of design and construction—reflected in the project's soft costs—reuse of existing components can reduce the cost of construction substantially.

2. RELATED CREDITS

When working on an adaptive reuse project, assess the site early on to determine which areas and materials would be valuable to reincorporate into the new development. Inventory the areas and square footage of the existing site and incorporate a reuse strategy into the initial design charrettes. Review these 2 credits:

- MR Credit 2: Construction Waste Management
- MR Credit 3: Materials Reuse

The development of a comprehensive reuse management plan that evaluates the anticipated materials saved will determine whether the project meets the requirements of MR Credit 1, Building Reuse. If reuse is not enough to achieve credit compliance, the materials can still contribute toward MR Credit 2, Construction Waste Management, if the material has not been applied to MR Credit 1.

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

If the project will reuse part of an existing building, inventory the existing conditions. The architect should develop a floor plan showing the location of existing structural components, exterior and party walls, and exterior windows and doors. The drawings should be detailed enough to determine the surface area of all elements to be reused.

Confirm that the structural and envelope elements designated for reuse can be reused and take the necessary steps to retain and maintain them. Projects that incorporate part of an existing building but do not meet the requirements for MR Credit 1 may apply the reused portion toward the achievement of MR Credit 2, Construction Waste Management. To do so, determine an approximate weight or volume for existing building elements.

5. TIMELINE AND TEAM

As a design strategy, building reuse has significant impact on all phases of a project, from schematic design through bidding and construction.

MR	
NC	Credit 1.1
CS	Credit 1

At site selection, the owner and project team should identify a project site that will utilize an existing building. In pre-design, the project team should analyze the cost savings associated with building reuse. During schematic design, the project team should consider how to reuse as much of the building as possible. The specifications for bid, developed by the architect in consultation with the owner, should outline measures to preserve the building during construction, and these should be implemented with project team oversight.

6. CALCULATIONS

This credit is based on the surface areas of major existing structural and envelope elements. Structural support elements such as columns and beams are considered part of the larger surfaces they support, so they are not quantified separately. Prepare a spreadsheet listing all envelope and structural elements within the building. Quantify each item, listing the floor area (m^2) of both the existing area and the retained area. Determine the percentage of existing elements that are retained by dividing the floor area (m^2) of the total retained materials area by the floor area (m^2) of the total existing materials area.

Take measurements as if preparing a bid for construction of a building. For structural floors and roof decking, calculate the surface area (m^2) of each component. For existing exterior walls and existing walls adjoining other buildings or additions, calculate the surface area (m^2) of the exterior wall only and subtract the area of exterior windows and exterior doors from both the existing and the reused area tallies. For interior structural walls (e.g., shear walls), calculate the surface area (m^2) of 1 side of the existing wall element. Table 1 provides an example of the calculations for MR Credit 1.1.

TABLE 1. SAMPLE BUILDING STRUCTURE AND ENVELOPE REUSE CALCULATION

STRUCTURE/ENVELOPE ELEMENT	EXISTING AREA (m^2)	EXISTING AREA (m^2)	PERCENTAGE REUSED (%)
Foundation/Slab on Grade	1,070	1,070	100
2nd Floor Deck	1,070	929	87
1st Floor Interior Structural Walls	22	22	100
2nd Floor Interior Structural Walls	13	13	100
Roof Deck	1,070	1,070	100
North Exterior Wall (excl. windows)	765	664	87
South Exterior Wall (excl. windows)	765	765	100
East Exterior Wall (excl. windows)	607	607	100
West Exterior Wall (excl. windows)	607	541	89
Total	5,989	5,681	95

Exclude the following items from this calculation: non-structural roofing material, window assemblies, structural and envelope materials that are deemed structurally unsound, hazardous materials, and materials that pose a contamination risk to building occupants.

MR	
NC	Credit 1.1
CS	Credit 1

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- For an existing building major renovation and/or addition, prepare a list of shell attributes; include element IDs and the total area of new, existing, and reused elements.
- Be able to explain why any existing building elements were excluded.
- Collect photos showing pre and post construction exterior elevations.

8. EXAMPLES

See Table 1 for an example of a typical building structure and envelope reuse calculation.

9. EXEMPLARY PERFORMANCE

CS

Project teams may earn an Innovation in Design credit for exemplary performance by maintaining 95% or more of the existing building structure.

10. REGIONAL VARIATIONS

This credit may have particular importance in areas with historic structures and neighbourhoods. Building reuse can encourage new development while preserving the history and character of an area. Reuse can also be a strategy for development in areas in need of inner-city investment. Where there is pressure to demolish existing structures and build larger buildings, renovations of existing buildings and building additions can become models of how to preserve and incorporate original structures and achieve associated environmental and financial benefits.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

The project team should communicate to building operators any special maintenance practices required by the reused materials, or any differences in life expectancy or durability compared with new materials.

12. RESOURCES

National Master Specification Guide to Environmentally Responsible Specifications for New Construction and Renovations
http://www.tpsgc-pwgsc.gc.ca/biens-property/ddn-nms/editeurs-publishers-eng.html

This guideline has been prepared for designers and specifiers involved in Construction, Renovation and Demolition (CRD) projects for the Federal Government of Canada. The purpose of this guideline is to assist project practitioners in developing environmentally enhanced or "green" specifications for construction, renovation, repair and refit projects, including associated demolition work. Particular emphasis is placed on the greening of the National Master Specification (NMS) as

MR	
NC	Credit 1.1
CS	Credit 1

a primary instrument for communicating environmental responsibility in CRD projects. Neither document cover any of the function issues or testing that may be required to ensure the structural integrity or performance of a salvaged material.

PRINT MEDIA

How Buildings Learn: What Happens after They're Built, by Stewart Brand (Viking Press, 1994).

13. DEFINITIONS

Adaptive reuse is the renovation of a space for a purpose different from the original.

Existing area is the total area of the building structure, core, and envelope that existed when the project area was selected. Exterior windows and doors are not included.

Prior condition is the state of the project space at the time it was selected.

Prior condition area is the total area of finished ceilings, floors, and full-height walls that existed when the project area was selected. It does not include exterior windows and doors.

Retained components are portions of the finished ceilings, finished floors, full-height walls and demountable partitions, interior doors, and built-in case goods that existed in the prior condition area and remain in the completed design.

Reused area is the total area of the building structure, core, and envelope that existed in the prior condition and remains in the completed design.

MR	
NC	Credit 1.2
CS	NA

BUILDING REUSE: MAINTAIN INTERIOR NON-STRUCTURAL ELEMENTS

	NC	CS
Credit	MR Credit 1.2	NA
Points	1 points	NA

INTENT

To extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.

REQUIREMENTS: NC

Use existing interior non-structural elements (e.g., interior walls, doors, floor coverings and ceiling systems) in at least 50% (by surface area) of the completed building, including additions. Hazardous materials remediated as a part of the project scope must be excluded from the calculation of the percentage maintained.

If the project includes an addition that is more than 2 times the total floor area of the existing building, this credit is not applicable. Government registered or designated heritage building projects are exempted from this floor area requirement.

INTERPRETATIONS

There are no interpretations for this credit.

MR	
NC	Credit 1.2
CS	NA

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Building reuse is a very beneficial strategy for reducing the overall environmental impact of construction. Reusing existing buildings significantly reduces the energy use associated with the demolition process as well as construction waste. Reuse strategies also reduce environmental impacts associated with raw material extraction, manufacturing, and transportation. Building reuse maintains the vital link between neighbourhoods of the past and present, reduces emissions and waste, and preserves open space. Projects that reuse a high percentage of non-structural components serve as examples of the value of preservation.

ECONOMIC ISSUES

Although retrofitting an existing building to accommodate new programmatic and LEED requirements may add to the complexity of design and construction—reflected in the project's soft costs—reuse of existing components can reduce overall construction costs by reducing costs associated with demolition, hauling fees, purchase of new construction materials, and labour.

2. RELATED CREDITS

Refer to the Related Credits section of MR Credit 1.1, Building Reuse—Maintain Existing Walls, Floors, and Roofs.

If reuse is not enough to achieve credit compliance, the materials can still contribute toward MR Credit 2, Construction Waste Management, or MR Credit 3, Materials Reuse (but not both) if the material has not been applied to MR Credit 1.

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

Confirm that the items designated for reuse can be reused and take the necessary steps to retain and maintain them in the finished work. Fixed items, such as non-structural walls and doors, are included in this credit and count toward the percentage of reuse when they perform the same function (e.g., doors reused as doors). If materials are used for another purpose (e.g., doors made into tables), they can count toward the achievement of MR Credit 3, Materials Reuse, but they cannot count toward both credits.

Projects that incorporate part of an existing building but do not meet the requirements for MR Credit 1 may apply the reused portion toward the achievement of MR Credit 2, Construction Waste Management. To do so, determine an approximate weight or volume for existing building elements.

5. TIMELINE AND TEAM

As a design strategy, building reuse has significant impact on all phases of a project, from schematic design through bidding and construction.

During schematic design, the architect and owner should identify non-structural building

MR	
NC	Credit 1.2
CS	NA

materials that can be retained and reused. The specifications for bid, developed by the architect in consultation with the owner, should outline measures to preserve the building during the construction process, and these should be implemented with project-team oversight.

Inventory the existing conditions. The architect should develop a floor plan showing the location of finished ceilings and flooring, interior wall partitions, doors within the interior walls, exterior and party walls, and exterior windows and doors. If existing built-in case goods will be reused, they should be documented as well. The architectural drawings should provide the detail needed to determine the surface area of all elements to be reused.

6. CALCULATIONS

Achievement of MR Credit 1.1 is not required for projects pursuing MR Credit 1.2.

This credit focuses on reuse of interior, non-structural elements and compares the retained and reused elements with the total completed area of interior elements. It is not necessary to calculate the total area of existing interior non-structural elements prior to demolition.

Prepare a spreadsheet listing all interior non-structural elements within the building. Quantify each item and then determine the total area, including new construction and the area of retained elements, in square metres. Determine the percentage of existing elements that are retained by dividing the total area of all retained interior non-structural elements by the total area of interior non-structural elements.

Equation 1

$$\text{Percentage Existing Elements} = \frac{\text{Area (m}^2\text{) of All Retained Interior Non-structural Elements}}{\text{Total Area (m}^2\text{) of Interior Non-structural Elements}} \times 100$$

If the total area of existing and/or reused non-structural interior components is a minimum of 50% of the area of all interior non-structural building elements, the project earns 1 point.

Take measurements as if preparing a bid for flooring, ceiling, or painting:

- Finished ceilings and flooring areas (tile, carpeting, etc.).
- Interior non-structural walls. Determine the finished area between floor and ceiling and count both sides.
- Exterior structural and party walls. If the interior finishes (e.g., drywall and plaster) have been reused, count only 1 side.
- Interior doors. Count surface area once.
- Interior casework. Calculate the visible surface area of the assembly; see the example in Figure 1.

Include items that have been saved but may have been relocated, such as full-height demountable walls and doors that were re-hung. Items counted for this credit cannot be included in MR Credit 3.

Table 1 illustrates a spreadsheet for determining credit compliance. The total area of all new and existing building materials (following construction) is determined. The total area of only the existing and reused components is then entered. The sum of the existing materials is then divided by the sum of the total building materials to obtain the overall percentage of retained components. Since the overall percentage of reused non-structural interior materials exceeds 50% of the total area of all non-structural interior building materials, the project earns 1 point.

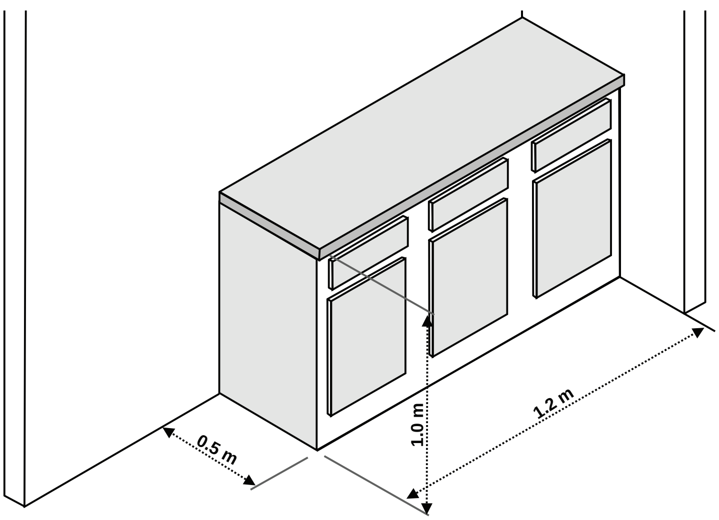
MR	
NC	Credit 1.2
CS	NA

TABLE 1. SAMPLE INTERIOR NON-STRUCTURAL REUSE CALCULATION

INTERIOR NON-STRUCTURAL ELEMENT	TOTAL AREA* (m^2)	EXISTING/ REUSED (m^2)	PERCENTAGE REUSED (%)
Gypsum Board Wall Partitions – Full Height	502	334	67%
Gypsum Board Wall Partitions – Partial Height	60	60	100%
Carpeting	929	0	0%
Resilient Flooring	33	33	100%
Ceramic Tile	14	14	100%
Suspended Ceiling Systems	966	966	100%
Gypsum Board Ceilings	14	14	100%
Interior Doors (Wood)	49	39	80%
Interior Windows / Sidelights	5	5	100%
Interior Doors (Metal)	4	4	100%
Interior Casework / Cabinetry	22	14	64%
Totals	2,598	1,483	57%

** Note: The Total Area calculation includes both new and existing/reused materials.*

FIGURE 1. AREA CALCULATION FOR EXISTING CASEWORK



SURFACE	AREA (m^2)
Top	0.6
Left side	0.5
Front	1.2
Rear	0
Right side	0
Total Reused Casework	2.3

MR	
NC	Credit 1.2
CS	NA

7. DOCUMENTATION GUIDANCE

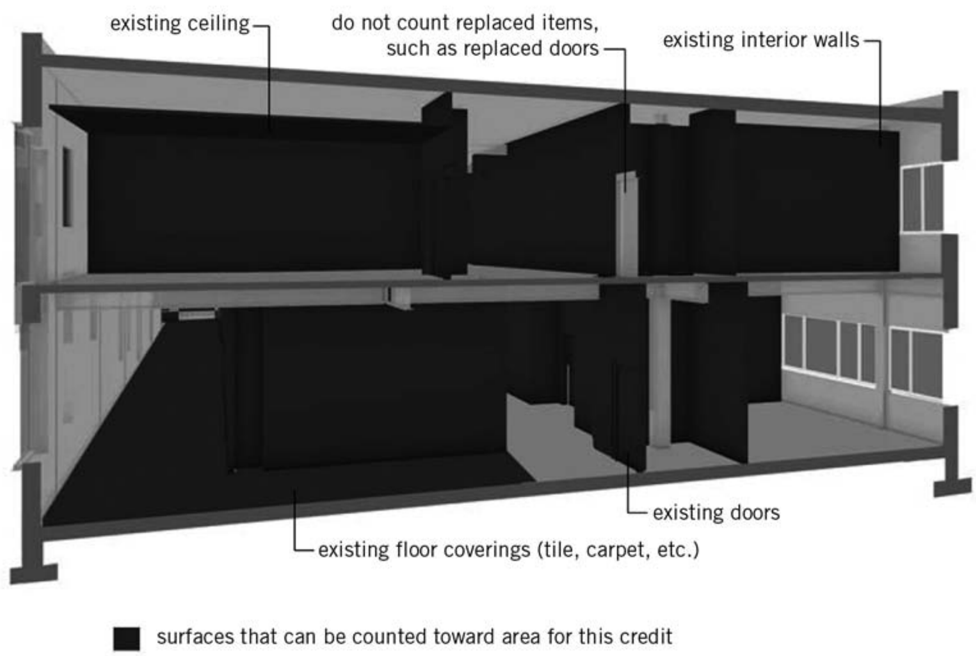
As a first step in preparing to complete the LEED documentation requirements, work through the following measure. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- For an existing building major renovation and/or addition, prepare a list of interior non-structural elements; include element IDs and the total area of new, existing, and reused elements.

8. EXAMPLES

Projects should evaluate the interior non-structural components to determine what can be reused. Figure 2 illustrates the eligible components.

FIGURE 2. ELIGIBLE COMPONENTS FOR MR CREDIT 1.2



9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

This credit may have particular importance in areas with historic structures, where reuse of components can preserve the history and character of a building and its location. When deciding what interior structures to preserve, the project team should consider not only the nature of the building and whether the materials will enhance the character of the project, but also the local historical context. Reuse of interior materials to divert waste from landfills can be particularly important in areas with constrained landfill space.

MR	
NC	Credit 1.2
CS	NA

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

The project team should communicate to building operators any special maintenance practices required by the reused materials, or any differences in life expectancy or durability compared with new materials.

12. RESOURCES

PRINT MEDIA

How Buildings Learn: What Happens after They're Built, by Stewart Brand (Viking Press, 1994).

13. DEFINITIONS

Adaptive reuse is the renovation of a space for a purpose different from the original.

Interior non-structural components reuse is determined by dividing the area of retained components by the area of the completed design.

Retained components are portions of the finished ceilings, finished floors, full-height walls and demountable partitions, interior doors, and built-in case goods that existed in the prior condition area and remain in the completed design.

Soft costs are expense items that are not considered direct construction costs. Examples include architectural, engineering, financing, and legal fees.

MR	
NC	Credit 2
CS	Credit 2

CONSTRUCTION WASTE MANAGEMENT

	NC	CS
Credit	MR Credit 2	MR Credit 2
Points	1-2 points	1-2 points

INTENT

To divert construction and demolition debris from disposal in landfills and incineration facilities. Redirect recyclable recovered resources back to the manufacturing process and redirect reusable materials to appropriate sites.

REQUIREMENTS: NC & CS

Recycle and/or salvage non-hazardous construction and demolition debris. Excavated soil and land-clearing debris do not contribute to this credit. Calculations can be done by weight or volume, but must be consistent throughout. The minimum percentage debris to be recycled or salvaged for each point threshold is as follows:

% RECYCLED OR SALVAGED	POINTS
50%	1
75%	2

INTERPRETATIONS

The use of construction and demolition waste material as an alternate daily cover for landfills does not constitute diversion for the purposes of MR Credit 2.

Estimation of construction waste values that do not designate waste type and end-use of waste material is unacceptable for determining end-of-project recycling rates for MR Credit 2.

Offsite sorting of construction and demolition debris can substitute for onsite sorting, provided the process follows these conditions:

- Actual weights and volumes of the construction waste and estimates of the materials composition by weight or volume must be provided.
- The recycler must confirm the destination and end use for each material diverted from landfill. Separate reports from end-use facilities are not required.
- The project diversion rate is based on the confirmed weight/volumes and the actual products diverted from landfill.

MR	
NC	Credit 2
CS	Credit 2

- End uses for salvage and recycling must be consistent with those allowed as acceptable under LEED Canada.

Wood used as firewood for wood-burning stoves and fireplaces is not an acceptable means of waste diversion for MR Credit 2.

Burning of clean wood waste to generate industrial process heat and/or electricity is considered appropriate diversion methodology provided that the wood complies with the requirements of eligible biofuels, as defined in EA Credit 2.

LEASED TENANT SPACES (NC)

If utilizing mandatory lease agreements to achieve NC certification, the direction to tenants must include the same (or higher) performance goal as is targeted in the overall application of this credit. The future leased tenant fit-up is not included in the calculations of this credit in either the numerator or the denominator. Further direction to future tenants on how to divert construction waste is commendable but is not required as part of the mandatory lease agreement.

CAMPUS

For campuses or multiple building projects it is acceptable to have a single development-wide Construction Waste Management (CWM) plan/program. Each LEED submission should use the accrued waste diversion rate for the entire project in the LEED certification documentation at the time of construction completion for the applicable phase. Note that both the cumulative and incremental total must meet the thresholds for credit achievement. It is not important for the projects to achieve the same level of LEED certification.

MR	
NC	Credit 2
CS	Credit 2

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Construction and demolition generate enormous quantities of solid waste. Commercial construction generates an average of 19 kg of waste per square metre of building area, most of which can potentially be recycled.[10] The greatest environmental benefit is achieved through source control—reducing the total waste generated. Use design strategies that minimize waste, such as shop fabrication of component parts, modular construction, and the ordering of materials cut to size. Work with manufacturers to minimize unnecessary packaging and making arrangements for pallets to be reclaimed after use can also reduce waste volumes and waste management costs. Extending the lifetime of existing landfills through effective construction waste management can avoid the need for expansion or new landfill sites.

Recycling of construction and demolition debris reduces demand for virgin resources and reduces the environmental impacts associated with resource extraction, processing and, in many cases, transportation.

ECONOMIC ISSUES

In the past, when landfill capacity was readily available and disposal fees were low, recycling or reuse of construction waste was not economically feasible. Construction materials were less expensive than labour, and construction site managers focused on worker productivity rather than on materials conservation. In addition, recycling infrastructure and recycled-materials marketplaces that process and resell construction debris did not exist. The economics of recycling has improved in recent years, particularly with the advent of international competition for both raw and recycled materials, and disposal costs have increased. More stringent waste disposal regulations coupled with ever-decreasing landfill capacity have changed the waste management equation.

Waste management plans require time and money to draft and implement; in the long term, however, they provide guidance to achieve substantial savings throughout the construction process.

Recyclable materials have differing market values, depending on the presence of local recycling facilities, reprocessing costs, and the availability of virgin materials on the market. In general, it is economically beneficial to recycle metals, concrete, asphalt, and cardboard. Market values normally fluctuate from month to month, so track the values and project different cost recapturing scenarios. When no revenue is received for materials, as is often the case for scrap wood and gypsum wallboard, it is still possible to benefit from recycling by avoiding landfill tipping fees.

2. RELATED CREDITS

Projects that reuse existing buildings but do not meet the threshold requirements for MR Credit 1 may apply the reused building portions toward achievement of MR Credit 2, Construction Waste Management:

- MR Credit 1: Building Reuse

If an existing building is found to contain contaminated substances, such as lead or asbestos, these materials should be remediated as required by the relevant regulatory agency.

MR	
NC	Credit 2
CS	Credit 2

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

This credit addresses how much waste material leaving the site is diverted from landfills. The percentage requirement represents the amount diverted through recycling and salvage divided by the total waste generated by the construction project.

Identify construction haulers and recyclers to handle the designated materials; they often serve as valuable partners in this effort. Make sure that job-site personnel understand and participate in construction debris recycling, and ask them to provide updates throughout the construction process. Obtain and retain verification records (e.g., waste haul receipts, waste management reports, and spreadsheets) to confirm that the diverted materials have been recycled or salvaged as intended. Diversion may include salvaged materials such as furniture, computers and equipment, white boards, lockers, doors, lighting, and plumbing fixtures. Salvaged material can be donated to charitable organizations such as Habitat for Humanity, reuse centers, non-profit organizations, or other buildings. Materials sold to the community can also be counted.

A project may choose to separate construction waste on-site or have commingled construction waste sorted at an off-site facility. On-site separation provides immediate feedback of the ongoing waste diversion efforts, but may require additional labour. Although commingled recycling can increase recycling costs, it might also simplify the waste management effort on-site and ensure that diversion rates will be high. This option is especially useful for projects with tight space constraints and no room for multiple collection bins.

5. TIMELINE AND TEAM

After researching regional recycling options, the project team should create a construction waste management plan during the design phase. The general contractor should identify on-site recycling locations and review recycling requirements with all subcontractors to ensure that the plan is implemented. During construction, the contractor should remind subcontractors of the plan requirements and confirm that the plan is implemented on the site. The contractor should continuously track construction waste and report to the project team. At the end of construction the contractor should complete the documentation and submit detailed records to the project team.

6. CALCULATIONS

Calculations for this credit are based on the amount of waste diverted from landfill or incineration compared with the total amount of waste generated on-site. Convert all materials to either weight or volume to calculate the percentage. Exclude excavated soil and land-clearing debris from calculations. Projects that crush and reuse existing concrete, masonry, or asphalt on-site should include the weight or volume of these materials in the calculations. Any construction debris processed into a recycled content commodity that has an open-market value may be applied to the construction waste calculation. Projects that use commingled recycling rather than on-site separation should obtain summaries of diversion rates from the recycler. Typically, the recycler should provide monthly reports.

Hazardous waste should be excluded from calculations and should be disposed of according to relevant regulations.

MR	
NC	Credit 2
CS	Credit 2

Table 1 provides an example of a summary calculation for waste diversion. If exact material weights are not available, use the conversion factors from Table 2 or another defensible conversion metric to estimate the weight of construction waste.

TABLE 1. SAMPLE CONSTRUCTION WASTE MANAGEMENT DIVERSION SUMMARY

DIVERSION/RECYCLING MATERIALS DESCRIPTION	DIVERSION/RECYCLING HAULER OR LOCATION	QUANTITY OF DIVERTED/ RECYCLED WASTE	UNITS (TONNES OR m^3*)
Concrete	ABC Recycling	138.0	tonnes
Wood	Z-Construction Reuse	10.2	tonnes
Gypsum Wallboard	ABC Recycling	6.3	tonnes
Steel	Re-Cycle Steel Collectors	1.1	tonnes
Crushed Asphalt	On-site Reuse	98.2	tonnes
Masonry	ABC Recycling	6.8	tonnes
Cardboard	ABC Recycling	1.6	tonnes
Total Construction Waste Diverted		262.2	tonnes
LANDFILL MATERIALS DESCRIPTION	**LANDFILL HAULER OR LOCATION**	**QUANTITY OF WASTE**	**UNITS (TONNES OR m^3*)**
General Mixed Waste	XYZ Landfill	52.3	tonnes
Total Construction Waste Sent to Landfill			52.3 tonnes
Total of All Construction Waste			314.5 tonnes
Percentage of Construction Waste Diverted from Landfill			83.4%
**Calculations can be done by weight or volume, but must be consistent throughout.*			

TABLE 2. SOLID WASTE CONVERSION FACTORS

MATERIAL	DENSITY (kg/m^3)
Cardboard	60
Gypsum Wallboard	300
Mixed Waste	210
Rubble	830
Steel	600
Wood	180

MR	
NC	Credit 2
CS	Credit 2

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Track and keep a summary log of all construction waste generated by type, the quantities of each type that were diverted and landfilled, and the total percentage of waste diverted from landfill disposal.
- Track waste management firms or receivers and collect supporting letters on the end use of materials.

8. EXAMPLES

A contractor is preparing for partial demolition of a 500 square metre urban structure built in 1918. The new owner intends to keep the structural components of the building but remove the existing interior walls and floors. The contractor, prior to construction, developed a construction waste management plan to aid in the demolition and construction process. The plan outlines the staging of waste materials during demolition to be sorted within the building before being delivered to local recycling facilities.

- Existing wood will be treated with care as it is removed from the building so that it can be reused by another local contractor or donated to a reuse store.
- Gypsum board from a previous building remodel will be composted.
- Existing doors will be removed, restored, and stored off-site before being reinstalled during construction.
- The construction waste will be commingled and sorted off-site because the site does not have enough room for sorting materials.
- All cardboard, wood, plastic, and metals will be placed in the same bins.
- The construction waste management plan outlines the responsibility of each subcontractor to recycle lunch waste in a separate, smaller container, to prevent contaminating the construction waste.
- The construction office is instructed to sort paper, plastic, cans, and bottles within the office.
- The contractor takes responsibility for enforcing the plan throughout the construction process.

Because most of the construction waste is sorted off-site, the contractor can document a construction waste diversion rate of 96%.

9. EXEMPLARY PERFORMANCE

Project teams may earn an Innovation in Design credit for exemplary performance by diverting 95% or more of total construction waste.

MR	
NC	Credit 2
CS	Credit 2

10. REGIONAL VARIATIONS

Recycling opportunities are expanding rapidly in many communities. Metal, vegetation, concrete, and asphalt recycling have long been available and affordable in most communities. Recycling options for paper, corrugated cardboard, plastics, and clean wood markets vary with regional and local recycling infrastructure. Some materials, such as gypsum wallboard, can be recycled only in communities that have reprocessing plants exist or where soil can handle the material as a stabilizing agent. The recyclability of a demolished material often depends on the extent of contamination. Demolished wood, for instance, is often not reusable or recyclable unless it is taken apart and the nails removed.

In urban areas, recycling resources are frequently more developed, and project managers can decide whether to separate waste on-site or hire a commingled waste recycler. In more rural and remote areas, recyclers may be harder to find. The environmental benefits of recycling in these cases need to be balanced against the environmental impacts of transporting waste long distances to recycling centers.

Other regional variances that affect the treatment of construction waste include landfill space, waste diversion options, and tipping fees.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

A challenging aspect of managing and diverting construction waste is identifying appropriate entities to receive the diverse waste types generated. Owners should develop policies for future remodelling, with specific construction waste recycling targets and end sources. General contractors should implement waste diversion strategies in their own company structure. Lessons learned from the project experience can be used to develop a company policy and education program for all employees.

12. RESOURCES

Government Resources

Check with the solid waste authority or natural resources department in your city or county. Many local governments provide information about regional recycling opportunities.

WEBSITES

BuildSmart - Sustainable Buildings Solutions
http://www.metrovancouver.org/BuildSmart/Pages/default.aspx

BuildSmart is a program to encourage the use of green building strategies and technologies. Although designed and administered by Metro Vancouver, many resources are applicable across Canada.

National Master Specification Guide to Environmentally Responsible Specifications for New Construction and Renovations
http://www.tpsgc-pwgsc.gc.ca/biens-property/ddn-nms/editeurs-publishers-eng.html

This guideline has been prepared for designers and specifiers involved in Construction, Renovation and Demolition (CRD) projects for the Federal Government of Canada. The purpose of this guideline is to assist project practitioners in developing environmentally enhanced or "green" specifications for construction, renovation, repair and refit projects, including associated demolition

MR	
NC	Credit 2
CS	Credit 2

work. Particular emphasis is placed on the greening of the National Master Specification (NMS) as a primary instrument for communicating environmental responsibility in CRD projects. Neither document cover any of the function issues or testing that may be required to ensure the structural integrity or performance of a salvaged material.

Smart Growth Online, Construction Waste Management Handbook
http://www.smartgrowth.org/library/articles.asp?art=15

This report by the National Association of Home Builders Research Center discusses residential construction waste management for a housing development in Homestead, Florida.

A Sourcebook for Green and Sustainable Building, Construction Waste
http://www.greenbuilder.com/sourcebook/ConstructionWaste.html

This website offers a guide to waste management during construction.

Triangle J Council of Governments, Waste Spec: Model Specifications for Construction Waste Reduction, Reuse, and Recycling
ftp://ftp.tjcog.org/pub/tjcog/regplan/solidwst/wastspec.pdf

This organization has developed model specifications for North Carolina. 10 case studies show the results of using the specifications.

U.S. EPA, Environmental Specifications for Research Triangle Park
http://www.epa.gov/rtp/campus/environmental/s_01120.htm

Learn about waste management and other specifications from EPA.

13. DEFINITIONS

Alternative daily cover is material (other than earthen material) that is placed on the surface of the active face of a municipal solid waste landfill at the end of each operating day to control vectors, fires, odours, blowing litter, and scavenging. It is not considered diversion from the landfill for the purposes of this credit.

Construction and demolition debris includes waste and recyclables generated from construction and from the renovation, demolition, or deconstruction of pre-existing structures. It does not include land-clearing debris, such as soil, vegetation, and rocks.

Construction Waste Calculation is used to determine the percentage of waste diverted from landfill and incineration facilities.

Construction Waste Management Plan is a document specific to a building project that outlines measures and procedures that divert construction waste materials from landfill and incineration facilities.

Incineration Facilities are waste management operations that use combustion as a means of reducing the volume of waste materials and/or producing heat or energy.

Recycling is the collection, reprocessing, marketing, and use of materials that were diverted or recovered from the solid waste stream.

Reuse returns materials to active use in the same or a related capacity as their original use, thus extending the lifetime of materials that would otherwise be discarded.

Tipping fees are charged by a landfill for disposal of waste, typically quoted per tonne.

MR	
NC	Credit 3
CS	Credit 3

MATERIALS REUSE

	NC	CS
Credit	MR Credit 3	MR Credit 3
Points	1-2 points	1 point

INTENT

To reuse building materials and products in order to reduce demand for virgin materials and reduce waste, thereby lessening impacts associated with the extraction and processing of virgin resources.

REQUIREMENTS

NC:

Use salvaged, refurbished or reused materials, the sum of which constitutes at least 5% or 10%, based on cost, of the total value of materials on the project. The minimum percentage materials reused for each point threshold is as follows:

REUSED MATERIALS	POINTS
5%	1
10%	2

CS: (1 Point)

Use salvaged, refurbished or reused materials, the sum of which constitutes at least 5%, based on cost, of the total value of materials on the project.

NC & CS:

Mechanical, electrical and plumbing components and specialty items such as elevators and equipment cannot be included in this calculation. Include only materials permanently installed in the project. Furniture may be included if it is included consistently in MR Credit 3: Materials Reuse through MR Credit 7: Certified Wood (MR Credit 6 in Core and Shell).

MR	
NC	Credit 3
CS	Credit 3

INTERPRETATIONS

The term "salvaged" within LEED refers to materials that have been salvaged from an existing building rather than salvaged from the natural environment.

Logs that are harvested from a wooded area flooded by a hydro-electric dam can be considered as pre-consumer recycled content for MR Credit 4, rather than salvaged, if methodology for harvesting them is relatively benign environmentally.

LEASED TENANT SPACES (NC)

If utilizing mandatory lease agreements to achieve NC certification, the direction to tenants must include the same (or higher) performance goal as is targeted in the overall application of this credit. The future leased tenant fit-up is not included in the calculations of this credit in either the numerator or the denominator. Further direction to future tenants on how to source salvageable materials is commendable but is not required as part of the mandatory lease agreement.

MR	
NC	Credit 3
CS	Credit 3

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Many existing materials can be salvaged, refurbished, or reused. Reuse strategies divert material from the construction waste stream, reducing the need for landfill space and environmental impacts from associated water and air contamination. Use of salvaged materials also avoids the environmental impacts of producing new construction products and materials. These impacts are significant because buildings account for a large portion of natural resource consumption, including 40% of raw stone, gravel, and sand as well as 25% of virgin wood.[11]

ECONOMIC ISSUES

Although some salvaged materials are more costly than new materials because of the high cost of labour involved in recovering and refurbishing processes, local demolition companies may be willing to sell materials recovered from existing buildings to avoid landfill tipping fees and to generate income. In some areas, municipalities and waste management companies have established facilities for selling salvaged building materials at landfill sites. Sometimes, salvaged materials are offered at prices that appear to be cost-effective but may include hidden costs, such as the need for reprocessing, excessive transportation costs, or liabilities associated with toxic contamination. Conversely, certain salvaged materials may be impossible to duplicate (e.g., turn-of-the century lumber and casework) and may be worth the higher cost compared with new materials.

2. RELATED CREDITS

The development of a comprehensive reuse management plan that evaluates the anticipated materials saved will help determine whether the project meets the requirements of the following credits:

- MR Credit 1: Building Reuse
- MR Credit 2: Construction Waste Management

Remanufactured materials are not considered a reuse of the material and do not contribute toward this credit. However, these materials can contribute toward the following credits:

- MR Credit 2: Construction Waste Management
- MR Credit 4: Recycled Materials

The project materials costs used here need to be consistent with those used in the following credits:

- MR Credit 4: Recycled Content
- MR Credit 5: Regional Materials
- MR Credit 6: Rapidly Renewable Materials

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

Using salvaged and refurbished materials in building projects extends the life of materials and can reduce overall initial costs. Use of salvaged materials can also add character to the building and can be used effectively as architectural details.

MR	
NC	Credit 3
CS	Credit 3

REUSED MATERIALS FOUND ON-SITE

Items that were "fixed" components on-site before construction began. To qualify as reused for this credit, these items must no longer be able to serve their original functions and must then be installed for a different use or in a different location. An example would be a door removed and modified to serve as the countertop for the receptionist station.

Walls, ceilings, and flooring: If such items continue to serve their original functions in the new building, they are excluded from this credit but are covered by MR Credit 1.2, Building Reuse—Maintain Interior Non-structural Components.

On a project site where an existing building is demolished or deconstructed, the materials that are retained from the demolition and reused (whether they serve their original function or not), are eligible for this credit.

REUSED MATERIALS FOUND OFF-SITE

Reusable materials eligible for this credit are not limited to items found within the project building. Materials obtained off-site qualify as reused if they have been previously used. These materials may be purchased as salvaged, similar to any other project material, or they may be relocated from another facility, including ones previously used by the occupant. The salvaged materials from both on-site and off-site can be applied to MR Credit 5, Regional Materials, if they comply with the requirements of that credit. Materials qualifying as reused for MR Credit 3 cannot be applied to MR Credits 1, 2, 4, 6, or 7.

This credit applies primarily to the LEED Materials Divisions. Do not include mechanical, electrical, and plumbing components or appliances and equipment in the calculations for this credit. This exclusion is consistent with MR Credits 4 and 5. Exclude furniture and furnishings (CSI Division 12 components) unless they are included consistently across MR Credits 3–7.

For salvaged furniture taken from the occupant's previous facility or location, demonstrate that these materials were purchased at least 2 years prior to the project's initiation. For example, if the owner is moving to a new construction or core and shell project, furniture and furnishings relocated to the new site can contribute to this credit because their reuse will eliminate the need for purchasing new furniture and furnishings.

Generally, opportunities to reuse building materials may be limited. Core materials that may be eligible include salvaged brick, structural timber, stone, and pavers. While considering the potential to reuse salvaged materials, confirm that they do not contain toxic substances, such as lead or asbestos.

5. TIMELINE AND TEAM

The incorporation of materials reuse as a design strategy affects cost estimates, the demolition phase (if salvaging from the project site), and the ultimate design development of the project. Coordination among the owner, architect or design team, and contractor should begin early in the pre-design phase and continue through design development so that knowledge of the site and building areas to be salvaged and reused can be creatively and efficiently worked into the basis of design, and opportunities to bring in salvaged materials from off-site can be incorporated into the project. Documentation should likewise begin early.

During pre-design, the project team should assess opportunities for materials reuse and the extent of site demolition involved, and set goals accordingly. In the design phase, the architect should incorporate salvaged or reused materials into the design and then, during the construction

MR	
NC	Credit 3
CS	Credit 3

documents and specifications development phase, identify sources and outline measures for their use. The contractor should locate sources for these materials and document and track their cost and quantity during construction. This recordkeeping will aid the project team in the credit submittal process.

6. CALCULATIONS

List the reused or salvaged materials used and their cost. Table 1 provides an example of a salvaged materials tracking log.

Determine the cost of each material. This cost will be the actual cost paid or, if the material came from on-site, the replacement value. The replacement value can be determined by pricing a comparable material in the local market; exclude labour and shipping. If a project team receives a discount from a vendor, the replacement value should reflect the discounted price as opposed to the list value. When the actual cost paid for the reused or salvaged material is below the cost of an equivalent new item, use the higher value in the calculations. When the cost to reclaim an item found on-site is less than the cost of an equivalent new item, use the cost of the new item (or replacement cost).

TABLE 1. SAMPLE SALVAGED MATERIALS TRACKING LOG

SALVAGED/REUSED MATERIAL DESCRIPTION	SOURCE FOR SALVAGED/REUSED MATERIAL	VALUE / PRODUCT COST ($)
Salvaged Brick	ABC Salvage Suppliers	$62,500
Salvaged Wood floor	Salvage Company Y	$24,200
Remanufactured Wood Doors (Used as Built-in Countertops)	On-site Salvage / Remanufacture	$4,200
Sub-total Salvaged/Reused Materials		$90,900
Total Construction Materials Cost – or 45% Default Materials Value		$1,665,498
Salvaged/Reused Materials as a Percentage of Total Materials Cost		5.5%

Determine the total materials cost by multiplying the total construction cost (hard costs of the LEED Materials Divisions) by 0.45. Alternatively, the total materials cost may be a tally of actual materials cost in the LEED Materials Divisions from the project schedule of values or a similar document. The benefit of using actual materials costs, as opposed to the default 45%, is that projects with less than 45% materials cost can more easily achieve the credit thresholds because total materials cost is in the denominator of the equation below. Furniture and furnishings (CSI Division 12 components) are excluded from the calculations for this credit unless they are included consistently across MR Credits 3–7.

Calculate the percentage of reuse materials according to Equation 1.

Equation 1

$$\text{Percentage Reused Materials} = \frac{\text{Cost of Reused Material (\$)}}{\text{Total Materials Cost (\$)}} \times 100$$

MR	
NC	Credit 3
CS	Credit 3

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Maintain a list of reused and salvaged materials, their corresponding costs (or cost calculation methodology). Include construction costs for materials in the LEED Materials Divisions. Note that photos may be needed to justify unusual reuse items.

OR

- Maintain a list of actual materials costs, excluding labour and equipment.

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

NC

An Innovation in Design credit for exemplary performance is available when a project team documents that the value of salvaged or reused materials used on the project is 15% or more of the total materials cost.

CS

An Innovation in Design credit for exemplary performance is available if the value of salvaged or reused materials used on the project is equal to at least 10% of the total materials cost.

10. REGIONAL VARIATIONS

This credit may have particular importance in areas with historic structures and neighbourhoods, or in offering the benefits of a non-virgin source of building material. British Columbia and Ontario have well-developed markets for salvaged material. Project teams should research rebuilding centers in their region, using the resources listed in this section. Where salvage markets are not as readily available, consider using deconstruction techniques. By increasing the demand for used materials, teams might encourage the development of a regional salvage market that would expand economic opportunities while diverting waste. Building reuse can encourage new development while preserving the history and character of an area, and materials reuse can work in tandem with this strategy.

MR	
NC	Credit 3
CS	Credit 3

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

There are no operations and maintenance considerations specific to reused or refurbished materials.

12. RESOURCES

Government Resources

Check with the solid waste authority or natural resources department in your city or county. Many local governments provide information about regional materials exchanges and other sources.

WEBSITES

Green Building Resource Guide, Savaged Building Materials Exchange
http://www.greenguide.com/exchange/search.html

The Green Building Resource Guide is a database of more than 600 green building materials and products selected specifically for their usefulness to the design and building professions.

Building Materials Reuse Association (formerly Used Building Materials Association)
http://www.bmra.org

The Building Materials Reuse Association is a non-profit, membership-based organization that represents companies and organizations involved in the acquisition and/or redistribution of used building materials.

Used Building Materials Exchange
http://www.build.recycle.net

The Used Building Materials Exchange is a free marketplace for buying and selling recyclables and salvaged materials.

The Greater Vancouver Regional District, Old to New: Design Guide, Salvaged Building Materials in New Construction
http://www.metrovancouver.org/about/publications/Publications/oldtonewdesignguidesalvmat08-1.pdf

This useful and detailed guidebook reviews the use of salvaged materials in real-life case studies.

13. DEFINITIONS

Refurbished materials are products that could have been disposed of as solid waste. These products have completed their life cycle as consumer items and are then refurbished for reuse without substantial alteration of their form. Refurbishing includes renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product.

Remanufactured materials are items that are made into other products. One example is concrete that is crushed and used as subbase.

Salvaged materials or **reused materials** are construction materials recovered from existing buildings or construction sites and reused. Common salvaged materials include structural beams and posts, flooring, doors, cabinetry, brick, and decorative items.

14. CASE STUDY

MR	
NC	Credit 3
CS	Credit 3

E'TERRA INN

LEED Canada-NC 1.0 Gold, 18 November 2005

Location: Tobermory, Ontario
Building Type: Hotel/Motel
Owner Type: Commercial
Building Size: 700m^2
Owner Name: E'Terra Inn
LEED Consultant: Enermodal Engineering Ltd.
Responsible Firm (for this credit): Owner and Enermodal Engineering Ltd.
Photo Credit: E'Terra

E'Terra Inn is an eco-lodge in Tobermory, Ontario built directly into the Niagara escarpment. This 700m^2 wood building provides environmentally-appropriate luxury accommodation in a wilderness setting. Being located in a wooded area, meant the owner was highly motivated to include a high amount of salvaged wood in the construction of the inn.

The owner and design team spent a significant amount of time and energy contacting lumber companies and salvage yards throughout southern Ontario to locate possible sources of salvaged wood. Salvaged wood was used for the railings, posts, beams, and cedar deck. This wood came from various sources including the following:

- Demolished industrial factories in the Toronto area
- Car dealerships
- Barns
- Train trussels

In the end, E'Terra used salvaged materials (wood and brick) for 13% of the building's construction materials – earning both resource reuse credits. Similarly, E'Terra achieved 21% raw materials savings, 75% construction waste diversion, 8% recycled content, and 40% regional content.

MR	
NC	Credit 4
CS	Credit 4

RECYCLED CONTENT

	NC	CS
Credit	MR Credit 4	MR Credit 4
Points	1-2 points	1-2 points

INTENT

To increase demand for building products that incorporate recycled content materials, thereby reducing impacts resulting from extraction and processing of virgin materials.

REQUIREMENTS: NC & CS

Use materials with recycled content such that the sum of post-consumer recycled content plus 1/2 of the pre-consumer content constitutes at least 10% or 20%, based on cost, of the total value of the materials in the project. The minimum percentage recycled for each point threshold is as follows:

RECYCLED CONTENT	POINTS
10%	1
20%	2

The recycled content value of a material assembly is determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.

Mechanical, electrical and plumbing components and specialty items such as elevators cannot be included in this calculation. Include only materials permanently installed in the project. Furniture may be included if it is included consistently in MR Credits 3: Materials Reuse through MR Credit 7: Certified Wood (MR Credit 6 in Core and Shell).

Recycled content is defined in accordance with the International Organization of Standards document, ISO 14021—Environmental Labels and Declarations - Self-declared Environmental Claims (Type II environmental labelling).

INTERPRETATIONS

LEASED TENANT SPACES (NC)

If utilizing mandatory lease agreements to achieve NC certification, the direction to tenants must include the same (or higher) performance goal as is targeted in the overall application of this credit. The future leased tenant fit-up is not included in the calculations of this credit in either the numerator or the denominator. Further direction to future tenants on how to source recycled materials is commendable but is not required as part of the mandatory lease agreement.

MR	
NC	Credit 4
CS	Credit 4

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Products with recycled content reduce virgin materials use and solid waste volumes. As the number of building products containing recycled content grows, the marketplace for recycled materials develops.

Post-consumer recycled content is derived from materials that can no longer be used for their original purpose, and pre-consumer recycled content consists of raw material diverted from the waste stream during the manufacturing process. Although the use of both types of recycled content is encouraged, post-consumer recycled content is accorded greater value because of its increased environmental benefit over the life cycle of the product.

ECONOMIC ISSUES

Many commonly used products are now available with recycled content, including metals, concrete, masonry, gypsum wallboard, acoustic tile, carpet, ceramic tile, rubber flooring and wall base, and insulation. Research all recycled-content materials for environmental considerations. For example, if the recycled-content product is not as durable as its conventional counterpart, the environmental benefits may be compromised by the need for more frequent replacement. Most recycled-content products, however, exhibit performance similar to products containing only virgin materials and can be incorporated into building projects with ease and little to no cost premium.

2. RELATED CREDITS

Coordinate recycled material procurement with a construction waste management plan to make use of on-site salvaged deconstruction and demolition waste. There are opportunities for synergies with the following credits:

- MR Credit 2: Construction Waste Management
- MR Credit 3: Materials Reuse

When purchasing new materials, look for recycled-content materials that use local waste products and are remanufactured locally to take advantage of synergies with MR Credit 5, Regional Materials.

Check recycled-content materials for problematic air emissions, especially with synthetic products such as plastic, rubber, or polyester. Make sure that any recycled-content materials are considered in the planning and execution of IEQ Credit 4, Low-Emitting Materials.

The project materials costs used here need to be consistent with those used in the following credits:

- MR Credit 3: Materials Reuse
- MR Credit 5: Regional Materials
- MR Credit 6: Rapidly Renewable Materials

3. SUMMARY OF REFERENCED STANDARDS

International Standard ISO 14021–1999, Environmental Labels and Declarations—Self-Declared Environmental Claims (Type II Environmental Labelling) (Or as listed under the Canadian Standards Association as CAN/CSA-ISO 14021-00 (R2009).)

MR	
NC	Credit 4
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International Organization for Standardization (ISO)
http://www.iso.org

This International Standard specifies requirements for self-declared environmental claims including statements, symbols, and graphics, for products. It further describes selected terms commonly used in environmental claims and gives qualifications for their use. It also describes a general evaluation and verification methodology for self-declared environmental claims and specific evaluation and verification methods for the selected claims.

4. IMPLEMENTATION

Establish goals for recycled content during the design phase and include them in the project specifications. Doing so is not a LEED requirement, but it can help in achieving the credit. To establish recycled content goals, first add a LEED general requirements section to Division 01 to allow for writing LEED performance requirements for overlapping work sections (such as building envelope and structure). Then, specify products and materials according to CSI MasterFormat™ classifications for Division 01 recycled-content requirements. Careful research may be required to determine the percentages of recycled content that can realistically be expected in specific products and materials.

Many standard materials contain recycled content because of how they are manufactured; examples are steel, gypsum board, and acoustical ceiling tile. Design and construction teams may need to research which materials contain high levels of recycled content or verify which models of a certain product line feature the desired recycled content; examples include carpet and ceramic tile.

Reusing materials reclaimed from the same process in which they are generated—though good practice—does not contribute toward the recycled content of the material. In other words, putting waste back into the same manufacturing process from which it came is not considered recycling because it was not diverted from the waste stream. Reuse of materials includes rework, regrind, or scrap product (ISO 14021); examples are glass culls, which are often reused in the making of new glass, as well as planer shavings, plytrim, sawdust, chips, bagasse, sunflower seed hulls, walnut shells, culls, trimmed materials, print overruns, over-issue publications, and obsolete inventories.

Distinguish between post-consumer and pre-consumer recycled content when tracking materials for the purpose of credit calculations (see Definitions, below).

CS

Because interior construction is not part of a Core & Shell project, look for opportunities to meet this credit by evaluating the major structural and envelope materials.

5. TIMELINE AND TEAM

Run preliminary calculations during the design phase, as soon as a project budget is available, to set appropriate recycled-content targets. Identification of materials that contain recycled content should begin during the preconstruction phase, whenever possible. All project team members, including the general contractor and subcontractors, should consult with suppliers prior to the buyout phase to determine the availability of materials and the specific amount of post-consumer and pre-consumer recycled content within each type of material. Careful planning before

MR	
NC	Credit 4
CS	Credit 4

construction can minimize capital expenses and enable the project team to verify whether the procured building materials contain the desired amount of recycled content.

The architect should identify and then specify products with recycled content. The contractor is responsible for ensuring the appropriate installation of these materials, documenting and tracking the cost and quantity of recycled materials, and providing this documentation to the project team.

6. CALCULATIONS

Determine the total materials cost for the project by multiplying the total construction cost (hard costs of the LEED Materials Divisions) by 0.45. Alternatively, the total materials cost may be a tally of actual materials cost in the LEED Materials Divisions from the project schedule of values or a similar document. The benefit of using actual materials costs, as opposed to the default 45%, is that projects with less than 45% materials cost can more easily achieve the 10% and 20% credit thresholds. The purpose of the default value is to streamline the documentation process because it can be challenging to separate the materials costs from labour and equipment costs for all materials on the project.

Materials costs include all expenses to deliver the material to the project site. Materials costs should account for all taxes and transportation costs incurred by the contractor but exclude any cost for labour and equipment once the material has been delivered to the site.

DETERMINE THE RECYCLED-CONTENT VALUE

To calculate the percentage of recycled-content materials used on a project, list all recycled-content materials and products and their costs.

For each product, identify the percentage of post-consumer and/or pre-consumer recycled content by weight, and list the recycled content information source. LEED requires that the information be from a reliable, verifiable source.

POST-CONSUMER RECYCLED CONTENT

Post-consumer recycled content is consumer waste, much of which comes from residential curbside recycling programs for aluminum, glass, plastic, and paper. To be a feedstock, the raw materials must have served a useful purpose in the consumer market before being used again. Other post-consumer feedstock is generated when construction and demolition debris is recycled.

PRE-CONSUMER RECYCLED CONTENT

Pre-consumer (or post-industrial) recycled content comes from process waste that an industry has sold or traded with another through the marketplace. For instance, a composite board manufacturer may obtain sawdust from a lumber mill or waste straw from a wheat farm. This definition does not include in-house industrial scrap or trimmings, which are normally fed back into the same manufacturing process.

Calculate the recycled-content value of each material according to Equation 1.

Equation 1

$$\text{Recycled Content Value (\$)} = \left(\text{\% Post-consumer Recycled Content} \times \text{Materials Cost}\right) + 0.5\left(\text{\% Pre-consumer Recycled Content} \times \text{Materials Cost}\right)$$

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NC	Credit 4
CS	Credit 4

Calculate the project's percentage recycled content according to Equation 2.

Equation 2

$$\text{Percentage Recycled Content} = \frac{\text{Total Recycled Content Value (\$)}}{\text{Total Materials Cost}} \times 100$$

Exclude furniture and furnishings (CSI Division 12 components) from the calculations for this credit unless they are included consistently across MR Credits 3–7. This credit applies primarily to the LEED Materials Divisions. Do not include mechanical, electrical, and plumbing components or appliances and equipment in the calculations for this credit. Compared with structural and finish materials, mechanical and electrical equipment tends to have a high dollar value relative to the amount of material it contains. That high dollar value would skew the results of the calculation.

DEFAULT RECYCLED CONTENT

For steel products where no recycled content information is available, assume the recycled content to be 25% post-consumer. No other material has been recognized as having a similarly consistent minimum recycled content. Many steel products contain 90% or higher recycled content if manufactured by the electric arc furnace process, so it may be beneficial to obtain actual information from the manufacturer rather than relying on the default value.

CALCULATING ASSEMBLY RECYCLED CONTENT

An assembly can be either a product formulated from multiple materials (e.g., a composite wood panel) or a product made up of subcomponents (e.g., a window system). For assembly recycled content values, determine the percentage by weight of the post-consumer recycled content and the pre-consumer recycled content. For subcomponents, determine the percentages of post-consumer and pre-consumer recycled content by using the weights of the component elements. No consideration is given to relative costs of the materials or the subcomponents when calculating these percentages of recycled content. For example, a pound of steel in a window assembly is of equal significance in determining recycled content as a pound of fabric on a movable wall panel.

To incorporate assembly recycled content into Equation 2, use Equation 3 and add the resulting value to Equations 2's total recycled content value:

Equation 3

$$\begin{array}{c}\text{Assembly}\\\text{Recycled}\\\text{Content}\\\text{Value (\$)}\end{array} = \frac{\begin{array}{c}\text{\% Postconsumer}\\\text{Recycled Content}\end{array}}{\begin{array}{c}\text{Total Assembly}\\\text{Weight}\end{array}} \times \begin{array}{c}\text{(Sub-}\\\text{component}\\\text{Weight)}\end{array} \times \begin{array}{c}\text{Assembly}\\\text{Cost}\end{array} + \frac{\begin{array}{c}\text{\% Pre-consumer}\\\text{Recycled Content}\end{array}}{\begin{array}{c}\text{Total Assembly}\\\text{Weight}\end{array}} \times \begin{array}{c}\text{(Sub-}\\\text{component}\\\text{Weight)}\end{array} \times 0.5 \times \begin{array}{c}\text{Assembly}\\\text{Cost}\end{array}$$

PORTLAND CEMENT REDUCTION VIA SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCMS)

The recycled content value of the cementitious materials is calculated based on Portland cement reduction rather SCMs content. Though the use of SCMs (such as fly ash, ground granulated blast furnace slag, and silica fume) it is possible to reduce the Portland cement content of concrete mixes. However, occasionally the mixes in SCM concrete result in the total cementitious materials content being increased (due to the differing chemical properties of SCMs versus Portland cement).

MR	
NC	Credit 4
CS	Credit 4

Therefore, it is a more accurate assessment of the environmental benefit of SCM concrete to express the 'recycled' content in terms of Portland cement reduction:

The Portland cement content (in kg/m^3) for each Base Mix is calculated as follows:

Portland Cement Content of Base Mix (kg/m^3) = design strength value in MPa at 28 days x K

where K = 10 for non-air-entrained concrete,

or K =12.5 for air-entrained concrete.

For example, the Base Mix Portland Cement Content for non-air- entrained concrete with a design strength of 30 MPa at 28 days is 300 kg/m^3. For an air-entrained mix with a design strength of 30 MPa at 28 days, the Base Mix Portland Cement content is 375 kg/m^3. This calculation is included in the LEED Portland Cement Reduction Calculator.

The percentage of Portland Cement Reduction (by mass) is used in the calculations, a multiplier factor of 2 is applied as shown in Equation 4. The x-2 multiplier is a further adjustment to account for the environmental merits of reducing Portland cement by substituting it with SCMs.

Equation 4

$$\text{Calculated Pre-consumer Recycled Content of Cementitious materials (\%)} = \left[\frac{\left(\text{Portland Cement Content of } \textit{Base Mix} - \text{Portland Cement Content in } \textit{Actual SCM Mix}\right)}{\text{Portland Cement Content of } \textit{Base Mix}} \times 100 \right] \times 2$$

The resulting percentage represents the cementitious materials pre-consumer recycled content to be used in the MR Credit 4 LEED Letter Template. This percentage is then multiplied by the total cost of all cementitious materials (not the total cost of the concrete). Thus, the applicant must determine the separate cost of cementitious materials from the overall concrete cost. If this is not possible to obtain this figure, it is acceptable to apportion the cost of the concrete mix based on the weight of the each component. For example if the Portland cement reduction is 40% and all cement materials represent 10% of the overall weight of the concrete, then 4% of the total cost of the concrete would be considered recycled. Note: the recycled content of the concrete can also be increased by using recycled materials for the other components in concrete (e.g., recycled aggregate).

EXAMPLE 1. SAMPLE PORTLAND CEMENT REDUCTION CALCULATION

MIX #	STRENGTH OF MIX (MPa)	AIR ENTRAINED (Y/N)	BASE MIX PORTLAND CEMENT	MASS OF PORTLAND CEMENT* (kg)	PRE-CONSUMER RECYCLED CONTENT OF CEMENTIOUS MATERIALS (%)	DOLLAR VALUE OF ALL CEMENTITIOUS MATERIALS (FROM CONCRETE SUPPLIER)	RECYCLED CONTENT VALUE PER m^3[% RECYCLED CONTENT /2 X DOLLAR VALUE]
2	25	N	250	200	40%	$35	$7.00
3	28	Y	350	300	28.4%	$45	$6.44

This column also includes any other cementitious ingredients that are not recycled.

MR	
NC	Credit 4
CS	Credit 4

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Record product names, manufacturers' names, costs, percentage post-consumer content, and percentage pre-consumer content.
- Collect cutsheets or manufacturers' letters to document the listed products' recycled content.
- Where appropriate, maintain a list of actual materials costs, excluding labour and equipment for the LEED Materials Divisions only; including Division 12 is optional.

8. EXAMPLES

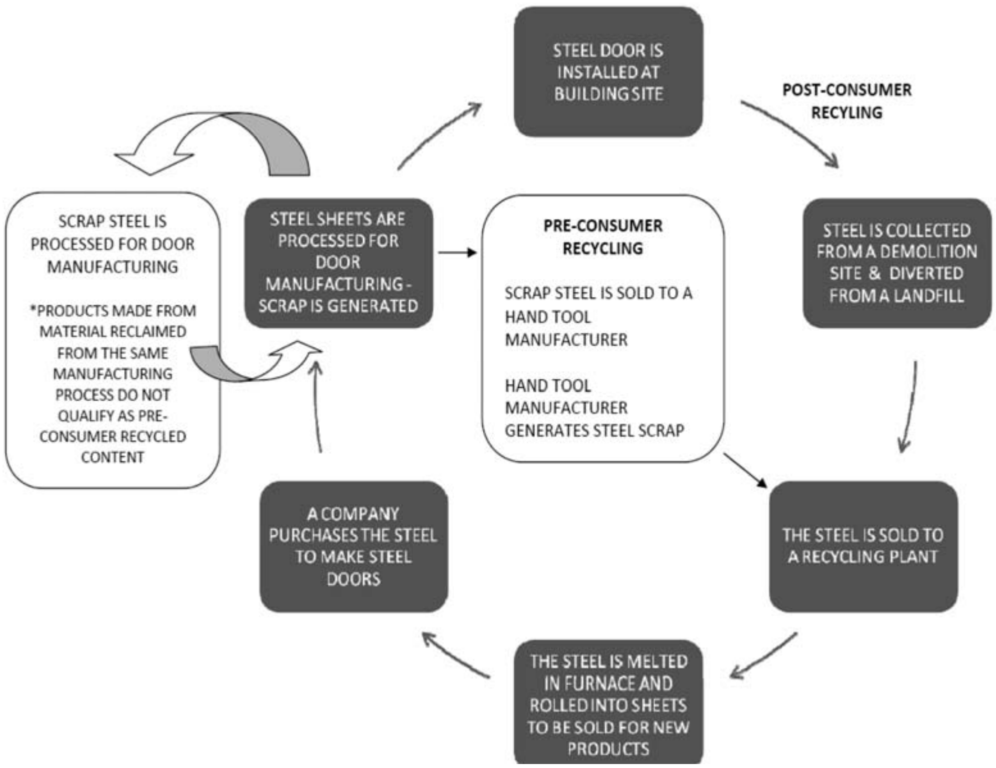
The total construction cost for an office building is $600,000. Using the default materials calculations, the total cost of materials (excluding labour and equipment) is $600,000 x 0.45 = $270,000. Table 1 lists recycled-content material purchased for the project. In this example, the combined value of post-consumer content plus half the pre-consumer content as a percentage of total cost of all materials is 11.31%. The project earns 1 point for MR Credit 4.

TABLE 1. SAMPLE CALCULATIONS FOR RECYCLED CONTENT

TOTAL CONSTRUCTION COST FOR DEFAULT TOTAL MATERIALS COST; OR						**$600,000**
PROVIDE TOTAL MATERIALS COST (EXCLUDE LABOUR, EQUIPMENT)						**$270,000**
PRODUCT NAME	**VENDOR**	**PRODUCT COST**	**% POST-CONSUMER**	**% PRE-CONSUMER**	**RECYCLED CONTENT VALUE (EQUATION 1)**	**RECYCLED CONTENT INFORMATION SOURCE**
Structural steel	Multi Steel	$40,000	10.00%	85.00%	$21,000	Structural manufacturer
Underlay aggregate	ABC Foundation	$21,000	20.00%		$4,200	Concrete manufacturer
Particleboard	Sol's Big Boards	$4,000		100.00%	$2,000	Manufacturer
Gypsum board	Gypsum R Us	$8,550		78.00%	$3,335	Manufacturer
Combined Value of Post-consumer + 1/2 Pre-consumer Content (Total Recycled Content Value)						$30,535
Combined Value of Post-consumer + 1/2 Pre-consumer Content, as a Percentage of Default Total Materials Cost (Total Percent Recycled Content) (Equation 2)						11.31%
Total Points Documented						1

MR	
NC	Credit 4
CS	Credit 4

FIGURE 1. PRE-CONSUMER VERSUS POST-CONSUMER RECYCLED CONTENT



9. EXEMPLARY PERFORMANCE

Project teams may earn an Innovation in Design credit for exemplary performance by achieving a total recycled-content value of 30% or more.

10. REGIONAL VARIATIONS

The location of the project site affects the availability of locally sourced materials. Availability of building materials containing recycled content may vary by region based on the proximity of suppliers. Some materials, such as structural steel, will be readily available for any project site; others may be manufactured or distributed in specific regions only. A project team might need to decide whether it is more sustainable to use a local material containing virgin content or to import materials containing recycled-content from a long distance.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Recycled-content materials may require different maintenance practices than conventional products. When specifying recycled products, request maintenance recommendations from the manufacturer and give this information to the operations team.

The duplication, replacement, and repair of recycled-content materials will be easier if information about the installed products has been maintained. Encourage the creation of a sustainable purchasing plan and provide building operators with lists of the installed products and their manufacturers, such as the documentation used in the LEED application.

MR	
NC	Credit 4
CS	Credit 4

12. RESOURCES

Government Resources

Check with the solid waste authority or natural resources department in your city or county. Many local governments provide information on recyclers and recycled content product manufacturers within their region.

WEBSITES

BuildingGreen, Inc., GreenSpec
http://www.buildinggreen.com/menus/index.cfm

GreenSpec contains detailed listings for more than 2,000 green building products, and each entry includes environmental data, manufacturer information, and links to additional resources.

Center for Resourceful Building Technology, Guide to Resource-Efficient Building Elements
http://crbt.ncat.org/

The directory of environmentally responsible building products is a resource that provides introductory discussions for each topic and contact information for specific products, including salvaged materials. (The CRBT project is no longer active, and the CRBT website is no longer updated. The National Center for Appropriate Technology is providing this website for archival purposes only.)

Environmental Choice Certified Products
http://www.ecologo.org/en

The EcoLogoM program certifies environmentally preferable, green goods and services with the Environmental Choice label. The program compares products and services with others in the same category, develops rigorous and scientifically relevant criteria, and awards the EcoLogo to those that are environmentally preferable throughout their lifecycles. The EcoBuyer Green Products and Service Database lists certified product categories, including all numbered product categories listed in this credit, as well as links to a list of all 7,500 EcoLogo-certified products.

Oikos
http://www.oikos.com

Oikos is a searchable directory of efficient building products and sustainable design resources.

Recycled Content: What Is It, and What Is It Worth?
Environmental Building News, February 2005.
http://www.buildinggreen.com/auth/article.cfm?filename=140201a.xml

U.S. EPA Comprehensive Procurement Guidelines Program
http://www.epa.gov/cpg/products.htm

The Comprehensive Procurement Guidelines Program contains EPA information on recycled-content materials with guidelines for recycled percentages. It also includes a searchable database of suppliers.

Construction Specifications Institute (CSI), Green Format
http://www.greenformat.com

This database features a standardized format for manufacturers to report recycled content as well other environmental and sustainable attributes. The website is based on principles of ISO 14021, Environmental Labels and Declarations—Self-Declared Environmental Claims (Type II Environmental Labelling), and ASTM E 2129, Standard Practice for Data Collection for Sustainability Assessment of Building Products.

MR	
NC	Credit 4
CS	Credit 4

13. DEFINITIONS

Assembly recycled content is the percentage of material in a product that is either post-consumer or pre-consumer recycled content. It is determined by dividing the weight of the recycled content by the overall weight of the assembly.

Fly ash is the solid residue derived from incineration processes. Fly ash can be used as a substitute for Portland cement in concrete.

Post-consumer recycled content is the percentage of material in a product that was consumer waste. The recycled material was generated by household, commercial, industrial, or institutional end-users and can no longer be used for its intended purpose. It includes returns of materials from the distribution chain (ISO 14021). Examples include construction and demolition debris, materials collected through recycling programs, discarded products (e.g., furniture, cabinetry, decking), and landscaping waste (e.g., leaves, grass clippings, tree trimmings).

Pre-consumer recycled content, formerly known as post-industrial content, is the percentage of material in a product that is recycled from manufacturing waste. Examples include planer shavings, sawdust, bagasse, walnut shells, culls, trimmed materials, overissue publications, and obsolete inventories. Excluded are rework, regrind, or scrap materials capable of being reclaimed within the same process that generated them (ISO 14021).

Recycled content is the proportion, by mass, of pre-consumer or post-consumer recycled material in a product (ISO 14021).

Virgin Materials/Resources have not been previously used or consumed.

MR	
NC	Credit 5
CS	Credit 5

REGIONAL MATERIALS

	NC	CS
Credit	MR Credit 5	MR Credit 5
Points	1-2 points	1-2 points

INTENT

To increase demand for building materials and products extracted, processed, and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation.

REQUIREMENTS: NC & CS

Use building materials or products that have been extracted, harvested, recovered and processed within 800 km (500 miles) (2,400 km if shipped by rail or water) of the final manufacturing site.

Demonstrate that the final manufacturing site is within 800 km (500 miles) (2,400 km if shipped by rail or water) of the project site for these products.

If only a fraction of a product or material is extracted, harvested, recovered, processed and manufactured locally, then only that percentage (by weight) must contribute to the regional value. The minimum percentage of regional materials for each point threshold is as follows:

REGIONAL MATERIALS	POINTS
20%	1
30%	2

Mechanical, electrical and plumbing components and specialty items such as elevators and equipment must not be included in this calculation. Include only materials permanently installed in the project. Furniture may be included if it is included consistently in MR Credits 3: Materials Reuse through MR Credit 7: Certified Wood (MR Credit 6 in Core and Shell).

MR	
NC	Credit 5
CS	Credit 5

INTERPRETATIONS

LEASED TENANT SPACES (NC)

If utilizing mandatory lease agreements to achieve NC certification, the direction to tenants must include the same (or higher) performance goal as is targeted in the overall application of this credit. The future leased tenant fit-up is not included in the calculations of this credit in either the numerator or the denominator. Further direction to future tenants on how to source regional materials is commendable but is not required as part of the mandatory lease agreement.

MR	
NC	Credit 5
CS	Credit 5

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

The use of regional building materials reduces transportation activities and associated pollution. Trucks, trains, ships, and other vehicles deplete finite reserves of fossil fuels and generate air pollution. It also is important to address the source of raw materials used to manufacture building products; some are harvested or extracted far from the point of manufacture, also contributing to air and water pollution associated with transportation.

ECONOMIC ISSUES

The availability of regionally manufactured building materials depends on the project location. In some areas, the majority of products needed for the project can be obtained within an 800 kilometre radius (2,400 km if shipped by rail or water). In other areas, only a small portion or no building materials can be sourced locally. However, the purchase of regional building materials is generally more cost-effective because of reduced transportation costs. Also, the support of regional manufacturers and labour forces retains capital in the community, contributing to a more stable tax base and a healthier local economy, as well as showcases the resources and skills of the region.

2. RELATED CREDITS

Specifying regional materials to achieve this credit may affect the levels of achievement for the following credits:

- MR Credit 3: Materials Reuse
- MR Credit 4: Recycled Content
- MR Credit 6: Rapidly Renewable Materials
- MR Credit 7: Certified Wood

Set goals early for materials use; assess the availability of regional materials and determine the best available products to minimize the project's environmental impact. The use of life-cycle assessment tools may be employed in the decision-making process.

The project materials costs used in this credit need to be consistent with those used in the following credits:

- MR Credit 3: Materials Reuse
- MR Credit 4: Recycled Content
- MR Credit 6: Rapidly Renewable Materials

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

The point of manufacture is considered the place of final assembly of components into the building product that is furnished and installed by the trade workers. For example, if the hardware comes from Hamilton, the lumber comes from Vancouver, and the joist is assembled in Winnipeg, then the location of the final assembly is Winnipeg.

It may require careful research to determine what local products are available, so evaluate this

MR	
NC	Credit 5
CS	Credit 5

credit early in the design process. Product manufacturers will be able to provide information on which of their products meet the extraction, harvesting, recovery, and processing criteria for this credit. Manufacturers will determine the distances from the final manufacturing site to the sites at which their products (all subcomponents and materials) were extracted, harvested, recovered, and processed.

The project team can then select products from manufacturing sites within 800 kilometres (500 miles) (2,400 km if shipped by rail or water) of the construction site. This credit is achieved by summing the cost of all materials that are deemed regional by the above criteria.

In cases where products and construction components are assembled on-site, the individual components that are extracted, harvested, recovered, and processed within 800 kilometres (500 miles) (2,400 km if shipped by rail or water) of the site will be counted toward this credit.

The general contractor should work with subcontractors and suppliers to verify availability of materials that are extracted, harvested, recovered, processed and manufactured locally. The contractor should run preliminary calculations based on the construction budget or schedule of values during the preconstruction phase. This will allow the construction team to focus on those materials with the greatest contribution to this credit as early as possible.

5. TIMELINE AND TEAM

Run preliminary calculations, as soon as a project budget is available, to set appropriate regional materials targets. Architects should specify in the construction documents products that are regional and work with the general contractor on approved alternatives that meet the requirements of this credit. During construction, the general contractor is typically responsible for documenting the amounts and values of regionally harvested, processed, and manufactured materials used on the project. The general contractor must track the materials cost of each locally harvested, processed and manufactured product that will be applied to this credit.

6. CALCULATIONS

Determine the total materials cost for the project by multiplying the total construction cost (hard costs in the LEED Materials Divisions) by 0.45. Alternatively, the total materials cost may be a tally of actual materials cost in the LEED Materials Divisions from the project schedule of values or a similar document. The benefit to using actual materials costs, as opposed to the default 45%, is that projects with less than 45% materials cost will find it easier to achieve the 20% and 30% credit thresholds, since total materials cost is in the denominator of the equation below. The purpose of the default value is to streamline the documentation process, since it is often challenging to break out the materials costs from labour and equipment costs for all materials on the project.

Materials costs include all expenses to deliver the material to the project site. Materials costs should account for all taxes and transportation costs incurred by the contractor but exclude any cost for labour and equipment once the material has been delivered to the site.

List those products that are extracted, harvested, recovered, processed and manufactured within 800 kilometres (500 miles) (2,400 km if shipped by rail or water) of the project site. Indicate the manufacturer, the product cost, the distance between the project site and the manufacturer location, and the distances between the manufacturer location and the extraction/harvesting/recovery/processing site(s) for each raw material in each product. Also indicate mode of travel (e.g., via road or rail/water). To simplify the sample tables, travel via road is assumed.

MR	
NC	Credit 5
CS	Credit 5

Calculate the percentage local materials according to Equation 1.

Equation 1

$$\text{Percentage Local Materials} = \frac{\text{Total Cost of Local Materials (\$)}}{\text{Total Materials Cost (\$)}} \times 100$$

The project achieves 1 point when the percentage of local material is 20% or greater, and 2 points when the percentage of local material is 30% or greater.

Table 1 lists sample materials and components eligible for this credit.

TABLE 1. SAMPLE REGIONAL MATERIALS

MANUFACTURING SITE TO POINT OF HARVEST, RECOVERY OR EXTRACTION	MANUFACTURING SITE TO POINT(S) OF PROCESSING	PROJECT SITE TO POINT OF MANUFACTURE OR ASSEMBLY	PRODUCT INCLUDED IN MR CREDIT 5 CALCULATIONS?
Flooring: Timber harvested, 450 km	Flooring: Rough Milling, 300 km	Flooring mill, 700 km	Yes
I Beams: Steel extraction, 1,000 km		Steel mill, 300 km	No
Concrete: Cement, 650 km Aggregate, 150 km	None	Cement plant, 900 km Gravel Pit: Aggregate and sand, 200 km	No for cement Yes for aggregate and sand
Drywall: Gypsum factory, 200 km	Processing Plant Step #1: 600 km Processing Plant Step #2: 900 km	Drywall supplier, 600 km	No

Furniture and furnishings (CSI Division 12) are excluded from the calculations for this credit, unless they are considered consistently across MR Credits 3–7. This credit applies primarily to the LEED Materials Divisions.

Do not include mechanical, electrical, and plumbing components or appliances and equipment in the calculations for this credit. Compared with structural and finish materials, mechanical and electrical equipment tends to have a high dollar value relative to the amount of material it contains and that high dollar value would skew the results of the calculation.

For materials with more than 1 point of manufacture, processing or extraction, all within the applicable 800-kilometre (500-mile) radius (2,400 km radius if shipped by rail or water), list the component with the greatest distance. If a portion of the material was either manufactured or extracted/harvested/recovered/processed beyond the 800-kilometre (500-mile) radius from the manufacturing site (2,400 km radius if shipped by rail or water), list only that portion and associated cost satisfying the credit requirement. Also indicate mode of travel (e.g., via road or rail/water). To simplify the sample tables, travel via road is assumed.

For assemblies or products manufactured within 800-kilometre (500-mile) (2,400 km if shipped by rail or water) of the project site that contain some components extracted/harvested/recovered/processed beyond the 800-kilometre (500-mile) radius (2,400 km radius if shipped by rail or water)

MR	
NC	Credit 5
CS	Credit 5

from the manufacturing site, use multiple lines when listing purchases. Base the proportionality of such products' costs on the weight of their various components (see the example for concrete in Tables 2 and 3).

REUSED AND SALVAGED MATERIALS

Reused and salvaged materials that satisfy the requirements of MR Credit 3 may also contribute to MR Credit 5. Use the location from which they were salvaged as the point of extraction, and use the location of the salvaged goods vendor as the point of manufacture (processing locations must still be considered). On-site salvaged materials automatically qualify.

RECYCLED MATERIALS

Recycled materials that satisfy the requirements of MR Credit 4 may also contribute to MR Credit 5. Use the location from which the material was collected or deposited as the point if extraction. In most cases this will be a recycling facility or scrap yard. Disregard the original source of the material. Use the location of the new product manufacturer as the point of manufacture. In some cases the recycling facility may also be the manufacturer.

TABLE 2. SAMPLE ASSEMBLY PERCENTAGE REGIONALLY EXTRACTED CALCULATION FOR CONCRETE

COMPONENTS	WEIGHT (kg)	DISTANCE BETWEEN FINAL MANUFACTURING LOCATION & EXTRACTION SITE (km)	WEIGHT CONTRIBUTING TO REGIONAL EXTRACTION (kg)
Cement	282	1,250	0
Fly Ash	282	125	282
Water	275	1	275
Slag	750	370	750
Recycled Concrete & Aggregate	1,000	8	1,000
Sand	1,200	18	1,200
Component Totals	3,789	NA	3,507
Percent Regionally Extracted Materials (3,507/3,789)			92.6%

MR	
NC	Credit 5
CS	Credit 5

TABLE 3. SAMPLE SPREADSHEET FOR REGIONAL MATERIALS

PRODUCT	MANUFACTURER	DISTANCE BETWEEN PROJECT & MANUFACTURER (km)	DISTANCE BETWEEN MANUFACTURER & PROCESSING (km)	DISTANCE BETWEEN MANUFACTURER & EXTRACTION/ HARVEST/ RECOVERY (km)	PRODUCT COST ($)	VALUE QUALIFYING AS REGIONAL	INFORMATION SOURCE
Plant material	Green's Landscape	5	NA	5	$6,770	$6,770	Contractor submittal
Concrete	Joe's Concrete	15	NA	15	$21,000	$21,000	Contractor submittal
Insulation	UR Warm	105	300	1,080	$9,250	-	Product cut sheet
Gypsum	Gypsum R Us	75	690	288	$8,550	$8,550	Letter from manufacturer
Carpet	Fibre Good	355	900	721	$15,333	-	Letter from manufacturer
Casework	Top Counter	18	400	320	$12,200	$12,200	Contractor submittal
Lumber	My Mill	110	760	320	$38,990	$38,990	Contractor submittal
Wood Doors	Close by	71	500 & 475	320	$7,000	$7,000	Contractor submittal
Total Cost of Regional Materials							$94,510
Total Materials Cost (LEED Materials Divisions)							$429,591
Percent Regional Materials							22%
Points Earned							1

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Compile a list of product purchases manufactured, extracted, harvested, recovered, and processed regionally.
- Record manufacturers' names, product costs, distances between the project and manufacturer, and distances between the manufacturer and the extraction, harvesting, recovery and processing site(s). Include mode of travel (e.g., road or rail/water) where appropriate.
- Where appropriate, retain cutsheets that document material as regional.
- Where appropriate, maintain a list of materials costs, excluding labour and equipment, for the LEED Materials Divisions only; including Division 12 is optional.

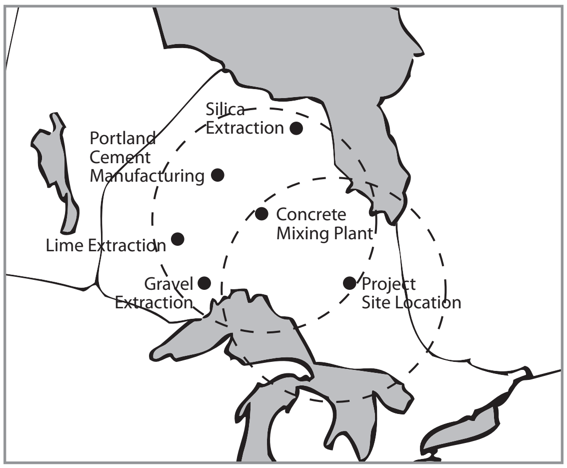
MR	
NC	Credit 5
CS	Credit 5

8. EXAMPLES

EXAMPLE 1

Figure 2 illustrates an example for a hypothetical slag concrete material that is extracted and processed within 800 kilometres (500 miles) of manufacture, and manufactured within 800 kilometres (500 miles) of a project site.

FIGURE 2. EXTRACTION AND MANUFACTURING LOCATION OF FLY ASH CONCRETE



EXAMPLE 2

The total construction costs for a library building are $600,000. Using the default materials calculations, the total cost of materials excluding labour and equipment is $600,000 x 0.45 = $270,000. Table 4 lists the regional materials purchased for the project. In this example, the cost of regionally harvested and manufactured products as a percentage of the total cost of materials is 35.3%. The project earns 2 points. (To simplify the example, all materials were assumed to travel via road rather than by rail/water.)

MR	
NC	Credit 5
CS	Credit 5

TABLE 4. SAMPLE CALCULATION FOR REGIONAL MATERIAL

TOTAL CONSTRUCTION COST FOR DEFAULT TOTAL MATERIALS COST; OR						**$600,000**
PROVIDE TOTAL MATERIALS COST (EXCLUDE LABOUR, EQUIPMENT)						**$270,000**
PRODUCT NAME	**VENDOR**	**PRODUCT COST ($)**	**DISTANCE BETWEEN PROJECT AND MANUFACTURER (km)**	**DISTANCE BETWEEN MANUFACTURER AND PROCESSING SITE (km)**	**DISTANCE BETWEEN MANUFACTURER AND EXTRACTION SITE (km)**	**REGIONAL CONTENT INFORMATION SOURCE**
Plant Material	Green Landscaping	$6,770	25 km	NA	5 km	Manufacturer
Concrete aggregate	Joe's Concrete	$41,000	5 km	NA	24 km	Concrete manufacturer
Gypsum board	Gypsum R Us	$8,550	75 km	400 & 523 km	463 km	Manufacturer
Wood flooring	Lumber Specialists	$38,990	119 km	780 km	515 km	Mill
Total cost of locally manufactured and extracted materials						$95,310
Cost of regionally manufactured products as a percentage of the cost of all materials						35.3%
POINTS DOCUMENTED						
20% regional materials						1
30% regional materials						1
Total points documented						2

EXAMPLE 3

Concrete dry mix is provided by a subcontractor. The dry mix contains cement, aggregate, sand, water, and admixtures with a definite proportion. While the concrete is manufactured within 32 kilometres (20 miles) from the project site, the aggregate is mined from a town 161 kilometres (100 miles) from the manufacturer, the cement plant is 966 kilometres (600 miles) from the manufacturer, and the sand is from 885 kilometres (550 miles) from the manufacturer. For each of these components there is no intermediate processing between extraction and manufacturing. In this case, only the aggregate will qualify for the regional material credit, where all materials travel via road (e.g., not by rail or water). The cost of the aggregate material can either be provided by the subcontractor or calculated on the basis of the percentage (by weight) of aggregate and total cost of the concrete mix. If the concrete mix was $100,000 and the aggregate was 10% by weight of the concrete, the aggregate cost will be assumed to be $10,000. Therefore, the concrete will account for $10,000 to the regional material credit.

9. EXEMPLARY PERFORMANCE

Project teams may earn an Innovation in Design credit for exemplary performance by achieving a total value of regionally harvested, extracted, and manufactured materials of 40% or more.

MR	
NC	Credit 5
CS	Credit 5

10. REGIONAL VARIATIONS

Local availability of materials will vary by region. Regional building materials are often consistent with regional design aesthetics and may be more stable in the local climate than materials from other regions. Consider the local architecture and adopt a design that incorporates locally produced materials wherever possible. Those project sites near sources for material origin and manufacture will have an advantage in the achievement of this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

The duplication, replacement, and repair of regional materials will be easier if information about the installed products has been maintained. Encourage the creation of a sustainable purchasing plan and provide building operators with lists of the installed products and their manufacturers, such as the documentation used in the LEED application.

12. RESOURCES

Government Resources

Check with the local chamber of commerce or regional and provincial economic development agencies for building material manufacturers in the region.

13. DEFINITIONS

Extraction is the removal of natural materials from the Earth for the purposes of human use. Examples include mining and forestry practices.

Harvested is a material that is all or part of a plant or that has been collected and removed from the location of its growth.

Manufacturing refers to the final assembly of components into the building product that is furnished and installed by the trade workers.

Manufacturing Process covers the activities associated with the production of materials, goods or products.

Manufacturing Site is the location of the final manufacturing process; a finished product ships from this location.

Processing is a series of operations involved in manufacture or treatment of a product or material. (See also manufacturing process.)

Regionally extracted materials are raw materials taken from within an 800 km (500 miles) (2,400 km if shipped by rail or water) radius of the manufacturing location.

Regionally manufactured materials are assembled as finished products within an 800 km (500-mile) (2,400 km if shipped by rail or water) radius of the project site. Assembly does not include on-site assembly, erection, or installation of finished components.

Subcomponent is a part of a product or material assembly that is composed of a single self-contained material or mixture.

MR	
NC	Credit 6
CS	NA

RAPIDLY RENEWABLE MATERIALS

	NC	CS
Credit	MR Credit 6	NA
Points	1 point	NA

INTENT

To reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials.

REQUIREMENTS: NC

Use rapidly renewable building materials and products for 2.5% of the total value of all building materials and products used in the project, based on cost. Rapidly renewable building materials and products are made from plants that are typically harvested within a 10-year cycle or shorter. Furniture may be included if it is included consistently in MR Credits 3: Materials Reuse through MR Credit 7: Certified Wood.

INTERPRETATIONS

LEASED TENANT SPACES (NC)

If utilizing mandatory lease agreements to achieve NC certification, the direction to tenants must include the same (or higher) performance goal as is targeted in the overall application of this credit. The future leased tenant fit-up is not included in the calculations of this credit in either the numerator or the denominator. Further direction to future tenants on how to source rapidly renewable materials is commendable but is not required as part of the mandatory lease agreement.

MR	
NC	Credit 6
CS	NA

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Many conventional building materials require large inputs of land, natural resources, capital, and time to produce. Conversely, rapidly renewable materials generally require fewer of these inputs and are likely to have fewer environmental impacts. Rapidly renewable resources are replenished faster than traditional materials—they are planted and harvested in a cycle of 10 years or less.

Sourcing rapidly renewable materials reduces the use of raw materials whose extraction and processing have greater environmental impacts. A common example is the use of agricultural fibre such as wheat in composite panels as a substitute for wood products, reducing the overall consumption of wood. Irresponsible forestry practices cause ecosystem and habitat destruction, soil erosion, and stream sedimentation; replacing wood products with rapidly renewable resources reduces a product's overall environmental impact. Because of their intensive production and shorter growing cycles, rapidly renewable crops also require significantly less land to produce the same amount of end product; some are by-products that are otherwise considered waste. Bio-based plastics (e.g., from corn starch) and other rapidly renewable resources are beginning to provide alternatives to some petroleum-based plastics.

Many products made from rapidly renewable materials have interesting visual or tactile qualities. Using these materials in a visually prominent way provides opportunities for learning about manufacturing processes, economics, environmental impacts, and embodied energy.

ECONOMIC ISSUES

Land saved by the use of rapidly renewable materials will be available for a variety of other uses, including open space and food crops. Because rapidly renewable resources can be harvested more quickly, they tend to give faster payback on investment for producers. Although rapidly renewable materials can carry a price premium over their conventional counterparts, as demand increases, they are expected to become cost-competitive with conventional materials.

2. RELATED CREDITS

Rapidly renewable materials like cork or bamboo plywood may come from distant sources and may impact achievement of the following credit:

- MR Credit 5: Regional Materials

To reduce the detrimental effects some materials have on IAQ, project teams should follow the guidelines of IEQ Credit 4: Low Emitting Materials and specify materials and furnishings that do not release harmful or irritating chemicals, such as volatile organic compounds (VOCs), from paints and solvents.

The project materials costs used in this credit need to be consistent with those used in the following credits:

- MR Credit 3: Materials Reuse
- MR Credit 4: Recycled Content
- MR Credit 5: Regional Materials

MR	
NC	Credit 6
CS	NA

3. SUMMARY OF REFERENCED STANDARDS

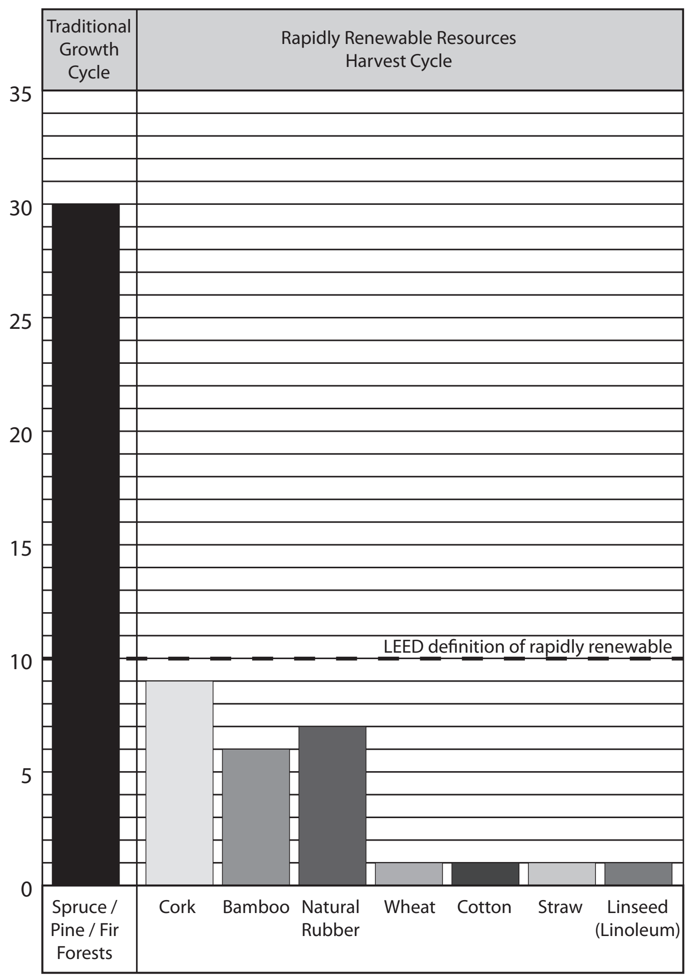
There are no standards referenced for this credit.

4. IMPLEMENTATION

Establish a goal for the use of rapidly renewable materials early in the design phase, identify possible building materials that may be substituted with rapidly renewable products, and find vendors that can achieve this goal. Examples of common rapidly renewable building materials are in the paragraph below, and Figure 1 illustrates the typical harvest rate of sample materials. Identify products and vendors in the project specifications and plans and work with the general contractor to source acceptable alternatives. During construction, make sure that the specified rapidly renewable materials are installed.

Examples of rapidly renewable materials include bamboo flooring and plywood, cotton batt insulation, linoleum flooring, sunflower seed board panels, wheatboard cabinetry, wool carpeting, cork flooring, bio-based paints, geotextile fabrics such as coir and jute, soy-based insulation and form-release agent, and straw bales.

FIGURE 1. HARVEST RATE OF SAMPLE MATERIALS



MR	
NC	Credit 6
CS	NA

5. TIMELINE AND TEAM

Run preliminary calculations during the early design phase, as soon as a project budget is available, to determine the feasibility of achieving this credit and identify the quantity of material (by cost) that must be purchased to meet the 2.5% threshold (refer to the Examples and Calculations sections). Research the availability and cost of rapidly renewable materials. The architect should specify these materials. During construction, the general contractor should ensure that the specified rapidly renewable materials are properly installed and collect product documentation from manufacturers to give to the project team.

6. CALCULATIONS

Determine the total materials cost for the project by multiplying the total construction cost (hard costs of the LEED Materials Divisions) by 0.45. Alternatively, the total materials cost may be a tally of actual materials cost in the LEED Materials Divisions from the project schedule of values or a similar document. The benefit to using actual materials costs, as opposed to the default 45%, is that projects with less than 45% materials cost will find it easier to achieve the credit thresholds, since total materials cost is in the denominator of the equation below. The purpose of the default value is to streamline the documentation process, since it is often challenging to break out the materials costs from labour and equipment costs for all materials on the project.

Materials costs include all expenses to deliver the material to the project site. Materials costs should account for all taxes and transportation costs incurred by the contractor but exclude any cost for labour and equipment once the material has been delivered to the site.

Identify those products that are considered rapidly renewable and their materials costs.

Calculate the percentage of rapidly renewable materials using Equation 1.

Equation 1

$$\begin{array}{c}\text{Percent of Rapidly}\\ \text{Renewable Materials}\end{array} = \frac{\text{Total Cost of Rapidly Renewable Material (\$)}}{\text{Total Materials Cost (\$)}} \times 100$$

The project achieves MR Credit 6 when rapidly renewable building materials and products account for 2.5% of the total materials cost of all building materials and products used in the project. Furniture and furnishings (CSI Division 12 components) are excluded from the calculations for this credit unless they are included consistently across MR Credits 3–7. This credit applies primarily to the LEED Materials Divisions. Mechanical, electrical and plumbing components, along with appliances and equipment, cannot be included in calculations for this credit. These are excluded because, when compared with structural and finish materials, mechanical and electrical equipment tend to have a high dollar value relative to the amount of material they contain.

ASSEMBLY RAPIDLY RENEWABLE CONTENT

Assemblies are products made of multiple materials, either in their formulation (e.g., particle board), or in their manufacture (e.g., workstation components). For assembly rapidly renewable content, the fraction of the assembly that is considered rapidly renewable is determined by weight. That fraction is then applied to the materials cost to determine the rapidly renewable materials cost for that assembly.

MR	
NC	Credit 6
CS	NA

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Compile a list of rapidly renewable product purchases.
- Record manufacturers' names, materials costs, the percentage of each product that is rapidly renewable criteria (by weight), and each compliant value.
- Retain cutsheets to document rapidly renewable criteria.
- Where appropriate, maintain a list of actual materials costs, excluding labour and equipment for the LEED Materials Divisions only; including Division 12 is optional.

8. EXAMPLES

The total construction cost for a school building is $600,000. Using the default materials calculations, the total cost of materials (excluding labour and equipment) is $600,000 x 0.45 = $270,000. Table 2 lists rapidly renewable materials purchased for the project. In this example, the total percentage of rapidly renewable content to total cost of all materials is 4.82%. The project earns 1 point.

TABLE 2. SAMPLE CALCULATIONS FOR RAPIDLY RENEWABLE MATERIAL

TOTAL CONSTRUCTION COST FOR DEFAULT TOTAL MATERIALS COST; OR					**$ 600,000**
PROVIDE TOTAL MATERIALS COST (EXCLUDE LABOUR, EQUIPMENT)					**$ 270,000**
PRODUCT NAME	**VENDOR NAME**	**ASSEMBLY PRODUCT COST ($)**	**% RAPIDLY RENEWABLE CONTENT (IF PART OF AN ASSEMBLY)**	**VALUE OF RAPIDLY RENEWABLE CONTENT**	**RECYCLED CONTENT INFORMATION SOURCE**
Countertop wheatboard	Rho Company	$6,700	30.00%	$2,010.00	Vendor
Linoleum flooring	Tau Floors	$882	50.00%	$441.00	Manufacturer letter
Bamboo window blinds	Upsilion Shades	$14,079	75.00%	$10,559.25	Website
Totals		$21,661		$13,010.25	
Value of rapidly renewable content					$13,010
Percentage cost of rapidly renewable content total cost of all materials					4.82%
Points documented					1

9. EXEMPLARY PERFORMANCE

Project teams may earn an Innovation in Design credit for exemplary performance by achieving a rapidly renewable materials content of 5% or more.

MR	
NC	Credit 6
CS	NA

10. REGIONAL VARIATIONS

Assess the availability of rapidly renewable materials that also contribute to MR Credit 5, Regional Materials.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Some rapidly renewable materials may require different maintenance practices. For example, bamboo and cork generally should not be exposed to excessive moisture from damp mopping and other common janitorial or maintenance activities. When sourcing rapidly renewable products, request maintenance recommendations from the manufacturer and give this information to the operations team.

The duplication, replacement, and repair of rapidly renewable materials will be easier if information about the installed products has been maintained. Encourage the creation of a sustainable purchasing plan and provide building operators with lists of the installed products and their manufacturers, such as the documentation used in the LEED application.

12. RESOURCES

BuildingGreen, Inc., Environmental Building News
http://www.buildinggreen.com/products/bamboo.html

Read an article in Environmental Building News on bamboo flooring that includes a listing of bamboo flooring suppliers.

BuildingGreen, Inc., GreenSpec
http://www.buildinggreen.com/menus/index.cfm

GreenSpec contains detailed listings for more than 2,000 green building products that include environmental data, manufacturer information, and links to additional resources.

Environmental Choice Certified Products
www.ecologo.org/en/

The EcoLogo^{M} program certifies environmentally preferable, green goods and services with the Environmental Choice label. The program compares products and services with others in the same category, develops rigorous and scientifically relevant criteria, and awards the EcoLogo to those that are environmentally preferable throughout their lifecycles. The EcoBuyer Green Products and Service Database lists certified product categories, including all numbered product categories listed in this credit, as well as links to a list of all 7,500 EcoLogo-certified products.

Environmental Design + Construction, Highlights of Environmental Flooring
http://www.edcmag.com

Read an Environmental Design + Construction article with information on bamboo flooring, linoleum, and wool carpeting.

Oikos
http://www.oikos.com

Oikos is a searchable directory of efficient building products and sustainable design resources.

MR	
NC	Credit 6
CS	NA

13. DEFINITIONS

Embodied energy is the energy used during the entire life cycle of a product, including its manufacture, transportation, and disposal, as well as the inherent energy captured within the product itself.

Life cycle assessment is an analysis of the environmental aspects and potential impacts associated with a product, process, or service.

Rapidly renewable materials are agricultural products, both fibre and animal, that take 10 years or less to grow or raise and can be harvested in a sustainable fashion.

Raw Materials are materials in its unprocessed, natural state considered usable for manufacture.

MR	
NC	Credit 6
CS	NA

14. CASE STUDY

VENTO RESIDENCES

LEED Canada-NC 1.0 Platinum, 31 October 2007

Location: Calgary, Alberta
Building Type: Mixed use
Owner Type: Commercial
Building Size: 2,700m^2
Owner Name: Windmill Development Group Ltd.
LEED Consultant: BuildGreen Consulting
Responsible Firm (for this credit):

Truly an Integrated Design Process to achieve this credit:

- Client / Owner / Developer: Windmill Development Group Ltd.
- Architect: Busby, Perkins and Will
- Interior Design: Penner and Associates
- Green Building Consultant: Sustainability Solutions Group
- Construction: Stuart Olson
- Product Supplier: Healthiest Home and Building Supplies

Photo Credit: Scott Pickles

The Vento is a mixed-use project located in the Bridgeland redevelopment, just northeast of downtown Calgary. The project includes 20 townhouse style residences, two affordable housing units owned and managed by the City, and retail spaces for small businesses.

The project team worked hard to generate ideas and strategies for achieving the owners' objective of a LEED Platinum project, as well as the creation of a beautiful, livable building in this revitalized

MR	
NC	Credit 6
CS	NA

Calgary neighbourhood. Seeking out healthy, renewable materials alongside materials that were locally produced and had recycled content proved to be a key challenge for the project.

During this process, several finishing materials were identified to help the project achieve the rapidly renewable materials targeted credit, while still allowing the other material and resource and indoor air quality credits to be met. Wool carpet, bamboo flooring, and Woodstalk composite used for the cabinetry were all chosen in order to achieve the team's rapidly renewable materials objective.

In the end, 5% of the total materials by cost were rapidly-renewably materials. In terms of other material and resource achievements, 15% of the total materials by cost were from recycled content and 28% of the materials by cost were locally extracted and manufactured.

CERTIFIED WOOD

	NC	CS
Credit	MR Credit 7	MR Credit 6
Points	1 point	1 point

INTENT

To encourage environmentally responsible forest management.

REQUIREMENTS: NC & CS

Use a minimum of 50% (based on cost) of wood-based materials and products that are certified in accordance with the Forest Stewardship Council's (FSC) Principles and Criteria, for wood building components. These components include at a minimum structural framing and general dimensional framing, flooring, sub-flooring, wood doors and finishes.

Include materials permanently installed in the project. Wood products purchased for temporary use on the project (e.g., formwork, bracing, scaffolding, sidewalk protection, and guard rails) may be included in the calculation at the project team's discretion. If any such materials are included, all such materials must be included in the calculation. If such materials are purchased for use on multiple projects, the applicant may include these materials for only one project, at its discretion. Furniture may be included if it is included consistently in MR Credits 3: Materials Reuse through MR Credit 7: Certified Wood (MR Credit 6 in Core and Shell).

INTERPRETATIONS

Pre-consumer recycled content cannot be excluded from the MR Credit 7 Certified Wood credit calculations. Exclusion of post-consumer wood is permitted to ensure that applicants are not penalised for the use of salvaged wood. Pre-consumer wood is seen as a co-product as it can play a key economic determinant role in the decision to mill lumber.

Non-wood forest products, such as bamboo, cork, agrifibre and rubber, are normally excluded from MR Credit 7. However, if these products are FSC-certified they may be included in the calculation (numerator and denominator) of MR Credit 7 at discretion of the applicant.

MR	
NC	Credit 7
CS	Credit 6

LEASED TENANT SPACES (NC)

If utilizing mandatory lease agreements to achieve NC certification, the direction to tenants must include the same (or higher) performance goal as is targeted in the overall application of this credit. The future leased tenant fit-up is not included in the calculations of this credit in either the numerator or the denominator. Further direction to future tenants on how to source certified wood is commendable but is not required as part of the mandatory lease agreement.

MR	
NC	Credit 7
CS	Credit 6

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

The negative environmental impacts of irresponsible forest practices can include forest destruction, wildlife habitat loss, soil erosion and stream sedimentation, water and air pollution, and waste generation. The Forest Stewardship Council (FSC) standard incorporates many criteria that contribute to the long-term health and integrity of forest ecosystems. From an environmental perspective, the elements of responsible FSC-certified forestry include sustainable timber harvesting (i.e., not removing more timber volume than replaces itself over the cutting interval, or rotation), preserving wildlife habitat and biodiversity, maintaining soil and water quality, minimizing the use of harmful chemicals, and conserving forests of high conservation value (e.g., endangered and old-growth forests).

ECONOMIC ISSUES

As more developing countries enter world forest product markets and their growing economies drive domestic consumption, the protection of forests will become a critical issue. As of 2007, FSC-certified forests represent the equivalent of 7% of the world's productive forests.[12] Currently, the costs of FSC-certified wood products are equal to or higher than conventional wood products, and availability varies by region. The price of FSC-certified wood products is expected to become more competitive with conventional wood products as the world's forest resources are depleted and the forest industry adopts more sustainable business principles.

Because irresponsible logging practices can have harmful social as well as environmental impacts, the socioeconomic and political components of FSC certification include respecting indigenous people's rights and adhering to all applicable laws and treaties. Certification also involves forest workers and forest-dependent communities as stakeholders and beneficiaries of responsible forest management. Responsible forest practices help stabilize economies and preserve forestland for future generations.

2. RELATED CREDITS

Project teams pursuing this credit may find opportunities to achieve other MR credits. An FSC strategy should be developed early to determine whether certified wood can be sourced and manufactured within 800 kilometres (500 miles) (2,400 km if shipped by rail or water) of the site. Additionally, when specifying mixed FSC materials and pursuing IEQ Credit 4.4, determine whether the finished product will be free of urea-formaldehyde. Refer to the following credits:

- MR Credit 5: Regional Materials
- IEQ Credit 4.4: Low-Emitting Materials—Composite Wood and Agrifibre Products

3. SUMMARY OF REFERENCED STANDARDS

Forest Stewardship Council Principles and Criteria
http://www.fsccanada.org

Certification by the Forest Stewardship Council (FSC) is a seal of approval awarded to forest managers who adopt environmentally and socially responsible forest management practices and to companies that manufacture and sell products made from certified wood. This seal enables consumers, including architects and specifiers, to identify and procure wood products from well-managed sources and thereby use their purchasing power to influence and reward improved forest

MR	
NC	Credit 7
CS	Credit 6

management activities around the world.

LEED accepts certification according to the comprehensive system established by the internationally recognized Forest Stewardship Council. FSC was created in 1993 to establish international forest management standards, known as the FSC principles and criteria, to ensure that forestry practices are environmentally responsible, socially beneficial, and economically viable. These principles and criteria are also intended to ensure the long-term health and productivity of forests for timber production, wildlife habitat, clean air and water supplies, climate stabilization, spiritual renewal, and social benefit. These global principles and criteria are translated into meaningful standards at a local level through region-specific standard-setting processes.

FSC also accredits and monitors certification organizations. The certifiers are independent, third-party auditors that are qualified to annually evaluate compliance with FSC standards on the ground and to award certifications. There are 2 types of certification:

- Forest management certification is awarded to responsible forest managers after their operations successfully complete audits of forestry practices and plans.
- Chain-of-custody (COC) certification is awarded to companies that process, manufacture, and/or sell products made of certified wood and who successfully complete audits to ensure proper use of the FSC name and logo; segregation of certified and noncertified materials in manufacturing and distribution systems; and observation of other relevant FSC rules (e.g., meeting minimum requirements for FSC fibre content in assembled and composite wood products).

The majority of FSC certification audits performed in North America are conducted by SmartWood and Scientific Certification Systems (SCS), which are based in the United States. A limited number are performed by SGS, which is based in Europe. The FSC Canada website lists regional offices for these and other certifiers.

4. IMPLEMENTATION

Establish a project goal for FSC-certified wood products and identify suppliers that can achieve this goal. Research the availability of the wood species and products that they want to use, and make sure that they are available from FSC-certified sources. Another method for lowering the impact of wood resources is to research and specify quality grades that are most readily available from well-managed forests. Using lower grades of wood can dramatically reduce pressure on forests, which produce only limited quantities of top-grade timber (i.e., Architectural Woodwork Institute (AWI) Grades 2 or 3 for lumber or veneer rather than Grade 1).

Contact local vendors, suppliers, and manufacturers that provide FSC-certified products as early as possible. Design teams should provide project bidders with a list of certified vendors and encourage them to make contact early in the project to establish product availability and pricing. Consult the Resources section for information about product databases and boilerplate forms. Since the availability of certain certified wood products may vary over the life of a project, teams should consider having the owner pre-purchase, store, and supply particular items to the contractor ("furnished by the owner, installed by the contractor," or FOIC). Finding a storage location that matches the final ambient moisture of the space will ensure proper installation. Because ambient moisture is usually higher during construction, a job site is not the best location to store wood.

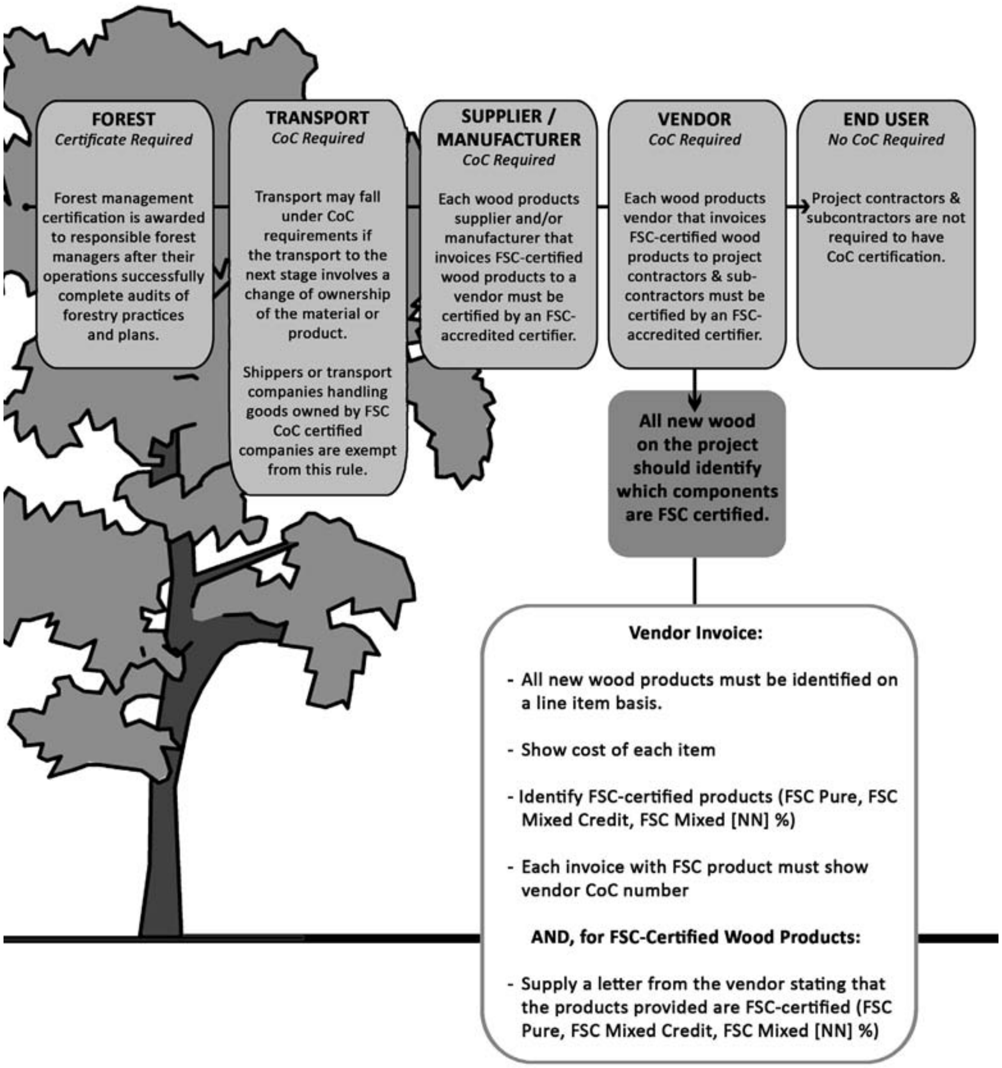
The design team should specify in contract documents that wood products must come from forests that are certified as well-managed according to the rules of the FSC, and the team should

MR	
NC	Credit 7
CS	Credit 6

require chain-of-custody documentation. Wherever possible, use a line-item strategy based on the current availability of specific products rather than a blanket approach.

Figure 1 is based on information from FSC's website (http://www.fsc.org/) and outlines the FSC process, explains when chain-of-custody documentation is required, and describes what types of information a project should collect.

FIGURE 1. FSC CERTIFICATION PROCESS AND CATEGORIES



MR	
NC	Credit 7
CS	Credit 6

CHAIN-OF-CUSTODY REQUIREMENTS

Collect all vendor invoices for permanently installed wood products, FSC certified or not, purchased by the project contractor and subcontractors. Vendors are defined as those companies that sell products to the project contractor or subcontractors.

Each vendor invoice must conform to the following requirements (except as noted below):

a. Each wood product must be identified on a line-item basis.

b. FSC products must be identified as such on a line-item basis.

c. The dollar value of each line item must be shown.

d. The vendor's COC certificate number must be shown on any invoice that includes FSC products.

Each wood product's vendor that invoices FSC certified products must be COC certified by an FSC-accredited certifier.

Exceptions: In some rare instances, it may not be practical for a vendor to invoice wood products on a line-item basis because the invoice would be dozens of pages long. In such cases, the invoice should indicate the aggregate value of wood products sold by the vendor. If the wood products are FSC certified, comply with the following requirements:

a. The vendor's COC number must be shown on the invoice.

b. The invoice must be supplemented by a letter from the vendor stating that the products invoiced are FSC certified.

c. The invoice or the letter must state whether the products are FSC Pure, FSC Mixed Credit, or FSC Mixed (NN)%.

5. TIMELINE AND TEAM

The incorporation of FSC-certified building materials will affect the financial planning stage, design development, and installation schedules of the project. Coordination among the owner, architect or design team, and contractor should begin early in the design development phase so that the availability, costs, and lead times of FSC-certified products can be anticipated and their purchase coordinated with the construction schedule.

During the design phase, the architect should incorporate certified wood products into the project plans and specifications. During construction, the contractor should review the project cost to verify that 50% of wood costs are FSC-certified. As materials are purchased during construction, the general contractor must obtain and retain COC certificates. At the end of construction, the general contractor should provide the documentation needed for the LEED certification application.

6. CALCULATIONS

List all new wood products (not reclaimed, salvaged, or with post-consumer recycled content) on the project and identify which components are FSC certified. The cost of all new wood products, both FSC certified and not, must be tallied. Develop a spreadsheet to calculate the amount of new wood and the amount of FSC-certified wood permanently installed on the project. Wood products that are not FSC certified and those that are identified on invoices as FSC Pure and FSC Mixed Credit should be valued at 100% of the product cost. Wood products identified as FSC Mixed (NN)%

MR	
NC	Credit 7
CS	Credit 6

should be valued at the indicated percentage of their cost, For example, a product identified as FSC Mixed 75% should be valued at 75% of the cost.

Wood products identified as FSC Recycled or FSC Recycled Credit do not count toward MR Credit 7, Certified Wood. They qualify instead as recycled-content products that may contribute to MR Credit 4, Recycled Content.

Using Equation 1, determine the percentage of FSC-certified wood.

Equation 1

$$\text{Certified Wood Material Percentages} = \frac{\text{FSC-certified Wood Material Value (\$)}}{\text{Total New Wood Material Value}} \times 100$$

FSC wood products purchased for temporary use on the project may be included in the credit calculation at the project team's discretion. If any such materials are included, all such materials must be included in the calculation. Examples of products used for temporary assemblies include formwork, bracing, scaffolding, sidewalk protection, and guard rails. If such materials are purchased for multiple projects, the project team may include these materials on 1—and only 1—project at its discretion.

ASSEMBLIES

In the case of manufactured products, such as windows and furniture systems that combine wood and non-wood materials, only the new wood portion can be applied toward the credit. To determine the value of the wood component(s), calculate the amount of new wood as a percentage of the total weight, volume, or cost, and the amount of FSC-certified wood as a percentage of the total weight, volume, or cost. Multiply these figures by the total value of the product as invoiced to project contractors, subcontractors, or buying agents.

Develop a separate spreadsheet for each assembly to calculate the amount of new wood and amount of FSC-certified wood for assemblies and enter the summary data as 1 line item on the comprehensive spreadsheet used to calculate the percentage of certified wood used in the project.

To incorporate assembly FSC-certified and new wood content into Equation 1, use Equations 2 and 3 and add the result to the appropriate category.

Equation 2

$$\text{Assembly FSC Certified Wood Material Value} = \frac{\text{Weight of FSC-certified Wood in Assembly}}{\text{Weight of Assembly}} \times \text{Assembly Value (\$)}$$

Equation 3

$$\text{Assembly New Wood Material Value} = \frac{\text{Weight of New Wood in Assembly}}{\text{Weight of Assembly}} \times \text{Assembly Value (\$)}$$

MR	
NC	Credit 7
CS	Credit 6

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Track certified wood purchases and retain associated COC documentation.
- Collect copies of vendor invoices for each certified wood product.
- Maintain a list that identifies the percentage of certified wood in each purchase.

8. EXAMPLES

See Table 1 for a sample calculation.

TABLE 1. SAMPLE ASSEMBLY PERCENTAGE WOOD-BASED CONTENT FOR BIFMA TYPICAL CONFIGURATION.

MANUFACTURER		LAMBDA FURNITURE		
PRODUCT LINE		HIGH END WORKSTATIONS		
BIFMA TYPICAL CONFIGURATION		WORKSTATION CONFIGURATION 0010		
COMPONENT	WEIGHT (kg)	LESS POST-CONSUMER WEIGHT (kg)	WOOD-BASED COMPONENT WEIGHT (kg)	FSC CERTIFIED WOOD WEIGHT (kg)
Wheat Board	13.0		13.0	13.0
Top Veneer	1.8		1.8	0.0
Other Wood	1.4	-0.5	0.9	0.6
Non-wood content	326.0		0.0	0.0
Total	342.2		15.7	13.6
Percent Wood (15.7/342.2)				4.6%
Percent FSC certified Wood (13.6/342.2)				4.0%

9. EXEMPLARY PERFORMANCE

Project teams may earn an Innovation in Design credit for exemplary performance by achieving an FSC-certified wood content of 95% or more of the project's total new wood.

10. REGIONAL VARIATIONS

This credit may have particular importance in areas with poor forestry practices or high forest conversion rates. Encouraging the development of local FSC markets and assigning economic value to responsible forestry practices will promote the retention of local, indigenous animal and plant species, the preservation of open space, the improvement of local air quality, and the reduction of heat-island effects for areas of developed infrastructure.

MR	
NC	Credit 7
CS	Credit 6

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

The duplication, replacement, and repair of certified wood products will be easier if information about the installed products has been maintained. Encourage the creation of a sustainable purchasing plan and provide building operators with lists of the installed products, their manufacturers, and COC certificates, such as the documentation used in the LEED application.

12. RESOURCES

WEBSITES

Forest Stewardship Council, United States
http://www.fscus.org/green_building

For information and practical tools such as databases of certified product suppliers, referral services, specification language, and the "Designing and Building with FSC" guide and forms.

PRINT MEDIA

Sustainable Forestry: Philosophy, Science, and Economics, by Chris Maser (St. Lucie Press, 1994).

The Business of Sustainable Forestry: Strategies for an Industry in Transition, by Michael B. Jenkins and Emily T. Smith (Island Press, 1999).

Governing Through Markets: Forest Certification and the Emergence of Non-State Authority, by Deanna Newsom, Benjamin Cashore, and Graeme Auld (Yale University Press, 2004).

Tapping the Green Market: Certification & Management of Non-Timber Forest Products, edited by Patricia Shanley, Alan R. Pierce, Sarah A. Laird and Abraham Guillén (Earthscan Publications, 2002).

13. DEFINITIONS

Chain-of-custody (COC) is a tracking procedure for a product from the point of harvest or extraction to its end use, including all successive stages of processing, transformation, manufacturing, and distribution.

Chain-of-custody certification is awarded to companies that produce, sell, promote, or trade forest products after audits verify proper accounting of material flows and proper use of the Forest Stewardship Council name and logo. The COC certificate number is listed on invoices for non-labelled products to document that an entity has followed FSC guidelines for product accounting.

Sustainable forestry is the practice of managing forest resources to meet the long-term forest product needs of humans while maintaining the biodiversity of forested landscapes. The primary goal is to restore, enhance, and sustain a full range of forest values, including economic, social, and ecological considerations.

A **vendor** of certified wood is the company that supplies wood products to contractors or subcontractors for on-site installation. A vendor needs a chain-of-custody number if it is selling FSC-certified products that are not individually labelled; this includes most lumber.

MR	
NC	Credit 7
CS	Credit 6

14. CASE STUDY

KINGSTON POLICE HEADQUARTERS

LEED Canada-NC 1.0 Gold, 25 January 2008

Location: Kingston, Ontario
Building Type: Public Safety
Owner Type: Government - Local
Building Size: 11,290m^2
Owner Name: Kingston Police
LEED Consultant: Enermodal Engineering Ltd.
Responsible Firm (for this credit): Enermodal Engineering Ltd.
Photo Credit: Enermodal Engineering Ltd. and Kingston Police

The new Kingston Police Headquarters represents a unique step forward in the design of police facilities, as it incorporates conventional security considerations with “green” building design. The headquarters successfully expresses a commitment to environmental stewardship shared by the Kingston Police, the Kingston Police Services Board, and the City of Kingston.

One of the most challenging aspects of the project was the incorporation of Forest Stewardship Council (FSC) certified wood products due to the number of custom wood finishes in the design. Because the building owner was committed to the use of sustainably harvested and processed wood, the design team engaged FSC Canada to assist in sourcing wood products. FSC certified products were used for millwork (including mail centres as shown in photograph), dimensional lumber blocking (placed in walls to hang millwork and baseboards), kitchenette stations, baseboards, storage, business centres, and shelving.

The selection of FSC wood products was made more complex because Kingston is not a major industrial centre so sourcing materials was a challenge. The design team was pleased that over 60% of the wood used in the building was FSC Certified.

Lessons learned:

- As EQc4.4 was also targeted (and achieved), communication between the LEED consultant, designers, and construction team was paramount to ensure both the FSC and UF requirements were satisfied for wood products (especially composite wood products).
- The services of FSC Canada were used to source FSC certified wood products. This is a free service provided by FSC Canada that helps clients find FSC products for a variety of uses ranging from lumber to furniture.

MATERIALS AND RESOURCES ENDNOTES

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[2]U.S. Environmental Protection Agency, Office of Solid Waste. Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2005. 2006. Retrieved February 2009, http://www.epa.gov/osw/rcc/resources/msw-2005.pdf.

[3]Statistics Canada. "Waste Management Industry Survey: Business and Government Sectors, 2006". 2008. Retrieved February 2009, http://www.statcan.gc.ca/pub/16f0023x/16f0023x2006001-eng.pdf.

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INDOOR ENVIRONMENTAL QUALITY (IEQ)

OVERVIEW

Canadians spend close to 90% of their time indoors, so the quality of the indoor environment has a significant influence on their well-being, productivity, and quality of life.[1] The U.S. Environmental Protection Agency (EPA) reports that pollutant levels of indoor environments may run 2 to 5 times—and occasionally more than 100 times—higher than outdoor levels.[2] Similarly, the World Health Organization (WHO) reported in its Air Quality Guidelines for Europe, 2nd edition, that most of an individual's exposure to air pollutants comes through inhalation of indoor air. Following the release in 1987[3] and 1990[4] of EPA reports that designated indoor air pollution as a top environmental risk to public health, assessing and managing indoor pollutants have become the focus of integrated governmental and private efforts. Recent increases in building-related illnesses and "sick building syndrome," as well as an increasing number of related legal cases, have further heightened awareness of indoor air quality (IAQ) among building owners and occupants.[5] Strategies to improve indoor environmental quality have the potential to reduce liability for building owners, increase the resale value of the building, and improve the health of building occupants.

For schools and schoolchildren, indoor environmental quality issues are even more urgent. Many pollutants cause adverse health reactions in the estimated 7 million children and adolescents who suffer from asthma,[6] contributing to 14.7 million days of absence in schools each year.[7] In fact, asthma is the leading chronic illness and chief cause of absenteeism among school-aged children.[8] In Canada, just under 5.12 million children[9] and approximately 340,000 teachers[10] (publicly funded schools) spend a considerable amount of time in school buildings. The indoor environmental quality in these buildings can have a significant effect on the health and well-being of students and staff, as well as on the quality and effectiveness of the learning environment.

In addition to health and liability concerns, productivity gains also drive indoor environmental quality improvements. With employees' salaries a significant cost in any commercial building, it makes good business sense to keep staff healthy and productive by improving and maintaining the quality of the indoor environment. The potential annual savings and productivity gains from improved indoor environmental quality in the United States are estimated at \$6 billion to \$14 billion from reduced respiratory disease, \$1 billion to \$4 billion from reduced allergies and asthma, \$10 billion to \$30 billion from reduced sick building syndrome symptoms, and \$20 billion to \$160 billion from direct improvements in worker performance that are unrelated to health.[11]

Over the past 20 years, research and experience have improved our understanding of what is involved in attaining high indoor environmental quality and revealed manufacturing and construction practices that can prevent many indoor environmental quality problems. The use of better products and practices has reduced potential liability for design team members and building owners, increased market value for buildings with exemplary indoor environmental quality, and boosted the productivity of building occupants. In a case study included in the 1994 publication, "Greening the Building and the Bottom Line," the Rocky Mountain Institute highlights how improved indoor environmental quality increased worker productivity by 16%, netting a rapid payback on the capital investment.[12]

This credit category addresses environmental concerns relating to indoor environmental quality; occupants' health, safety, and comfort; energy consumption; air change effectiveness; and air contaminant management. The following are important strategies for addressing these concerns and improving indoor environmental quality:

IMPROVING VENTILATION

Actions that affect employee attendance and productivity will affect an organization's bottom line. One study estimates a 283% return on investment associated with increased ventilation in less than 6 months.[13]

Specify building systems that will provide a high level of indoor air quality. Increased ventilation in buildings may require additional energy use, but the need for additional energy can be mitigated by using heat-recovery ventilation and/or economizing strategies. Indoor air quality design can help take advantage of regional climate characteristics and reduce energy costs. In regions with significant heating and/or cooling loads, for example, using exhaust air to heat or cool the incoming air can significantly reduce energy use and operating costs.

MANAGING AIR CONTAMINANTS

Protecting indoor environments from contaminants is essential for maintaining a healthy space for building occupants. Several indoor air contaminants should be reduced to optimize tenants' comfort and health. There are 3 basic contaminants:

Environmental tobacco smoke (ETS), or secondhand smoke, is both the smoke given off by ignited tobacco products and the smoke exhaled by smokers. Environmental tobacco smoke contains thousands of chemicals, more than 50 of which are carcinogenic.[14] Exposure to environmental tobacco smoke is linked to an increased risk of lung cancer and heart disease in nonsmoking adults[15] and associated with increased risk of sudden infant death syndrome and asthma, bronchitis, and pneumonia in children.[16] Smoking should be eliminated in all indoor building spaces and limited to designated outdoor areas.

Carbon dioxide (CO_2) concentrations can be measured to determine and maintain adequate outdoor air ventilation rates in buildings. CO_2 concentrations are an indicator of air change effectiveness. Elevated levels suggest inadequate ventilation and possible buildup of indoor air pollutants. CO_2 levels should be measured to validate indications that ventilation rates need to be adjusted. Although relatively high concentrations of CO_2 alone are not known to cause serious health problems, they can lead to drowsiness and lethargy in building occupants.[17]

Particulate matter in the air degrades the indoor environment. Airborne particles in indoor environments include lint, dirt, carpet fibres, dust, dust mites, mould, bacteria, pollen, and animal dander. These particles can exacerbate respiratory problems such as allergies, asthma, emphysema, and chronic lung disease.[18] Air filtration reduces the exposure of building occupants to these airborne contaminants, and high-efficiency filters greatly improve indoor air quality. Protecting air handling systems during construction and flushing the building before occupancy further reduce the potential for problems to arise once the building is occupied.

SPECIFYING LESS HARMFUL MATERIALS

Preventing indoor environmental quality problems is generally much more effective and less expensive than identifying and solving them after they occur. A practical way to prevent indoor environmental quality problems is to specify materials that release fewer and less harmful chemical compounds. Adhesives, paints, carpets, composite wood products, and furniture with low levels of potentially irritating off-gassing can reduce occupants' exposure and harm. Appropriate scheduling of deliveries and sequencing of construction activities can reduce material exposure to moisture and absorption of off-gassed contaminants.

ALLOWING OCCUPANTS TO CONTROL DESIRED SETTINGS

Working with building occupants to assess their needs will help improve building efficiencies. Providing individual lighting controls and area thermostats can improve occupants' comfort and productivity and save energy. Individual controls enable occupants to set light levels appropriate to tasks, time of day, personal preferences, and individual variations in visual acuity. Individual thermostats enable them to more accurately meet their heating and cooling needs during different seasons.

PROVIDING DAYLIGHT AND VIEWS

Daylighting reduces the need for electric lighting, which lowers energy use and thereby decreases the environmental effects of energy production and consumption. Natural daylight also increases occupants' productivity and reduces absenteeism and illness. Studies have shown that providing daylight and exterior views can measurably increase academic performance in schools. Courtyards, atria, clerestory windows, skylights, interior light shelves, exterior fins, louvers, and adjustable blinds, used alone or in combination, are effective strategies to achieve deep daylight penetration. The desired amount of daylight depends on the tasks in a given space. Daylit buildings often have several daylight zones with differing target light levels. In addition to light levels, daylighting strategies affect interior color schemes, direct beam penetration, and integration with the electric lighting system.

Building occupants with access to outside views have an increased sense of well-being, leading to higher productivity and increased job satisfaction. Important considerations for providing views include building orientation, window size and spacing, glass selection, and locations of interior walls.

CORE AND SHELL

In their design and construction, core and shell projects can affect indoor air quality in 2 ways. First, the design and construction teams can influence the quality of interior spaces, such as lobbies, central circulation areas, and building cores. Second, and more important, Core & Shell design and construction decisions can directly affect the indoor environmental quality of tenant spaces outside the control of the Core & Shell submittal. Examples include ventilation design and careful design consideration for tenants' ability to optimize daylight and views. Design and construction teams in Core & Shell projects should consider how their decisions could enable tenant fit-outs to deliver high indoor environmental quality to building occupants.

SCHOOLS

Schools can present their own challenges when defining regularly occupied spaces. The following list identifies school spaces considered to be regularly occupied for applicability to indoor environmental quality credits. In these spaces, daylight, views, thermal comfort, and/or acoustics affect the quality of occupants' regular use. LEED® will evaluate exceptions to these classifications on a case-by-case basis for spaces with atypical uses or those in which the strategies required for compliance may compromise the function of the space.

Classroom and core learning spaces classified as regularly occupied spaces consist of spaces that are used for at least 1 hour per day for educational activities where the primary functions are teaching and learning. Examples of these activities include art, laboratories, classrooms, gymnasium, library, etc.

Other regularly occupied spaces include all nonlearning spaces that are used by occupants for 1 or more hours per day to perform work-related activities. Examples of these include conference room, administrative office, cafeteria, offices, staff rooms, etc.

Spaces considered not regularly occupied are those that occupants pass through and those that are not regularly used for at least 1 hour per day (i.e. administration waiting room, corridor, locker room, stage, stairs, etc.

SUMMARY

Ensuring excellent indoor environmental quality requires the joint efforts of the building owner, design team, contractors, subcontractors, and suppliers. To provide optimal indoor environmental quality, automatic sensors and individual controls can be integrated with the building systems to adjust temperature, humidity, and ventilation. Sensors can measure building CO_2 levels and indicate the need for increased outdoor airflow to eliminate high levels of volatile organic compounds (VOCs) and other air contaminants. Other indoor environmental quality issues addressed by the *LEED Canada for New Construction* and *LEED Canada for Core & Shell* rating systems include daylighting and lighting quality, thermal comfort, acoustics, and access to views. These issues all have the potential to enhance the indoor environment and optimize interior spaces for building occupants.

CREDIT	TITLE	NC	CS
IEQ Prerequisite 1	Minimum Indoor Air Quality Performance	Required	Required
IEQ Prerequisite 2	Environmental Tobacco Smoke (ETS) Control	Required	Required
IEQ Credit 1	Outdoor Air Delivery Monitoring	1 point	1 point
IEQ Credit 2	Increased Ventilation	1 point	1 point
IEQ Credit 3.1	Construction Indoor Air Quality Management Plan During Construction	1 point	NA
IEQ Credit 3	Construction Indoor Air Quality Management Plan During Construction	NA	1 point
IEQ Credit 3.2	Construction Indoor Air Quality Management Plan Before Occupancy	1 point	NA
IEQ Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1 point	1 point
IEQ Credit 4.2	Low-Emitting Materials—Paints and Coatings	1 point	1 point
IEQ Credit 4.3	Low-Emitting Materials—Flooring Systems	1 point	1 point
IEQ Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1 point	1 point
IEQ Credit 5	Indoor Chemical and Pollutant Source Control	1 point	1 point
IEQ Credit 6.1	Controllability of Systems—Lighting	1 point	NA
IEQ Credit 6.2	Controllability of Systems—Thermal Comfort	1 point	NA
IEQ Credit 6	Controllability of systems—Thermal Comfort	NA	1 point
IEQ Credit 7.1	Thermal Comfort—Design	1 point	NA
IEQ Credit 7	Thermal Comfort—Design	NA	1 point
IEQ Credit 7.2	Thermal Comfort—Verification	1 point	NA
IEQ Credit 8.1	Daylight and Views—Daylight	1 point	1 point
IEQ Credit 8.2	Daylight and Views—Views	1 point	1 point

IEQ	
NC	Prerequisite 1
CS	Prerequisite 1

MINIMUM INDOOR AIR QUALITY PERFORMANCE

	NC	CS
Prerequisite	IEQ Prerequisite 1	IEQ Prerequisite 1
Points	Required	Required

INTENT

To establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants.

REQUIREMENTS: NC & CS

Meet the minimum requirements of Sections 4 through 7 of ASHRAE 62.1-2007, Ventilation for Acceptable Indoor Air Quality (with errata but without addenda[a]).

AND

CASE 1. MECHANICALLY VENTILATED SPACES

Mechanical ventilation systems must be designed using the ventilation rate procedure or the applicable local code, whichever is more stringent.

CASE 2. NATURALLY VENTILATED SPACES

Naturally ventilated buildings must comply with ASHRAE 62.1-2007, paragraph 5.1 (with errata but without addenda).

CS ADDITIONAL REQUIREMENT:

Mechanical ventilation systems installed during core and shell construction must be capable of meeting projected ventilation levels based on anticipated future tenant requirements.

INTERPRETATIONS

There are no interpretations for this prerequisite.

[a] Project teams wishing to use ASHRAE approved addenda for the purposes of this prerequisite may do so at their discretion. Addenda must be applied consistently across all LEED credits.

IEQ	
NC	Prerequisite 1
CS	Prerequisite 1

1. BENEFITS AND ISSUES TO CONSIDER

Minimum indoor air quality (IAQ) performance in buildings improves occupant comfort, well-being, and productivity compared with buildings with poor IAQ performance. Key strategies for maintaining minimum IAQ include limiting potential indoor contaminant sources, limiting the introduction of contaminants from potential outdoor sources, and—most importantly—determining and maintaining at least the minimum zone outdoor airflow and the minimum outdoor air intake flow required by the ventilation rate procedure of Standard 62.1–2007.

ENVIRONMENTAL ISSUES

Providing minimum IAQ performance improves IAQ generally. Doing so can require higher energy use to operate compliant HVAC systems compared with systems that do not meet the ventilation guidelines of ASHRAE 62.1–2007. Compared with the personnel costs of the occupants, any premium associated with ensuring IAQ is insignificant. Poor IAQ can cause occupant illness, and the additional energy cost of ensuring IAQ may be offset by improved occupant productivity and lower absentee rates.

ECONOMIC ISSUES

Because ASHRAE 62.1–2007 is the required standard for ventilation design for many areas, no additional design effort or cost will be required to meet this prerequisite in general. Its successful implementation reduces potential liability regarding IAQ issues for architects, builders, owners, building operators, and occupants.

2. RELATED CREDITS

Some IAQ problems can be solved by diluting contaminant concentration, but this strategy may affect indoor thermal comfort and increase energy use. The building commissioning and measurement and verification processes are tools that can be used to improve IAQ while minimizing energy efficiency losses, as described in the following:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Credit 3: Enhanced Commissioning
- EA Credit 5: Measurement and Verification

Dense neighbourhoods and heavy traffic as well as existing site contamination can adversely affect the quality of outside air for ventilation. Refer to these 2 credits:

- SS Credit 3: Brownfield Redevelopment
- SS Credit 4: Alternative Transportation

To reduce the detrimental effects some materials have on IAQ, follow the guidelines of the prerequisites and credits below and specify materials and furnishings that do not release harmful or irritating chemicals, such as volatile organic compounds (VOCs) from paints and solvents. Occupants' activities such as chemical handling and smoking can also affect air quality.

- IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control
- IEQ Credits 4: Low-Emitting Materials
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control

IEQ	
NC	Prerequisite 1
CS	Prerequisite 1

3. SUMMARY OF REFERENCED STANDARDS

American National Standards Institute (ANIS)/ ASHRAE Standard 62.1–2007: Ventilation for Acceptable Indoor Air Quality
American Society of Heating, Refrigerating, and Air-Conditioning Engineers
http://www.ashrae.org

This standard specifies minimum ventilation rates and IAQ levels so as to reduce the potential for adverse health effects. The standard specifies that ventilation systems be designed to prevent uptake of contaminants, minimize growth and dissemination of microorganisms, and if necessary, filter particulates.

The standard outlines a ventilation rate procedure and an IAQ procedure for compliance. The ventilation rate procedure prescribes outdoor air quality levels acceptable for ventilation; treatment measures for contaminated outdoor air; and ventilation rates for residential, commercial, institutional, vehicular, and industrial spaces. The IAQ procedure is a performance-based design approach in which the building and its ventilation system maintain concentrations of specific contaminants at or below certain determined limits to achieve an indoor air quality acceptable to building occupants and/or visitors. For the purposes of this procedure, acceptable perceived indoor air quality means there is no dissatisfaction related to thermal comfort, noise and vibration, lighting, and psychological stressors. The IAQ procedure also includes criteria for the following situations: reducing outdoor air quantities when recirculated air is treated by contaminant-removal equipment, and ventilating when a space's air volume is used as a reservoir to dilute contaminants.

The IAQ procedure incorporates quantitative and subjective evaluation and restricts contaminant concentrations to acceptable levels.

ASHRAE updated the standard in 2007 to include requirements for buildings that allow smoking in designated areas to separate areas with environmental tobacco smoke (ETS) from those without ETS. The standard now also clarifies how designers must analyze mechanical cooling systems to limit indoor relative humidity that would cause dampness-related problems such as mould and microbial growth.

4. IMPLEMENTATION

Local code can be used in lieu of ASHRAE when the local code is more stringent. For the purposes of this credit, the code that requires providing more outside air is considered more stringent. Mechanical and natural ventilation systems should provide adequate outside air to building occupants. Under-ventilated buildings may be stuffy, odourous, uncomfortable, and/or unhealthy for occupants. ASHRAE 62.1–2007 establishes minimum requirements for ventilation air rates in various types of occupied zones and building ventilation systems. The standard takes into account a space's floor area, number of occupants and their activities, and the ventilation system.

STRATEGIES

There are 3 basic methods for ventilating buildings:

- mechanical ventilation (i.e., active ventilation);
- natural ventilation (i.e., passive ventilation); and
- mixed-mode ventilation (i.e., both mechanical and natural ventilation).

IEQ	
NC	Prerequisite 1
CS	Prerequisite 1

MECHANICALLY VENTILATED SPACES: VENTILATION RATE PROCEDURE

For mechanical ventilation systems, ASHRAE 62.1–2007, Section 6, explains how to determine the minimum required ventilation rates for various applications, using either the ventilation rate procedure or the indoor air quality procedure. The ventilation rate procedure is easier to apply and used more frequently and is the prescribed approach for this prerequisite.

The ventilation rate procedure methodology is found in Section 6.2 of ASHRAE 62.1–2007. The standard's Table 6-1, Minimum Ventilation Rates in Breathing Zone, explains how to determine both the amount of outdoor air needed to ventilate people-related source contaminants and area-related source contaminants for various occupancy categories. The outdoor air rate for people-related source contaminants takes into account the number of occupants and their activities. The area-related sources portion accounts for background off-gassing from building materials, furniture, and materials typically found in that particular occupancy. Finally, the required zone outdoor airflow is the breathing zone outdoor airflow adjusted to reflect the "zone air distribution effectiveness" using adjustment factors in Table 6-2 of the standard. For multiple-zone systems, outdoor air intake flow is adjusted to reflect the "system ventilation efficiency" of the air distribution configuration, using adjustment factors in Table 6-3 of the standard.

If an occupancy category is not included in ASHRAE 62.1–2007, it is up to the designer to choose one that best corresponds to the usage of the space. Explain the rationale for the selection in the submission. Spaces that do not qualify as occupiable spaces are not necessarily excluded from ventilation rate procedure calculations. Additional ventilation and odour or pollutant control might be necessary to meet this prerequisite.

NATURALLY VENTILATED SPACES

ASHRAE 62.1–2007, Section 5.1, provides requirements on the location and size of ventilation openings for naturally ventilated buildings. All naturally ventilated spaces must be within 7.5 metres (25 feet) of (and permanently open to) operable wall or roof openings to the outdoors; the operable area also must be at least 4% of the space's net occupiable floor area. Interior spaces without direct openings to the outdoors can be ventilated through adjoining rooms if the openings between rooms are unobstructed and have a free area of at least 8% of the interior room area and at least 2.3 square metres (25 square feet). As appropriate, all other nonventilation-related requirements (e.g., exhaust for combustion appliances, outdoor air assessment, and outdoor air intakes) in the standard must be met.

An engineered natural ventilation system can show compliance with acceptable engineering calculations or multi-nodal bulk airflow simulation.

MIXED-MODE VENTILATED SPACES

For mixed-mode ventilated spaces and hybrid ventilation systems, meet the minimum ventilation rates required by Chapter 6 of ASHRAE 62.1–2007 regardless of ventilation mode (natural ventilation, mechanical ventilation, or both mechanical and natural ventilation). Project teams can use any acceptable engineering calculation methodology to demonstrate compliance.

IEQ	
NC	Prerequisite 1
CS	Prerequisite 1

CS

Core & Shell buildings may not have final occupancy counts. Projects that do not have occupancy counts must use the default occupant densities provided in ASHRAE 62.1–2007 Table 6-1, based on the intended use of the space. Projects that do have tenant occupancy counts must use these numbers as long as the gross floor area per occupant results in an occupant density that is not greater than the default occupant density in Table 6-1.

Sometimes both occupancy of the building and distribution of occupancy are unknown. Occupancy distribution is for calculating the percentage of outside air on a system level under ASHRAE 62.1–2007. For the Core & Shell project, it is usually necessary to determine the system level outside air without the distribution of people. For example, a typical office building has office and conference room space, and the conference rooms require more outdoor air than the offices. If these spaces are all on the same system, the system-level outside air may be increased to account for the outside air requirements of the conference rooms. The location of conference rooms and other densely occupied spaces will be unknown in a core and shell building. For the sake of the calculations, assume a reasonable distribution of people.

5. TIMELINE AND TEAM

Early in the design process, the architect and mechanical engineer teams determine and design the most appropriate ventilation system for the project building. The design team may include the building owner, tenants, facility manager, and maintenance personnel as applicable; these team members should be present in the design meetings to share ideas on the building owner's needs, special requirement areas, zone categories, occupant density, and occupant needs.

6. CALCULATIONS

For mechanically ventilated spaces, calculations pertaining to the ventilation rate procedure (VRP) methodology are found in Section 6.2 of ASHRAE 62.1–2007. The breathing zone outdoor airflow is equal to the sum of the outdoor airflow rate required per person times the zone population, plus the outdoor airflow rate required per unit area times the zone floor area.

Breathing zone outdoor airflow is the design outdoor airflow required in the breathing zone of the occupied space or spaces in a zone and is calculated as follows:

$$Vbz = Rp \times Pz + Ra \times Az$$

Where:

Rp = outdoor airflow rate required per person as determined from Table 6-1 in ASHRAE 62.1–2007;

Pz = zone population, the largest number of people expected to occupy the zone during typical usage;

Ra = outdoor airflow rate required per unit area as determined from Table 6-1 in ASHRAE 62.1–2007; and

Az = zone floor area; the net occupied floor area of the zone.

IEQ	
NC	Prerequisite 1
CS	Prerequisite 1

Zone outdoor airflow is the outdoor airflow that must be provided to the zone by the supply air distribution system and is calculated as follows:

$$Voz = \frac{Vbz}{Ez}$$

Where:

Ez = Zone air distribution effectiveness as determined from Table 6-2 in ASHRAE 62.1–2007.

For **single-zone systems**, in which 1 air handler supplies a mixture of outdoor air and recirculated air to only 1 zone, the **outdoor air intake flow** is (Vot) = Voz.

For **100% outdoor air systems**, in which 1 air handler supplies only outdoor air to 1 or more zones, $Vot = \sum^{n}_{Zone=1}[Voz]_{Zone.}$

For **multiple-zone recirculating systems**, in which 1 air handler supplies a mixture of outdoor air and recirculated return air to more than 1 zone, calculate the **outdoor air intake flow** (Vot) as follows:

- Determine the **zone primary outdoor air fraction** (Zp) = Voz/Vpz, where **Vpz** is the **zone primary airflow** (i.e., the primary airflow to the zone from the air handler, including outdoor air and recirculated air). For VAV systems, Vpz is the minimum expected primary airflow for design purposes.
- Determine the **system ventilation efficiency (Ev)** from Table 6-3 in ASHRAE 62.1–2007.
- Determine the **uncorrected outdoor air intake (Vou)** = $D \cdot \sum^{n}_{Zone=1}[Rp \times Pz + Ra \times Az]_{Zone}$ where *n* is the total number of zones served by the system, and the **occupant diversity** (D) may be used to account for variations in occupancy within zones served by the same system: $D = Ps / \sum^{n}_{Zone=1}[Pz]_{Zone}$, and where Ps is the **system population**, the total population in the area served by the system and *n* is the total number of zones served by the system.

The outdoor air intake flow for the multiple-zone recirculating system may then be determined by this calculation:

$$Vot = \frac{Vou}{Ev}$$

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- For mechanically or naturally ventilated spaces, demonstrate compliance with the applicable sections of ASHRAE 62.1–2007; see Calculations.
- For natural ventilated spaces also maintain documentation (e.g., diagram) that visually indicates air flows.
- For Core & Shell projects, create a description of future tenants, space types, and expected uses.

IEQ	
NC	Prerequisite 1
CS	Prerequisite 1

8. EXAMPLES

The following are examples of the ASHRAE 62.1–2007 ventilation rate procedure calculations. Refer to the ASHRAE standard for project-specific applications.

TABLE 1. SAMPLE SUMMARY CALCULATIONS FOR DETERMINING OUTDOOR AIR VENTILATION RATES

Zone	Occupancy Category	Outdoor Airflow Rate Required per Person (Rp)	Zone Population (Pz)	Outdoor Airflow Rate Required per Unit Area (Ra)	Zone Floor Area (Az)	Zone Air Distribution Effectiveness (Ez)	Breathing Zone Outdoor Airflow (Vbz)
VAV-1	Office space	2.5 L/s	8	0.3 L/s/m²	29 m²	1.0	29 L/s
VAV-2	Conference room	2.5 L/s	10	0.3 L/s/m²	25 m²	1.0	33 L/s

TABLE 2. VENTILATION RATE PROCEDURE FOR MULTIPLE-ZONE, VARIABLE-VOLUME SYSTEM

INPUTS FOR POTENTIALLY CRITICAL ZONES					
Zone Name		Zone title turns purple italic for critical zone(s)		Corner Open Office	North Conference Room
Zone Tag				VAV-1	VAV-2
Space Type		Select from pull-down list		Office space	Conference/ meeting
Floor Area of zone	Az	m²		29	25
Design population of zone	Pz	P (default value listed; may be overridden)		8	10
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	L/s		278	142
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A		ITU	ITU
Local recirc. air fraction representative of ave system return air	Er			0.50	0.50
Inputs for Operating Condition Analyzed					
Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list		CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez			1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep			0.95	0.90

IEQ	
NC	Prerequisite 1
CS	Prerequisite 1

POTENTIALLY CRITICAL ZONES										
North Conference Room	North Private Office	Corner Open Office	South Private Office	Reception	West Open Office	East Private Office	Interior Private Office	Interior Private Office	Interior Conference Room	Server Room
VAV-2	VAV-3	VAV-4	VAV-5	VAV-6	VAV-7	VAV-8	VAV-9	VAV-10	VAV-11	VAV12
Conference/ meeting	Office Space	Office Space	Office Space	Reception areas	Office Space	Office Space	Office Space	Office Space	Conference/ meeting	Computer (not printing)
25	10	29	15	24	32	13	6	6	20	13
10	1	8	1	3.5	5	1	1	1	8	0
142	57	219	101	118	212	73	24	24	94	24
ITU	ITU	ITU	ITU	ITU	ITU	ITU	ITU	ITU	ITU	ITU
0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.90	0.90	0.90	0.90	0.90	0.90	0.80	0.70	0.70	0.75	0.80

TABLE 3. RESULTS FROM VENTILATION RATE PROCEDURE

Results		
System Ventilation Efficiency	Ev	0.78
Outdoor air intake airflow rate required at condition analyzed	Vot	156 L/s
Outdoor air intake rate per unit floor area	Vot/As	0.71 L/s/m^2
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	6.8 L/s/p
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	13%
Uncorrected outdoor air intake airflow rate	Vou	122 L/s

TABLE 4. SAMPLE SUMMARY CALCULATIONS FOR NATURALLY VENTILATED SPACES

ZONE	FLOOR AREA (m^2)	NATURAL VENTILATION OPENING AREA (m^2)	OPENING AREAS AS PERCENTAGE OF FLOOR AREA	IS DISTANCE TO OPENING 7.5 METRES OR LESS?
General office	743	31	4.17	Yes
Training room	70	3	4.29	Yes
Break room	20	1	5.00	Yes

IEQ	
NC	Prerequisite 1
CS	Prerequisite 1

9. EXEMPLARY PERFORMANCE

This prerequisite is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations associated with this prerequisite.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

For mechanically ventilated systems, provide the building operator with copies of the ventilation rate procedure calculations for each zone used to show compliance with ASHRAE 62.1–2007. Over the building's life, these can be updated with actual occupancy values to adjust delivered ventilation rates as appropriate.

Provide maintenance personnel with the information needed to understand, maintain, and adjust the ventilation system, and retain mechanical design documents showing zone configurations. Include appropriate setpoints, control sequences, and recommendations for typical corrective actions in the facility's building operating plan and sequence of operations document. Establish procedures and schedules for testing and maintaining exhaust systems and include them in the building's preventive maintenance plan.

12. RESOURCES

WEBSITES

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
http://www.ashrae.org

ASHRAE advances the science of heating, ventilation, air conditioning, and refrigeration for the public's benefit through research, standards writing, continuing education, and publications. To purchase ASHRAE standards and guidelines, visit the bookstore on the ASHRAE website.

Cost-Effective Open-Plan Environment (COPE) Research Reports
http://www.nrc-cnrc.gc.ca/eng/projects/irc/cope.html

Institute for Research in Construction, National Research Council and COPE Consortium provides in-depth studies of open-plan office design variables and their effect on occupant satisfaction, including workstation design, indoor air quality and thermal comfort, lighting and acoustics. Studies include field and literature reviews, mock-up office experiments, and simulations to investigate the many elements of the open-plan office. (Some reports are not yet available.) Reports include:

- Environmental Satisfaction in Open-Plan Environments: 2. Effects of Workstation Size, Partition Height and Windows
- Office Air Distribution Systems and Environmental Satisfaction
- A Literature Review on the Relationship between Outdoor Ventilation Rates in Offices and Occupant Satisfaction
- Investigation of Air and Thermal Environments in a Mock-up Open Plan Office: Measurements and CFD Simulations
- The Effect of Office Design on Workstation Lighting: Simulation Results
- Effects of Office Design on the Annual Daylight Availability

IEQ	
NC	Prerequisite 1
CS	Prerequisite 1

Indoor Air Quality
http://www.tpsgc-pwgsc.gc.ca/biens-property/gd-env-cnstrctn/annb-3-eng.html

Architectural and Engineering Services, Public Works and Government Services Canada (PWGSC). Public Works and Government Services Canada maintains an educational guide of IAQ tips.

U.S. EPA's Indoor Air Quality website
http://www.epa.gov/iaq

EPA's IAQ website includes a variety of tools, publications, and links to address IAQ concerns in schools and large buildings.

13. DEFINITIONS

Active ventilation is synonymous with mechanical ventilation.

Air-conditioning is the process of treating air to meet the requirements of a conditioned space by controlling its temperature, humidity, cleanliness, and distribution. (ASHRAE 62.1–2007)

Breathing zone is the region within an occupied space between 0.9 and 1.8 metres (3 and 6 feet) above the floor. Note that this definition varies from that of ASHRAE 62.1-2007, which states that the breathing zone is between 0.9 and 1.8 metres (3 and 6 feet) from the floor, and 0.6 metres (2 feet) from the walls as well as fixed air-conditioning equipment.

Contaminants are unwanted airborne elements that may reduce air quality. (ASHRAE 62.1–2007)

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Mechanical ventilation, or active ventilation, is provided by mechanically powered equipment such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows. (ASHRAE 62.1–2007)

Mixed-mode ventilation combines mechanical and natural ventilation methods.

Natural ventilation, or passive ventilation, is provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building. (ASHRAE 62.1–2007)

Off-gassing is the emission of volatile organic compounds (VOCs) from synthetic and natural products.

Outdoor air is the ambient air that enters a building through a ventilation system, either through intentional openings for natural ventilation or by infiltration. (ASHRAE 62.1–2007)

Passive ventilation uses the building layout, fabric, and form to provide natural ventilation to a conditioned space using nonmechanical forms of heat transfer and air movement.

Thermal comfort exists when occupants express satisfaction with the thermal environment.

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space. (ASHRAE 62.1-2007).

IEQ	
NC	Prerequisite 2
CS	Prerequisite 2

ENVIRONMENTAL TOBACCO SMOKE (ETS) CONTROL

	NC	CS
Prerequisite	IEQ Prerequisite 2	IEQ Prerequisite 2
Points	Required	Required

INTENT

To prevent or minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to environmental tobacco smoke (ETS).

REQUIREMENTS: NC & CS

OPTION 1

Prohibit smoking in the building.

Prohibit on-property smoking within 7.5 metres (25 feet) of entries, outdoor air intakes and operable windows.

Provide signage to allow smoking in designated areas, prohibit smoking in designated areas or prohibit smoking on the entire property.

OR

OPTION 2

CASE 1. ALL PROJECTS

Prohibit smoking in the building except in designated smoking areas.

Prohibit on-property smoking within 7.5 metres (25 feet) of entries, outdoor air intakes and operable windows.

Provide signage to allow smoking in designated areas, prohibit smoking in designated areas or prohibit smoking on the entire property.

Provide designated smoking rooms designed to contain, capture and remove ETS from the building. At a minimum, the smoking room must be directly exhausted to the outdoors, away from air intakes and building entry paths, with no re-circulation of ETS-containing air to non-smoking areas and enclosed with impermeable deck-to-deck partitions. Operate exhaust sufficient to create a negative pressure differential with the surrounding spaces of at least an average of 5 Pascals (Pa) (0.02 inches of water gauge) and with a minimum of 1 Pa (0.004 inches of water gauge) when the doors to the smoking rooms are closed.

IEQ	
NC	Prerequisite 2
CS	Prerequisite 2

Verify performance of the smoking rooms' differential air pressures by conducting 15 minutes of measurement, with a minimum of 1 measurement every 10 seconds, of the differential pressure in the smoking room with respect to each adjacent area and in each adjacent vertical chase with the doors to the smoking room closed. Conduct the testing with each space configured for worst-case conditions of transport of air from the smoking rooms (with closed doors) to adjacent spaces.

Note: Option 2 is intended for isolated smoking rooms. For residential buildings where smoking is allowed in all residential suites (i.e. adjacent rooms/suites cannot be operated at negative pressure with respect to each other) then compliance path Case 2 must be used.

CASE 2. MULTI-UNIT RESIDENTIAL BUILDINGS, HOTELS, MOTELS AND DORMITORIES ONLY

Prohibit smoking in all common areas of the building.

Locate any exterior designated smoking areas where smoking is permitted, at least 7.5 metres (25 feet) from entries, outdoor air intakes and operable windows opening to common areas.

Prohibit on-property smoking within 7.5 metres (25 feet) of entries, outdoor air intakes, and operable windows. Provide signage to allow smoking in designated areas, prohibit smoking in designated areas or prohibit smoking on the entire property.

Weatherstrip all exterior doors and operable windows in the residential units to minimize leakage from the outdoors.

Minimize uncontrolled pathways for ETS transfer between individual residential units by sealing penetrations in walls, ceilings and floors in each unit and by sealing vertical chases adjacent to the units.

Weatherstrip all doors in the residential units leading to common hallways to minimize air leakage into the hallway. If the common hallways are pressurized with respect to the residential units then doors in the residential units leading to the common hallways need not be weatherstripped provided that the positive differential pressure is demonstrated as in Option 2, Case 1 above, considering the residential unit as the smoking room (note: this is not recommended as it may be difficult to achieve the required pressure differential in all units in mid to high rise residential buildings).

Demonstrate acceptable sealing of residential units by a blower door test conducted in accordance with ANSI/ASTM-E 779-03, Standard Test Method for Determining Air Leakage Rate By Fan Pressurization.

Use the progressive sampling methodology defined in Chapter 4 (Compliance Through Quality Construction) of the Residential Manual for Compliance with California's 2001 Energy Efficiency Standards. Residential units must demonstrate an Equivalent Normalized Leakage Area of less than 1.65cm²/m² of enclosure area (2.37in²/100ft²) when calculated using the equivalent leakage area as per the Can/CGSB-149.10-M86 calculation methodology (i.e., 10 Pa, Cd = 0.61). This typically converts to an Effective Normalized Leakage Area of 0.875cm²/ m² (1.25in² per 100ft²) when calculated using the effective leakage area as per the ASTM methodology (i.e., 4 Pa, Cd = 1.0).

INTERPRETATIONS

MURBs

For Case 2, when residential unit doors leading to the common hallways are not weatherstripped, the positive differential pressure of the residential units must be demonstrated between the unit and the hallway with all manually controlled exhausts off.

For Case 2, an Air Tightness Quality Assurance Plan should be implemented to ensure that the project meets the required air tightness requirements (see Section 4, Implementation).

For Case 2, if the leakage area target is NOT met, prepare a "lessons learned" report that includes the following:

- Blower door test results.
- A description of how the blower door test was used to identify leakage sites.
- A narrative explaining the mitigative or remedial activities undertaken to seal uncontrolled air leakage sites to and from individual dwelling units and other areas.
- The copy of the Air Tightness Quality Assurance Plan implemented.

IEQ	
NC	Prerequisite 2
CS	Prerequisite 2

1. BENEFITS AND ISSUES TO CONSIDER

The purpose of this prerequisite is to limit the exposure of building occupants to environmental tobacco smoke (ETS), or secondhand smoke. ETS is produced by burning cigarettes, pipes, or cigars. It contains thousands of different compounds, many of which are known carcinogens.[19] By prohibiting smoking indoors, occupants will have less exposure to ETS. Smoking boundaries will increase the quality of air inside the building and around the building perimeter, and will decrease risk to occupants' health.

The relationship between smoking and various health risks, including lung disease, cancer, and heart disease, is well documented. A strong link between ETS and similar health risks has also been demonstrated.

The most effective way to avoid health problems associated with ETS is to prohibit smoking indoors. If this cannot be accomplished, indoor smoking areas must be isolated from nonsmoking areas and have separate ventilation systems to prevent the introduction of tobacco smoke contaminants to nonsmoking areas.

ENVIRONMENTAL ISSUES

Separate smoking areas occupy additional space and may result in a larger building, greater material use, and increased energy for ventilation. However, these environmental impacts can be offset by the gains in health and well-being of building occupants who are more comfortable, have higher productivity rates, lower absenteeism, and less illness.

ECONOMIC ISSUES

Providing separate smoking areas adds to the design and construction costs of most projects, and maintaining designated smoking areas also adds to lease and operating costs. Prohibiting indoor smoking can increase the useful life of interior fixtures and furnishings.

Smoking within a building contaminates indoor air and can cause occupant reactions, including irritation, illness, and decreased productivity. These problems increase expenses and liability for building owners, tenants, operators, and insurance companies. Strict no-smoking policies improve the health of the community as a whole, resulting in lower health care and insurance costs.

2. RELATED CREDITS

The use of separate ventilation systems to isolate smoking areas from the rest of the building requires additional energy and commissioning, as well as measurement and verification efforts. This prerequisite is related to the following prerequisites and credits:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Credit 1: Optimize Energy Performance
- EA Credit 3: Enhanced Commissioning
- EA Credit 5: Measurement and Verification

Because smoking, both indoors and outdoors, affects the IAQ performance of the building, this prerequisite is also related to the following prerequisites and credits:

- IEQ Prerequisite 1: Minimum Indoor Air Quality Performance
- IEQ Credit 1: Outdoor Air Delivery Monitoring
- IEQ Credit 2: Increased Ventilation

IEQ	
NC	Prerequisite 2
CS	Prerequisite 2

Project teams may wish to address smoking-related contaminants in the building in conjunction with other sources of air pollutants, as outlined in the following credits:

- IEQ Credit 4: Low-Emitting Materials
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control

3. SUMMARY OF REFERENCED STANDARDS

American National Standards Institute (ANSI)/ASTME–779–03, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
To purchase this standard, go to: http://www.astm.org
This test method covers a standardized technique for measuring air leakage rates through a building envelope under controlled pressurization and depressurization; it should produce a measurement of the air tightness of a building envelope.

Residential Manual for Compliance with California's 2001 Energy Efficiency Standards (For Low Rise Residential Buildings), Chapter 4
www.energy.ca.gov/title24/archive/2001standards/residential_manual/res_manual_chapter4.PDF
According to this chapter of the manual, "The Standards require quality design and construction of mechanical ventilation systems and air distribution systems. They also offer compliance credit for the construction of less leaky building envelopes. With the 2001 Standards, testing of ducts, refrigerant charge, and airflow was added to the prescriptive requirements (Package D) and is assumed as part of the standard design in performance calculations. Many of the compliance credit options require installer diagnostic testing and certification, and independent diagnostic testing and field verification by a certified home energy rater."

4. IMPLEMENTATION

Prohibit smoking in the building. Provide appropriately located designated smoking areas outside the building away from building entrances, operable windows, and ventilation systems. These designated areas should also be located away from concentrations of building occupants or pedestrian traffic. Post information about the building's nonsmoking policy for all occupants to read.

If interior smoking areas are incorporated within the building, separate ventilation systems must be installed and their effectiveness tested to ensure that they are isolated from the nonsmoking portions of the building.

The design criteria and instructions for Option 1 and Option 2, Case 1 are detailed in the credit requirements and the referenced standard for Case 2.

For multi-unit residential buildings, hotels, motels or dormitories following Case 2, an Air Tightness Quality Assurance Plan should be implemented to ensure that the project meets the required air tightness requirements. The Air Tightness Quality Assurance Plan includes but is not limited to the following components:

- Design details for all penetrations into or through suite partitions,
- Records of blower door tests conducted on the test suites before and after corrective or remedial work, noting the sources of excessive air leakage and corrective or remedial work that was undertaken to reduce the leakage,
- Records of representative blower door tests undertaken in accordance with the testing and sampling methodology noted in this Reference Guide,

IEQ	
NC	Prerequisite 2
CS	Prerequisite 2

- A brief narrative, prepared after completion of blower door testing, describing mitigative or remedial activities undertaken to seal uncontrolled air leakage sites to and from individual dwelling units and other areas, and leakage area measurements demonstrating the effectiveness of the remedial measures. Provide 6 – 12 photographs of activities undertaken to seal uncontrolled air leakage sites for at least two dwelling units.

CS

In many regions of North America, municipal regulations prohibit indoor smoking. In regions where indoor smoking is allowed and a building owner allows some indoor smoking, the smoking area in a core and shell building must carefully follow all of the requirements for smoking areas listed in this prerequisite. It is important to protect other tenants from the environmental tobacco smoke (ETS), so make sure that the smoking area functions as intended. Air from the smoking area must not return to a common HVAC system. The building must accommodate a separate exhaust system that removes ETS from the smoking area. In many buildings, the space for mechanical equipment and chases is limited, so extra space for a separate exhaust system may be difficult to find.

5. TIMELINE AND TEAM

The building smoking policy and site smoking policy should be drafted by the facility manager and signed by the facility manager, property manager, or owner. This policy should be in place over the life of the building. Enforcing the building policy is the responsibility of the facility manager. Enforcing the site policy is the responsibility of the groundskeeper. Any building modifications made to accommodate new smoking rooms should be coordinated by the facility manager in consultation with the building owner.

6. CALCULATIONS

There are no calculations required for this prerequisite.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Develop an environmental tobacco smoke policy that details areas where smoking is prohibited.
- Maintain documentation (e.g., site plans and renderings) that visually indicates how the smoking policy has been implemented on-site.
- Track and record testing data for any interior smoking rooms to verify that there is no cross contamination to adjacent spaces.

IEQ	
NC	Prerequisite 2
CS	Prerequisite 2

8. EXAMPLES

FIGURE 1. COMPLIANT SMOKING ROOM

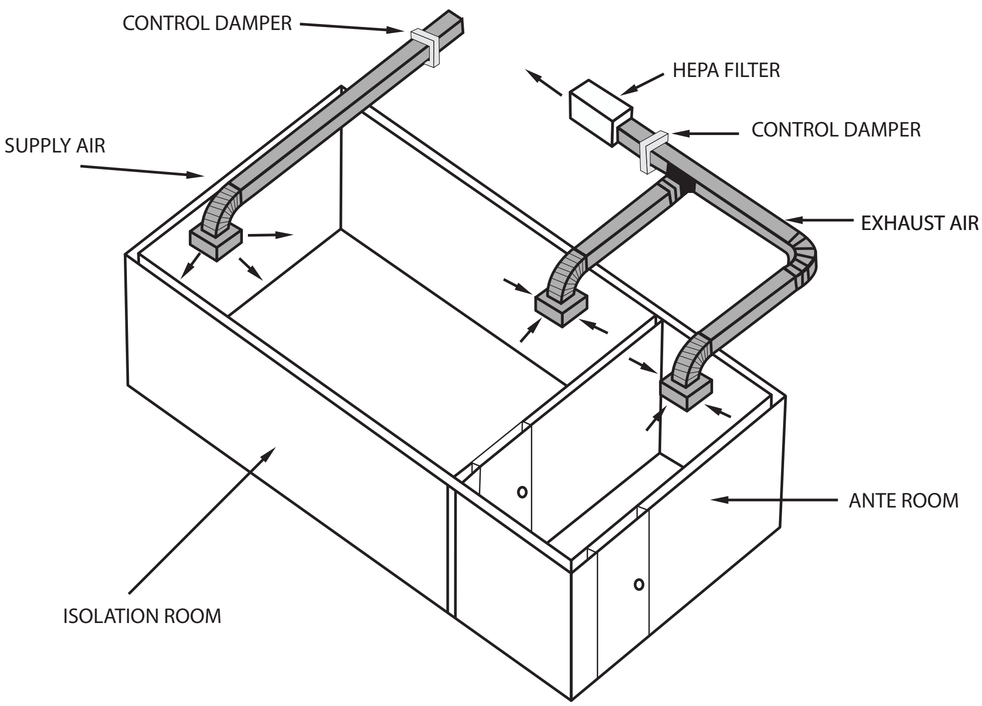


Figure 1 illustrates the degree of isolation required to comply with this prerequisite. The anteroom helps prevent pollutants from entering the rest of the building. Air enters and exits the designated smoking room through control dampers, maintaining a constant flow. Upon exiting, the air may or may not be filtered before exiting the building. Air recirculated into the room is filtered.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

In addition to the federal Tobacco Act, which regulates the manufacture, sale, labelling and promotion of tobacco, each province, and some municipalities, has their own set of laws that address, among other issues, smoking in public places.[20]

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Communicate the building's smoking policy to all occupants, establish a plan for enforcement, and designate the person responsible for implementing the policy.

IEQ	
NC	Prerequisite 2
CS	Prerequisite 2

12. RESOURCES

WEBSITES

American National Standards Institute (ANSI)/ASTM–E779–03, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
To purchase this standard go to: http://www.astm.org

This test method covers a standardized technique for measuring air leakage rates through a building envelope under controlled pressurization and depressurization; it should produce a measurement of the air tightness of a building envelope.

Department of Justice, Non-smokers' Health Act
http://laws.justice.gc.ca/eng/N-23.6/page-1.html

An Act to regulate smoking in the federal work-place and on common carriers and to amend the Hazardous Products Act in relation to cigarette advertising.

Health Canada, Healthy Living, Second-hand Smoke
http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/life-vie/shs-fs-eng.php

This document describes health effects of second-hand smoke.

Isolation Rooms and Pressurization Control
http://www.engr.psu.edu/AE/iec/abe/control/isolation.asp

This document describes the engineering involved in negative pressure rooms.

Setting the Record Straight: Secondhand Smoke Is a Preventable Health Risk
U.S. EPA
http://www.epa.gov/smokefree/pubs/strsfs.html

This EPA document reviews laboratory research on ETS and federal legislation aimed at curbing ETS-related problems.

PRINT MEDIA

The Chemistry of Environmental Tobacco Smoke: Composition and Measurement, 2nd edition, by R.A. Jenkins, B.A. Tomkins, et al. (CRC Press & Lewis Publishers, 2000).

The Smoke-Free Guide: How to Eliminate Tobacco Smoke from Your Environment, by Arlene Galloway (Gordon Soules Book Publishers, 1988).

13. DEFINITIONS

Environmental tobacco smoke (ETS), or secondhand smoke, consists of airborne particles emitted from the burning end of cigarettes, pipes, and cigars, and is exhaled by smokers. These particles contain about 4,000 different compounds, up to 50 of which are known to cause cancer.

Mechanical ventilation is ventilation provided by mechanically powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows (ASHRAE 62.1–2007).

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space. (ASHRAE 62.1–2007).

IEQ	
NC	Credit 1
CS	Credit 1

OUTDOOR AIR DELIVERY MONITORING

	NC	CS
Credit	IEQ Credit 1	IEQ Credit 1
Points	1 point	1 point

INTENT

To provide capacity for ventilation system monitoring to help promote occupant comfort and well-being.

REQUIREMENTS: NC & CS

Install permanent monitoring systems to ensure that ventilation systems maintain design minimum requirements. Configure all monitoring equipment to generate an alarm when the airflow values or carbon dioxide (CO_2) levels vary by 10% or more from the design values via either a building automation system alarm to the building operator or a visual or audible alert to the building occupants. All outdoor airflow and/or CO_2 sensors must be calibrated as part of EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems and recalibration requirements must be included in the project O&M Manual.

AND

CASE 1. MECHANICALLY VENTILATED SPACES

Monitor CO_2 concentrations within all densely occupied spaces (those with a design occupant density of 25 people or more per 93 square metres (1000 square feet)). CO_2 monitors must be between 0.9 and 1.8 metres (3 feet and 6 feet) above the floor.

Provide a direct outdoor airflow measurement device capable of measuring the minimum outdoor air intake flow with an accuracy of plus or minus 15% of the design minimum outdoor air rate, as defined by ASHRAE 62.1-2007 (with errata but without addenda[a]) for mechanical ventilation systems where 20% or more of the design supply airflow serves non-densely occupied spaces.

[a] Project teams wishing to use ASHRAE approved addenda for the purposes of this credit may do so at their discretion. Addenda must be applied consistently across all LEED credits.

IEQ	
NC	Credit 1
CS	Credit 1

CASE 2. NATURALLY VENTILATED SPACES

Monitor CO_2 concentrations within all naturally ventilated spaces. CO_2 monitors must be between 0.9 and 1.8 metres (3 feet and 6 feet) above the floor. One CO_2 sensor may be used to monitor multiple spaces if the natural ventilation design uses passive stack(s) or other means to induce airflow through those spaces equally and simultaneously without intervention by building occupants. CO_2 monitoring is required in densely occupied spaces.

INTERPRETATIONS

LEASED TENANT SPACE (NC & CS)

For unfinished leased tenant space a minimum of one (1) CO_2 sensor per tenant or one (1) sensor per 500 m^2, whichever is greater, and not less than one (1) sensor per floor should be provided in the base building design, provided to the tenant for fit-up or made part of a mandatory lease agreement.

MURB

For residential building projects follow Case 1 for Mechanically ventilated spaces and Case 2 for Naturally ventilated spaces.

IEQ	
NC	Credit 1
CS	Credit 1

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Measuring CO_2 concentrations to determine and maintain adequate outdoor air ventilation rates in buildings is one recommended method for achieving better indoor air quality (IAQ). Increasing ventilation rates may require additional energy inputs, which generate additional air and water pollution.

CO_2 concentrations are an indicator of air-change effectiveness, with elevated levels suggesting inadequate ventilation and possible buildup of indoor air pollutants. Although CO_2 alone is not harmful, high concentrations in indoor environments displace oxygen and therefore can lead to headaches, dizziness, and increased heart rate.[21]

Ambient outdoor CO_2 concentrations may fluctuate between approximately 300 and 500 ppm, depending on local and regional factors. Time-of-day fluctuations (e.g., from nearby major highways) and annual fluctuations, if any, should also be considered.

ECONOMIC ISSUES

Installing CO_2 and ventilation rate monitoring systems requires an investment in equipment, installation, annual calibration, and maintenance. However, these systems enable building owners, facility managers, maintenance personnel, and occupants to detect air quality problems quickly so that corrective action can be taken. Reduced absenteeism and increased occupant productivity, though difficult to quantify, are important factors when evaluating investment in these systems. Effective air quality monitoring can also extend the life of a building's HVAC system and reduce energy use by ensuring that the amount of makeup air provided accurately reflects building occupancy loads.

CO_2 and ventilation rate monitoring systems increase initial construction costs compared to less efficiently and effectively controlled spaces. Capital and annual costs for air-flow monitoring equipment maintenance and calibration procedures may be offset by reduced absenteeism, increased occupant productivity, and reduced HVAC energy use.

2. RELATED CREDITS

Monitoring of airflow can allow for performance trending and alert building operators about potential IAQ problems. The monitoring capability can help inform the commissioning process and enable robust measurement and verification, both to maximize energy performance and to ensure consistent indoor air quality. The following credits and prerequisite are related to this credit:

- IEQ Prerequisite 1: Minimum IAQ Performance
- IEQ Credit 2: Increased Ventilation
- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Credit 3: Enhanced Commissioning
- EA Credit 5: Measurement and Verification

IEQ	
NC	Credit 1
CS	Credit 1

CO_2 is commonly mitigated within indoor spaces by increasing the ventilation rates. However, the quantity of outside air required to mitigate high CO_2 depends on the concentration of CO_2 in the outside air. Dense neighbourhoods, heavy traffic, and existing site contamination can raise CO_2 levels and lower the quality of outside air available for ventilation purposes. Alternative transportation amenities, such as bicycle corridors or public transportation, can reduce the need for single-occupant vehicles and decrease CO_2 concentrations. Refer to this credit:

- SS Credit 4: Alternative Transportation

3. SUMMARY OF REFERENCED STANDARDS

American National Standards Institute (ANSI)/ASHRAE Standard 62.1–2007: Ventilation for Acceptable Indoor Air Quality
American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
http://www.ashrae.org
This standard specifies minimum ventilation rates and IAQ levels so as to reduce the potential for adverse health effects. The standard specifies that ventilation systems be designed to prevent uptake of contaminants, minimize growth and dissemination of microorganisms, and, if necessary, filter particulates.

The standard outlines a ventilation rate procedure and an IAQ procedure for compliance. The ventilation rate procedure prescribes outdoor air quality levels acceptable for ventilation; treatment measures for contaminated outdoor air; and ventilation rates for residential, commercial, institutional, vehicular, and industrial spaces. The IAQ Procedure is a performance-based design approach in which the building and its ventilation system maintain concentrations of specific contaminants at or below certain previously determined limits in order to achieve an indoor air quality acceptable to building occupants and/or visitors. For the purposes of this procedure, acceptable perceived indoor air quality excludes dissatisfaction related to thermal comfort, noise and vibration, lighting, and psychological stressors. The IAQ procedure also includes criteria for the following situations: reducing outdoor air quantities when recirculated air is treated by contaminant-removal equipment and ventilating when a space's air volume is used as a reservoir to dilute contaminants. The IAQ procedure incorporates quantitative and subjective evaluation and restricts contaminant concentrations to acceptable levels.

ASHRAE updated the standard in 2007 to include requirements for buildings that allow smoking in designated areas to separate areas with environmental tobacco smoke (ETS) from those without ETS. The standard now also clarifies how designers must analyze mechanical cooling systems to limit indoor relative humidity that would cause dampness-related problems such as mould and microbial growth.

Project teams wishing to use ASHRAE-approved addenda for the purposes of this credit may do so at their own discretion. Apply addenda consistently across all LEED credits.

4. IMPLEMENTATION

Building HVAC systems are designed to flush out indoor airborne contaminants by exhausting old air and replacing it with outdoor air. The rate of ventilation air exchange is usually determined during the design phase, and is based on space density and type of occupancy. Many conventional ventilation systems do not directly measure the amount of outdoor air that is delivered. Implementation of the following strategies is recommended to achieve this credit.

IEQ	
NC	Credit 1
CS	Credit 1

OUTDOOR AIR FLOW MONITORING

Monitoring the outdoor air flow rate confirms that the HVAC equipment is providing the required ventilation rate. Air balance control methodologies, such as fan-tracking and measuring building-pressurization, do not directly prove that appropriate ventilation air is being provided and do not satisfy the credit requirement. The ventilation rate can be measured at the outdoor air intake of an air distribution system using a variety of airflow devices, including Pitot tubes, Venturi meters, rotating vane anemometers, and mass air flow sensors. These sensors must be installed according to the manufacturer's best practices guidelines. The ventilation rate for a particular HVAC system can be accurately determined from a mass balance calculation if both supply air flow and return air flow are directly measured with air flow monitoring devices. To satisfy the requirements of this credit, the measurement devices must detect when the system is 15% below the design minimum outdoor air rate. When the ventilation system fails to provide the required levels of outside air, the monitoring system should be configured to deliver a visible or audible alert to the system operator to indicate that operational adjustments might be necessary.

The minimum outdoor air rate might change based on the design and modes of the HVAC system. Constant volume systems with steady-state design occupancy conditions usually have different outdoor air rates for weekdays and nighttime or off-peak conditions. In variable air volume systems, the rate of outdoor air needs to stay above the design minimum, even when the supply air flow is decreased because of reduced thermal load conditions.

For those HVAC systems where it is difficult to monitor outdoor airflow it is acceptable to use CO_2 monitoring (see section below).

CO_2 MONITORING

CO_2 monitors can also measure the effectiveness of the ventilation system in delivering outdoor air. Properly placed CO_2 monitors can confirm that a ventilation system is functioning properly. There are 2 typical system configurations that generally meet the requirements of this credit.

The first approach involves CO_2 sensors that use measured concentration to provide an alert if the ventilation system is not functioning properly. An indoor concentration of 1000 parts per million (ppm) was commonly used in the past as the set point for the alarm, but a higher alarm concentration may be appropriate when the design complies with Standard 62.1–2007, because the effective ventilation rate per person has been reduced significantly for some zones. ASHRAE 62.1– 2007, Users Manual Appendix A, provides more information about CO_2 sensors, including demand control ventilation.

Locate CO_2 monitors so that they provide accurate representative readings of the CO_2 concentrations in occupied spaces. Multiple CO_2 monitoring stations throughout occupied spaces provide better information and control than a single CO_2 monitor for the entire system. A single CO_2 monitor, typically installed in the return air duct, is less expensive and easier to use than providing multiple sensors, but it may not be able to identify underventilated areas in the building.

The second approach for buildings with HVAC systems that have limited airflow monitoring capabilities (small capacity air handling units or split systems) is to use differential CO_2 monitoring to satisfy the credit requirements. This approach requires CO_2 monitors in all occupied spaces, an outdoor CO_2 monitor, and a means by which the air handling units can provide a greater amount of outside air if the CO_2 delta between the spaces reaches or exceeds 530 ppm.

For outdoor CO_2 sensors, use reliable measurement data to determine conservative set points based on an ambient CO_2 concentration. Alternatively, use 400 ppm for the assumed constant outdoor CO_2 value, because it is a conservative assumption and supported in California's Title 24 energy code.

IEQ	
NC	Credit 1
CS	Credit 1

NC

CO_2 MONITORING IN DENSELY OCCUPIED SPACES

The CO_2 level for each densely occupied space in a mechanically ventilated building needs to be monitored to satisfy the credit requirements. The density factor is 25 people per 93 square metres (1000 square feet); for example, a 22 square metres (240-square-foot) conference room that accommodates 6 or more people would need a CO_2 monitor. CO_2 monitors in densely occupied spaces should be mounted within the space's vertical breathing zone between 0.9 and 1.8 metres (3 and 6 feet) above the floor.

VENTILATION AIR FLOW MONITORING IN NON-DENSELY OCCUPIED SPACES

For mechanically ventilated spaces with an occupant density of less than 25 people per 93 square metres (1000 square feet), this *LEED Canada for New Construction* credit requires that the outdoor ventilation rate be directly measured and compared against the minimum required ventilation rate.

Typically, air flow monitoring stations located in the outdoor air intakes of each central HVAC air distribution system will provide those measurements. The direct outdoor airflow measurement device must be capable of measuring the outdoor airflow rate at all expected system operating conditions, within an accuracy of plus or minus 15% of the design minimum outdoor air rate.

CO_2 MONITORING IN NATURALLY VENTILATED SPACES

Monitoring CO_2 levels in the occupied spaces in naturally ventilated buildings gives building occupants and operators feedback so that they can adjust the ventilation by, for example, opening windows. The CO_2 monitors in naturally ventilated spaces should be mounted in the vertical breathing zone between 0.9 and 1.8 metres (3 and 6 feet) above the floor.

BUILDING TYPE

Airflow and CO_2 monitoring systems can be applied to any building or HVAC system type, including both mechanically and naturally ventilated buildings. In addition to ventilation alarms, these systems can provide building operators and automated control systems with information about making necessary operational adjustments, such as increasing or decreasing intake airflow rates.

For naturally ventilated buildings and spaces served by HVAC systems that do not permit active control of ventilation rates, CO_2 monitors in the occupied spaces can provide building occupants and facilities staff with useful information that enables operational adjustments, such as opening windows or adjusting fixed ventilation rates in under-ventilated areas.

IEQ	
NC	Credit 1
CS	Credit 1

CS

VENTILATION AIR FLOW MONITORING

The outdoor ventilation rate in mechanically ventilated spaces must be measured and compared to the minimum required ventilation. Typically, air flow monitoring stations, located in the outdoor intakes of each central HVAC air distribution system, will measure the outdoor ventilation rate. The direct outdoor airflow measurement device must be capable of measuring the outdoor airflow rate at all expected system operating conditions within an accuracy of plus or minus 15% of the design minimum outdoor air rate.

VENTILATION AIR FLOW MONITORING CONSIDERATIONS

Providing the required amount of outside air to occupied spaces is very important for core and shell buildings. Sufficient outside air must be provided to the tenant spaces at all times. Airflow monitoring stations can measure and track outdoor air quantities, which helps ensure that proper ventilation is provided.

Project teams may want to include measures that enable building occupants to monitor the CO_2 in their spaces. The control system can be specified to include expansion capability so that occupants can use CO_2 monitors and earn points in the *LEED Canada for Commercial Interiors* rating system.

5. TIMELINE AND TEAM

The placement of outdoor air sensors and intakes should be coordinated with the design team before construction documents are prepared. Engage a mechanical engineer to work on the issues of outdoor air delivery monitoring no later than the design development phase.

6. CALCULATIONS

There are no calculations required for this credit.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Incorporate airflow monitors and CO_2 sensors into floor plans, schematics, elevations (where applicable), and mechanical schedules.
- Commission ventilation systems to monitor for excess energy use.
- Alarm systems should be checked to verify settings according to ANSI/ASHRAE 62.1–2007 for mechanical ventilation systems.
- Any automated building systems used for the project should be calibrated according to manufacturer guidelines. Routine function checks of alarm systems are recommended.

IEQ	
NC	Credit 1
CS	Credit 1

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Ambient outdoor CO_2 concentrations may fluctuate between approximately 300 and 500 ppm based on local and regional factors. Project teams should consider time-of-day fluctuations near major congested highways and any annual fluctuations. High ambient CO_2 concentrations typically indicate combustion or other contaminant sources. Low ventilation rates may yield a sense of stuffiness or general dissatisfaction with IAQ.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Provide the building owner and facility manager with the information needed to understand, maintain, and use the monitoring system. Establish appropriate setpoints and control sequences, as well as recommendations for typical corrective actions, in the facility's operating plan and sequence of operations document.

Establish procedures and schedules for inspecting CO_2 monitors and airflow monitoring stations, recalibrating sensors based on the manufacturer's requirements, and testing and maintaining the exhaust systems, and include them in the building's preventive maintenance plan.

Use CO_2 sensors that require recalibration no less than every 5 years. A CO_2 monitor that has fallen out of calibration may indicate that indoor CO_2 concentrations are lower or higher than they actually are, leading to underventilation or overventilation of the space.

12. RESOURCES

WEBSITES

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
http://www.ashrae.org

ASHRAE 62.1–2007 Users Manual, Appendix A. This manual provides information on CO_2 sensors including demand-controlled ventilation. This organization advances the science of heating, ventilation, air conditioning, and refrigeration for the public's benefit through research, standards writing, continuing education, and publications. To purchase ASHRAE standards and guidelines, visit the bookstore on the ASHRAE website.

Building Air Quality: A Guide for Building Owners and Facility Managers
http://www.epa.gov/iaq/largebldgs/baqtoc.html

This EPA publication details IAQ sources in buildings and methods to prevent and resolve IAQ problems.

IEQ	
NC	Credit 1
CS	Credit 1

Indoor Air Quality in Office Buildings
http://www.hc-sc.gc.ca/ewh-semt/pubs/air/office_building-immeubles_bureaux/index-eng.php

A Technical Guide: A Health Canada publication on IAQ sources in buildings and methods to prevent and resolve IAQ problems.

PRINT MEDIA

ASHRAE 55–2004: Thermal Environmental Conditions for Human Occupancy (ASHRAE, 2004).

ASHRAE 62.1–2007: Ventilation for Acceptable Indoor Air Quality (ASHRAE, 2007).

ASHRAE 62.2–2004: Ventilation for Acceptable Indoor Air Quality in Low-Rise Residential Buildings (ASHRAE, 2004).

CSA Standard Z204-94 (R1999), Guideline for Managing Indoor Air Quality in Office Buildings: This guideline defines acceptable indoor air quality (IAQ) and provides methods to help achieve acceptable indoor air quality in office buildings, throughout the conception, design, construction, commissioning, operation, and maintenance stages.

13. DEFINITIONS

Breathing zone is the region within an occupied space between 0.9 and 1.8 metres (3 and 6 feet) above the floor. Note that this definition varies from that of ASHRAE 62.1-2007, which states that the breathing zone is between 0.9 and 1.8 metres (3 and 6 feet) from the floor, and 0.6 metres (2 feet) from the walls as well as fixed air-conditioning equipment.

CO_2 is carbon dioxide.

Demand control ventilation is the automatic reduction of outside air to a level below design rates when occupancy is less than design determined by occupancy indicators; such as, time-of-day schedules, a direct count of occupants, or an estimate of occupancy or ventilation rate per person using occupancy sensors.

Densely occupied space is an area with a design occupant density of 25 people or more per 93 square metres (1,000 square feet) or 3.7 square metres or less per person (40 square feet or less per person).

HVAC systems are equipment, distribution systems, and terminals that provide the processes of heating, ventilating, or air-conditioning. (ASHRAE 90.1-2007)

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Mechanical ventilation is provided by mechanically powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows. (ASHRAE 62.1–2007)

Natural ventilation is provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building. (ASHRAE 62.1–2007)

Occupants in a commercial building are workers who either have a permanent office or workstation in the building or typically spend a minimum of 10 hours per week in the building. In a residential building, occupants also include all persons who live in the building.

IEQ	
NC	Credit 1
CS	Credit 1

Outdoor air is the ambient air that enters a building through a ventilation system, either through intentional openings for natural ventilation or by infiltration. (ASHRAE 62.1–2007)

ppm is parts per million.

Return air is removed from a space and then recirculated or exhausted. (ASHRAE 62.1–2007)

Thermal comfort exists when occupants express satisfaction with the thermal environment.

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space. (ASHRAE 62.1–2007)

Volatile organic compounds (VOCs) are carbon compounds that participate in atmospheric photochemical reactions (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonates, and ammonium carbonate). The compounds vaporize at normal room temperatures.

IEQ	
NC	Credit 2
CS	Credit 2

INCREASED VENTILATION

	NC	CS
Credit	IEQ Credit 2	IEQ Credit 2
Points	1 point	1 point

INTENT

To provide additional outdoor air ventilation to improve indoor air quality (IAQ) and promote occupant comfort, well-being and productivity.

REQUIREMENTS: NC & CS

CASE 1. MECHANICALLY VENTILATED SPACES (NON-RESIDENTIAL)

Increase breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates required by ASHRAE Standard 62.1-2007- Ventilation for Acceptable Indoor Air Quality (with errata but without addenda[a]) as determined by IEQ Prerequisite 1: Minimum Indoor Air Quality Performance.

CASE 2. NATURALLY VENTILATED SPACES (NON-RESIDENTIAL)

Determine that natural ventilation is an effective strategy for the project by following the flow diagram process shown in Figure 2.8 of the Chartered Institution of Building Services Engineers (CIBSE) Applications Manual 10: 2005, Natural Ventilation in Non-domestic Buildings.

AND

OPTION 1

Show that the natural ventilation systems design meets the recommendations set forth in the CIBSE manuals appropriate to the project space.

PATH 1. CIBSE Applications Manual 10: 2005, Natural ventilation in Non-domestic Buildings.

PATH 2. CIBSE AM 13:2000, Mixed Mode Ventilation.

[a] Project teams wishing to use ASHRAE approved addenda for the purposes of this credit may do so at their discretion. Addenda must be applied consistently across all LEED credits.

IEQ	
NC	Credit 2
CS	Credit 2

OR

OPTION 2

Use a macroscopic, multi-zone, analytic model to predict that room-by-room airflows will effectively naturally ventilate, defined as providing the minimum ventilation rates required by ASHRAE 62.1-2007 Chapter 6 (with errata but without addenda), for at least 90% of occupied spaces.

CS ADDITIONAL REQUIREMENT:

The core and shell buildings that are designed to be naturally ventilated must provide the capability for the tenant build-out to meet the requirements of this credit.

CASE 3. RESIDENTIAL BUILDINGS ONLY

Design ventilation systems in accordance with ASHRAE 62.1-2007 and provide outside air through a central or individual system, ducted directly to the suite with air distributed to all regularly occupied areas in the suite.

INTERPRETATIONS

This increase in outdoor air above ASHRAE 62.1-2007 values must be accounted for in EA Credit 1 by modelling the proposed building with 30% higher outdoor air in the breathing zone than the baseline/reference building (see EA Credit 1 and the *LEED Canada Energy Modelling Rules*).

IEQ	
NC	Credit 2
CS	Credit 2

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Canadians spend about 90% of their time indoors, where concentrations of pollutants are often much higher than those outside.[22] Of the thousands of chemicals and biological pollutants found indoors, many are known to have significant health impacts. Risks include asthma, cancer, and reproductive and developmental problems.[23] Increasing ventilation above minimum standards improves the indoor air quality (IAQ) of a building's occupied spaces and directly benefits occupants' health and well-being.

ECONOMIC ISSUES

Depending on the climate, increasing ventilation rates by 30% beyond ASHRAE 62.1–2007 can yield higher HVAC energy costs and potentially greater HVAC capacity needs than those associated with the minimum ventilation rates established in the standard. This increase in HVAC capacity and energy use will be more pronounced in extreme climates than in mild, temperate climates. Some projects may choose to increase the outdoor air intake rate and accept higher HVAC equipment and energy costs because research indicates that the resulting IAQ is associated with improved employee health, welfare, well-being, and productivity. The use of heat transfer equipment, like heat recovery wheels, can precondition intake air and minimize the extent to which increased ventilation requires additional energy to heat and cool intake air.

Although a naturally ventilated building may have less equipment than a comparable mechanically ventilated building, natural ventilation designs may require additional costs for operable windows, increased thermal mass, and other architectural elements that enable passive ventilation and space conditioning. Energy and maintenance costs for naturally ventilated buildings tend to be lower than for comparable mechanically ventilated spaces.

For mechanically ventilated and air-conditioned buildings, increasing ventilation rates will require somewhat greater HVAC system capacity and energy use, adding to both capital and operational costs. Natural ventilation systems can provide increased ventilation rates and good IAQ. They also allow for individual occupant control over thermal comfort and ventilation via operable windows while potentially reducing operating costs compared to mechanical ventilation systems.

CS

Increased outdoor air rates may result in improved tenant attraction and retention.

2. RELATED CREDITS

Ventilation strategies influence the overall energy performance of the building and require commissioning as well as measurement and verification. Increased ventilation can increase energy consumption. Installing a permanent ventilation performance monitoring system can facilitate the achievement and maintenance of increased ventilation. For these reasons, increased ventilation is related to the following other credits:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance

IEQ	
NC	Credit 2
CS	Credit 2

- EA Credit 3: Enhanced Commissioning
- EA Credit 5: Measurement and Verification
- IEQ Credit 1: Outdoor Air Delivery Monitoring

3. SUMMARY OF REFERENCED STANDARDS

American National Standards Institute (ANIS)/ ASHRAE Standard 62.1–2007: Ventilation For Acceptable Indoor Air Quality
American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
http://www.ashrae.org
This standard specifies minimum ventilation rates and IAQ levels so as to reduce the potential for adverse health effects. The standard specifies that ventilation systems be designed to prevent uptake of contaminants, minimize growth and dissemination of microorganisms, and, if necessary, filter particulates.

The standard outlines a ventilation rate procedure and an IAQ procedure for compliance. The ventilation rate procedure prescribes outdoor air quality levels acceptable for ventilation; treatment measures for contaminated outdoor air; and ventilation rates for residential, commercial, institutional, vehicular, and industrial spaces. The IAQ Procedure is a performance-based design approach in which the building and its ventilation system maintain concentrations of specific contaminants at or below certain previously determined limits in order to achieve an indoor air quality acceptable to building occupants and/or visitors. For the purposes of this procedure, acceptable perceived indoor air quality excludes dissatisfaction related to thermal comfort, noise and vibration, lighting, and psychological stressors. The IAQ procedure also includes criteria for the following situations: reducing outdoor air quantities when recirculated air is treated by contaminant-removal equipment and ventilating when a space's air volume is used as a reservoir to dilute contaminants. The IAQ procedure incorporates quantitative and subjective evaluation and restricts contaminant concentrations to acceptable levels.

ASHRAE updated the standard in 2007 to include requirements for buildings that allow smoking in designated areas to separate areas with environmental tobacco smoke (ETS) from those without ETS. The standard now also clarifies how designers must analyze mechanical cooling systems to limit indoor relative humidity that would cause dampness-related problems such as mould and microbial growth.

Project teams wishing to use ASHRAE-approved addenda for the purposes of this credit may do so at their own discretion. Apply addenda consistently across all LEED credits.

Chartered Institute of Building Services Engineers (CIBSE) Applications Manual 10–2005, Natural Ventilation in Non-Domestic Buildings
CIBSE, London
http://www.cibse.org
CIBSE Applications Manual 10–2005 provides guidance for implementing natural ventilation in non-residential buildings. It provides detailed information on how to adopt natural ventilation as the sole servicing strategy for a building or as an element in a mixed mode design. According to the publisher, this manual "is a major revision of the Applications Manual (AM) first published in 1997. At the time, there was a significant expansion of interest in the application of engineered natural ventilation to the design of non-domestic buildings. The original AM10 sought to capture the state of knowledge as it existed in the mid-90s and present it in a form suited to the needs of every member of the design team. Some 10 years on from the time when the initial manual was conceived, the state of knowledge has increased, and experience in the design and operation of

naturally ventilated buildings has grown. This revision of AM10 is therefore a timely opportunity to update and enhance the guidance offered to designers and users of naturally ventilated buildings."

IEQ	
NC	Credit 2
CS	Credit 2

4. IMPLEMENTATION

A green building should provide its occupants with superior indoor air quality (IAQ) to support their productivity and well-being. Providing adequate ventilation rates is key to maintaining superior IAQ. Underventilated buildings may be stuffy, odorous, uncomfortable and/or unhealthy.

Building ventilation systems, including both active HVAC systems and natural ventilation systems, are designed and installed to introduce fresh outside air into the building while exhausting an equal amount of building air. HVAC systems also typically provide thermal comfort. Building conditioning systems that provide enhanced ventilation air as efficiently and effectively as possible will help to maintain a high standard of indoor air quality in the building.

STRATEGIES

There are 3 basic methods for ventilating buildings:

- mechanical ventilation (i.e., active ventilation);
- natural ventilation (i.e., passive ventilation); and
- mixed-mode ventilation (i.e., both mechanical and natural ventilation).

Projects employing both mechanical and natural ventilation (i.e., mixed-mode ventilation) must exceed the minimum ventilation rates required by ASHRAE 62.1–2007, Chapter 6, by at least 30%.

MECHANICALLY VENTILATED SPACES: VENTILATION RATE PROCEDURE

Section 6 of ASHRAE 62.1–2007 outlines guidelines for determining ventilation rates for various applications of mechanical ventilation systems, using either the ventilation rate procedure or the IAQ procedure. The ventilation rate procedure is easier to apply and used more frequently than the IAQ procedure. It is the recommended approach in IEQ Prerequisite 1, Minimum Indoor Air Quality Performance.

When following the ventilation rate procedure, use the methodology found in Section 6.2 of ASHRAE 62.1–2007. The breathing zone outdoor airflow is equal to the sum of the outdoor airflow rate required per person times the zone population, plus the outdoor airflow rate required per unit area times the zone floor area. The standard's Table 6-1, Minimum Ventilation Rates in Breathing Zone, provides information by occupancy category to determine both the amount of outdoor air needed to ventilate people-related source contaminants and area-related source contaminants. The people-related sources figure of the outdoor air rate addresses actual occupancy density and activity. The area-related sources figure accounts for background off-gassing from building materials, furniture, and materials typically found in that particular occupancy. Finally, the required zone outdoor airflow is the breathing zone outdoor airflow adjusted to reflect the "zone air distribution effectiveness" using adjustment factors in Table 6-2 of the standard. For multiple-zone systems, outdoor air intake flow is adjusted to reflect the "system ventilation efficiency" for the air distribution configuration, using adjustment factors in Table 6-3 of the standard.

IEQ	
NC	Credit 2
CS	Credit 2

NATURALLY VENTILATED SPACES

When choosing natural ventilation, there are 2 ways to demonstrate credit compliance: one is by using the compliance path found in Chapter 2 of the CIBSE Applications Manual 10–2005 (AM10); the other is to provide documentation using a macroscopic, multi-zone, analytic model that predicts room-by-room air flow rates.

When using AM10 (see Figure 2-1), begin by establishing the required flow rates through each space. There is an acceptable average rate needed for IAQ and thermal comfort; exceeding this rate results in wasted energy during heating seasons. Additional ventilation is needed for summer cooling requirements. There are several ways to determine the acceptable average rate needed for IAQ and thermal comfort, such as by using a separate manual or simulation software listed in AM10; project teams should explain their choice. Submittals must include a narrative with information on the building, its orientation, and the glazing ratios. Include a summary of the internal heat gains and weather conditions; explain the ventilation strategy, including the airflow paths, rates planned for different operational periods during the day and night, peak internal temperatures, and means of shading for summer solar gains; provide sample calculations on how the opening size for operable windows, trickle vents and louvers was determined; and include the calculations for the driving pressure, showing the effects of both wind and stack-induced pressure differentials.

When using a macroscopic, multi-zone, analytic model that predicts room-by-room air flow rates, provide a narrative with the same information listed above and demonstrate that 90% of the occupied areas meet the room-by-room airflow rates. Indicate what standard was used, such as Volume A of the CIBSE Guide, ASHRAE 62.1–2007, Section 6.2, or other.

CS

In some instances, project teams may not know who will be the final occupants of core and shell buildings. In that case, use the default occupancy counts provided in ASHRAE 62.1-2007 Table 6-1. These numbers can be used for projects where occupancy is unknown as long as the gross floor area per occupant is no greater than that in the default occupant density in Table 6-1. Other numbers can be used if justification is provided.

Core & Shell projects with multiple-zoned systems should use a "system ventilation efficiency," that reflects the expected occupant distribution. A tenant fit test or sample plan can be used to approximate the occupant distribution and estimate the "system ventilation efficiency." Not accounting for spaces with a high occupant density can lead to undersized ventilation systems and can affect compliance with ASHRAE 62.1–2007.

LEED Canada for Core & Shell requires that applicants demonstrate that the delivered minimum zone outdoor airflow is at least 30% higher than the minimum airflow required by ASHRAE 62.1–2007 for each zone.

IEQ	
NC	Credit 2
CS	Credit 2

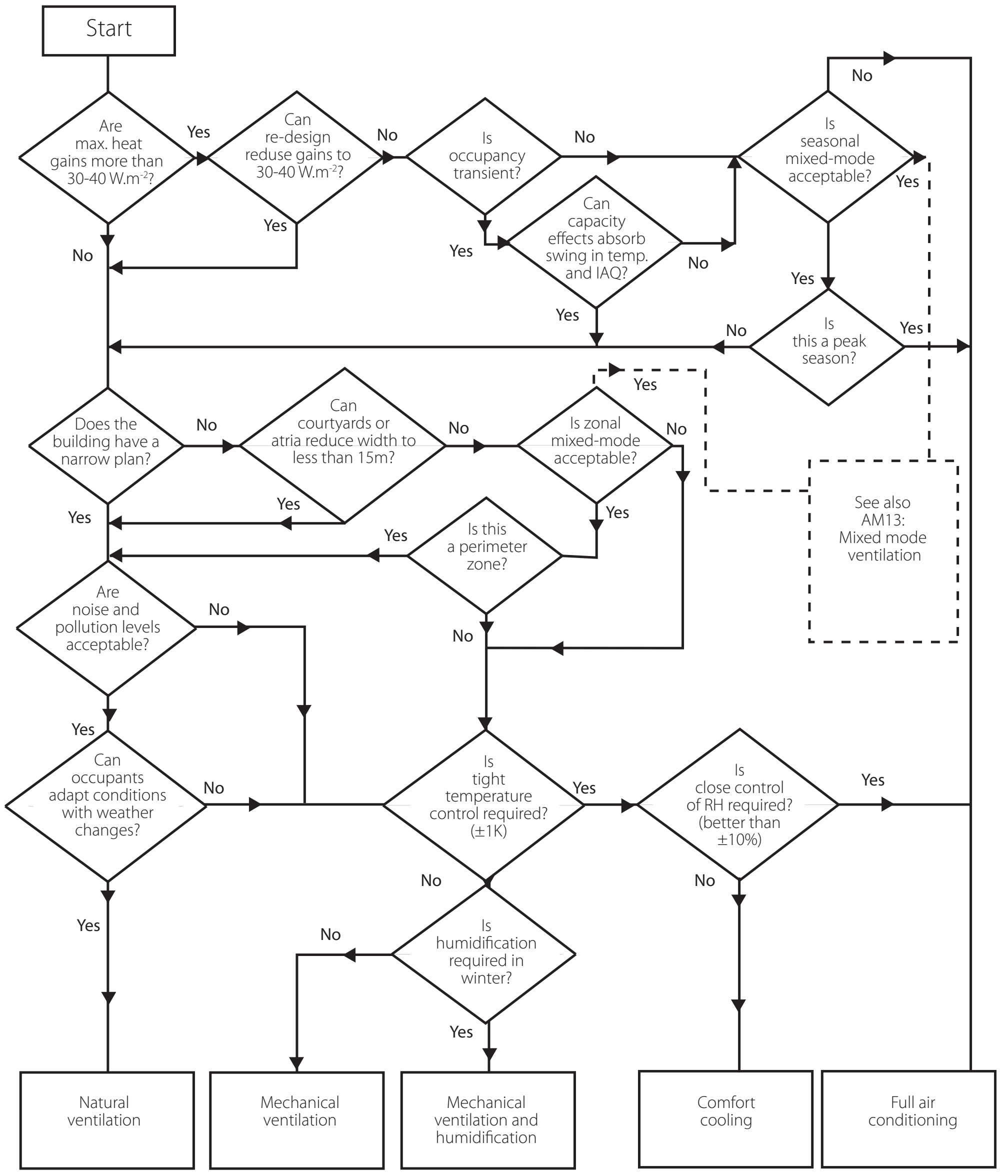
Table 1 shows how the sample space used in IEQ Prerequisite 1 has attained the 30% increase.

TABLE 1. ASHRAE 62.1–2007 VENTILATION RATE PROCEDURE

ZONE		STANDARD CASE: ASHRAE 62.1–2007 VERIFICATION RATE PROCEDURE										DESIGN CASE		
				TABLE 6-1			TABLE 6-2		TABLE 6-3					
ZONE	**OCCUPANCY CATEGORY**	**AREA (m^2)**	**PEOPLE OUTDOOR AIR RATE (L/S/ PERSON)**	**AREA OUTDOOR AIR RATE ($L/s/m^2$)**	**OCCUPANT DENSITY (#/ 100 m^2)**	**BREATHING ZONE OUTDOOR AIR FLOW Vbz (L/s)**	**ZONE AIR DISTRIBUTION EFFECTIVENESS Ez**	**ZONE OUTDOOR AIR FLOW Voz (L/s)**	**SYSTEM VENTILATION EFFICIENCY Ev**	**MINIMUM OUTDOOR AIR INTAKE FLOW Vot (L/s)**	**DESIGN OUTDOOR AIR INTAKE FLOW (L/s)**	**ZONE PRIMARY AIR FLOW FACTION Vpz (L/s)**	**PRIMARY OUTDOOR AIR FRACTION Zp = Voz/Vpz**	**% INCREASE OVER STANDARD**
General Office	Office Space	755	2.5	0.3	5	321	1.0	321	1.0	321	425	3,776	0.09	32%
Training Room	Lecture Classroom	70	3.8	0.3	65	194	1.2	162	0.9	180	236	661	0.24	31%
Break Room	Conference Meeting	19	2.5	0.3	50	30	1.0	30	1.0	30	40	236	0.13	36%
Total		836				545		513		531	701	4,673		32%
Notes:	*For the general office space, air distribution is overhead, hence Ez = 1. Outdoor air fraction, Zp, < 0.15, hence system ventilation efficiency is 1.0.* *For the training room, air distribution is underfloor, hence Ez = 1.2. Outdoor air fraction, Zp < 0.25, hence system ventilation efficiency is 0.9.* *For the break room, air distribution is overhead, hence Ez = 1. Outdoor air fraction, Zp, < 0.15, hence system ventilation efficiency is 1.0.*													

IEQ	
NC	Credit 2
CS	Credit 2

FIGURE 1. SELECTING NATURAL VENTILATION FOR NONDOMESTIC BUILDINGS



From CIBSE Applications Manual 10–2005. Reproduced with permission from the Chartered Institute of Building Services Engineers, London.

5. TIMELINE AND TEAM

Most project teams decide early on whether to have a mechanical ventilation system, a passive ventilation system, or a combination. This decision might be influenced by the building size and type, as well as climatic, economic, and organizational considerations. Figure 1, from CIBSE AM–10, provides a decision diagram to help teams make an informed evaluation. In addition, project teams considering natural ventilation should evaluate site conditions and building design. Potential IAQ problems might arise from traffic exhaust, nearby polluting industries, and neighbouring waste management sites.

IEQ	
NC	Credit 2
CS	Credit 2

For mechanical ventilation, the design and operating setpoints of the HVAC system will largely determine ventilation rates. Building owners and designers should determine whether increasing ventilation rates beyond ASHRAE 62.1–2007 requirements is a good idea for the facility. If so, the HVAC design and sizing should account for increased ventilation rates.

Occupants generally take a primary role in managing ventilation conditions in naturally ventilated buildings by opening and closing windows. Naturally ventilated buildings generally have somewhat more variable ventilation rates than actively conditioned buildings.

In addition to designing the HVAC systems properly and selecting appropriate building materials, the project team may choose to increase ventilation rates beyond standard practice as one way of providing superior indoor air quality. Managing IAQ concerns during construction and operation is also appropriate for many green building projects.

6. CALCULATIONS

MECHANICALLY VENTILATED SPACES

To show compliance in mechanically ventilated spaces, use the calculations in the ASHRAE User Manual and the IEQ Prerequisite 1 Section 6, Calculations and the LEED Letter Template. The same calculations are used to document IEQ Prerequisite 1.

NATURALLY VENTILATED SPACES

Determine the opening sizes for operable windows, trickle vents, and louvers in accordance with CIBSE Applications Manual 10–2005. Alternatively, for project teams using a macroscopic, multi-zone, analytic model that predicts room-by-room airflow rates, provide the room-by-room outdoor airflow rates predicted by the analysis and a comparison with minimum ventilation rates required by ASHRAE 62.1–2007, Section 6.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Size mechanical equipment to accommodate increased ventilation rates.
- For naturally ventilated projects, maintain appropriate visual documentation (e.g., plans) of open areas within the project.

8. EXAMPLES

Ventilation rates as specified by ASHRAE must be determined for each space. The example in Table 2 calculates the percentage increase in ventilation for 3 sample spaces, each of which provides increased ventilation sufficient to meet the credit requirements.

IEQ	
NC	Credit 2
CS	Credit 2

TABLE 2. SAMPLE SUMMARY CALCULATIONS FOR INCREASED MECHANICAL VENTILATION

ZONE	OCCUPANCY	AREA (m^2)	STANDARD ZONE OUTDOOR AIRFLOW Voz ($L/s/m^2$)	DESIGN ZONE OUTDOOR AIRFLOW ($L/s/m^2$)	PERCENTAGE INCREASE
General office	Office space	743	0.45	0.59	31.1
Training room	Lecture hall	70	2.34	3.05	32.7
Break room	Conference, meeting	20	1.72	2.24	30.2

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Additional ventilation is more practical for mild climates, where increasing ventilation beyond the ASHRAE 62.1–2007 minimum rates will not have as great an impact on HVAC systems' capacity and energy consumption as in hot, humid, or cold climates. Natural ventilation and passive conditioning approaches are also more typical in mild and temperate climates, although there are precedents for passively conditioned buildings in all climates. There may be variable conditions in naturally ventilated buildings, but occupants are satisfied because they control their environment.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

For mechanically ventilated systems, provide the building operator with copies of the ventilation rate procedure calculations for each zone used to show compliance with ASHRAE 62.1–2007. Over the building's life, these can be updated with actual occupancy values to adjust delivered ventilation rates as appropriate.

Provide maintenance personnel with the information needed to understand, maintain, and use the ventilation system and retain mechanical design documents showing zone configurations. Establish appropriate setpoints and control sequences, as well as recommendations for typical corrective actions, and include them in the facility's building operating plan and sequence of operations document. Establish procedures and schedules for testing and maintaining exhaust systems, and include them in the building's preventive maintenance plan.

IEQ	
NC	Credit 2
CS	Credit 2

12. RESOURCES

WEBSITES

Air Change Effectiveness Measurements in Two Modern Office Buildings
http://www.fire.nist.gov/bfrlpubs/build94/PDF/b94024.pdf

A case study on ventilation effectiveness.

American National Standards Institute (ANSI)/ ASHRAE Standard 62.1–2007: Ventilation For Acceptable Indoor Air Quality
ASHRAE
http://www.ashrae.org

ASHRAE advances the science of heating, ventilation, air conditioning, and refrigeration for the public's benefit through research, standards writing, continuing education, and publications. To purchase ASHRAE standards and guidelines, visit the bookstore on the ASHRAE website.

Building Air Quality Action Plan
U.S. EPA
http://www.epa.gov/iaq/largebldgs/#Building%20Air%20Quality%20Action%20Plan

Building Assessment, Survey, and Evaluation Study
U.S. EnviroEPA
http://www.epa.gov/iaq/base/index.html

Chartered Institute of Building Services Engineers (CIBSE) Applications Manual 10–2005, Natural Ventilation in Non-domestic Buildings
CIBSE, London
http://www.cibse.org

CIBSE Applications Manual 10–2005 provides guidance for implementing natural ventilation in non-residential buildings. It provides detailed information on how to adopt natural ventilation as the sole servicing strategy for a building or as an element in a mixed mode design. According to the publisher, this manual "is a major revision of the Applications Manual (AM) first published in 1997. At the time, there was a significant expansion of interest in the application of engineered natural ventilation to the design of nondomestic buildings. The original AM10 sought to capture the state of knowledge as it existed in the mid-90s and present it in a form suited to the needs of every member of the design team. Some 10 years on from the time when the initial manual was conceived, the state of knowledge has increased, and experience in the design and operation of naturally ventilated buildings has grown. This revision of AM10 is therefore a timely opportunity to update and enhance the guidance offered to designers and users of naturally ventilated buildings."

CIB
http://www.ecbcs.org/docs/index.htm

Air Flow Patterns within Buildings, Annex 20
Multizone Airflow Modelling, Annex 23
Air Flow in Large Enclosures, Annex 26
Control Strategies for Hybrid Ventilation in New & Retrofitted Office Buildings, Annex 35

Cost-Effective Open-Plan Environment (COPE) Research Reports
http://www.nrc-cnrc.gc.ca/eng/projects/irc/cope/reports.html

Institute for Research in Construction, National Research Council and COPE Consortium has in-depth studies of open-plan office design variables and their effect on occupant satisfaction,

IEQ	
NC	Credit 2
CS	Credit 2

including workstation design, indoor air quality and thermal comfort, lighting and acoustics. Studies include field and literature reviews, mock-up office experiments, and simulations to investigate the many elements of the open-plan office. (Some reports are not yet available.) Reports include:

- Environmental Satisfaction in Open-Plan Environments: 2. Effects of Workstation Size, Partition Height and Windows
- Office Air Distribution Systems and Environmental Satisfaction
- A Literature Review on the Relationship between Outdoor Ventilation Rates in Offices and Occupant Satisfaction
- Investigation of Air and Thermal Environments in a Mock-up Open Plan Office: Measurements and CFD Simulations
- The Effect of Office Design on Workstation Lighting: Simulation Results
- Effects of Office Design on the Annual Daylight Availability

Hype vs. Reality: New Research Findings on Underfloor Air Distribution Systems:
http://www.cbe.berkeley.edu/RESEARCH/pdf_files/Lehrer2003_UFAD.pdf

Describes potential benefits, pitfalls and design and construction issues of underfloor air distribution systems.

Mixed Mode Ventilation: HVAC Meets Mother Nature
http://www.esmagazine.com/Articles/Feature_Article/f20a4e5bd9ba8010VgnVCM100000f932a8c0

A May 2000 article in Engineered Systems about various options for building ventilation.

Underfloor Air Technology
http://www.cbe.berkeley.edu/underfloorair/Default.htm

This extensive website by the University of Berkeley's Center for the Built Environment offers an overview of underfloor air distribution systems provides design and construction design guidelines, research, sample plans and sections, as well as several detailed case studies and information resources.

PRINT MEDIA

ASHRAE Handbook: Fundamentals, ASHRAE, 2001.

ASHRAE Handbook: HVAC Systems and Equipment, ASHRAE, 2004.

Grumman, D. ASHRAE GreenGuide, ASHRAE, 2003.

Designer's Guide to Ceiling-Based Air Diffusion, ASHRAE, 2002.

Displacement Ventilation in Non-Industrial Premises, REHVA, 2001.

Chen, Q. & Glicksman, L. System Performance Evaluation and Design Guidelines for Displacement Ventilation, ASHRAE, 2003.

Bauman, F. & Daly, A. Underfloor Air Distribution Design Guide, ASHRAE, 2000.

UK CIBSE Application Manuals <www.cibse.org>
- AM10, "Natural Ventilation in Nondomestic Buildings"
- AM 11, "Building Energy & Environmental Modeling"
- AM13, "Mixed Mode Ventilation"

IEQ	
NC	Credit 2
CS	Credit 2

13. DEFINITIONS

Air-conditioning is the process of treating air to meet the requirements of a conditioned space by controlling its temperature, humidity, cleanliness, and distribution (ASHRAE 62.1–2007).

Breathing zone is the region within an occupied space between 0.9 and 1.8 metres (3 and 6 feet) above the floor. Note that this definition varies from that of ASHRAE 62.1-2007, which states that the breathing zone is between 0.9 and 1.8 metres (3 and 6 feet) from the floor, and 0.6 metres (2 feet) from the walls as well as fixed air-conditioning equipment.

Conditioned space is the part of a building that is heated or cooled, or both, for the comfort of occupants. (ASHRAE 62.1–2007)

Contaminants are unwanted airborne elements that may reduce air quality. (ASHRAE 62.1– 2007)

Exfiltration is air leakage through cracks and interstices and through the ceilings, floors, and walls.

Exhaust air is removed from a space and discharged outside the building by means of mechanical or natural ventilation systems.

HVAC systems are equipment, distribution systems, and terminals that provide the processes of heating, ventilating, or air-conditioning. (ASHRAE 90.1-2007)

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Infiltration is air leakage into conditioned spaces through cracks and interstices in ceilings, floors, and walls. (ASHRAE 62.1–2007).

Mechanical ventilation is provided by mechanically powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows. (ASHRAE 62.1–2007)

Mixed-mode ventilation combines mechanical and natural ventilation methods.

Natural ventilation is provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building. (ASHRAE 62.1–2007)

Off-gassing is the emission of volatile organic compounds (VOCs) from synthetic and natural products.

Outdoor air is the ambient air that enters a building through a ventilation system, either through intentional openings for natural ventilation or by infiltration. (ASHRAE 62.1–2007)

Recirculated air is removed from a space and reused as supply air, delivered by mechanical or natural ventilation.

Supply air is air delivered by mechanical or natural ventilation to a space, composed of any combination of outdoor air, recirculated air, or transfer air. (ASHRAE 62.1–2007)

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space. (ASHRAE 62.1–2007)

IEQ	
NC	Credit 3.1
CS	Credit 3

CONSTRUCTION IAQ MANAGEMENT PLAN: DURING CONSTRUCTION

	NC	CS
Credit	IEQ Credit 3.1	IEQ Credit 3
Points	1 point	1 point

INTENT

To reduce indoor air quality (IAQ) problems resulting from construction or renovation and promote the comfort and well-being of construction workers and building occupants.

REQUIREMENTS: NC & CS

Develop and implement an IAQ Management Plan for the construction and pre-occupancy phases of the building as follows:

- During construction, meet or exceed the recommended control measures of the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) IAQ Guidelines For Occupied Buildings Under Construction, 2nd Edition 2007, ANSI/SMACNA 008-2008 (Chapter 3).
- Protect stored on-site and installed absorptive materials from moisture damage.
- If permanently installed air handlers are used during construction, filtration media with a minimum efficiency reporting value (MERV) of 8 must be used at each return air grille, as determined by ASHRAE 52.2-1999 (with errata but without addenda[a]). Replace all filtration media immediately prior to occupancy.

INTERPRETATIONS

LEASED TENANT SPACE (NC)

For NC certification, mandatory lease agreements are required for leased tenant space not fit-up at the time of certification. The lease agreements must indicate to future tenants direction on the requirements of this credit by listing the approaches required by the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) IAQ Guidelines For Occupied Buildings Under Construction, 2nd Edition 2007, ANSI/SMACNA 008-2008 (Chapter 3).

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[a] Project teams wishing to use ASHRAE approved addenda for the purposes of this credit may do so at their discretion. Addenda must be applied consistently across all LEED credits.

IEQ	
NC	Credit 3.1
CS	Credit 3

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Reducing indoor air contaminants improves comfort levels, lowers absenteeism, and increases productivity. Demolition and construction practices lead to increased exposure to indoor air pollutants through the introduction of synthetic building materials, power equipment and vehicles, new furnishings, and finish materials. The negative effects of the construction process on indoor air quality can be heightened by reduced ventilation rates (typical during the construction phase) and a lack of attention to pollutant source control. If unaddressed, the contamination can result in poor IAQ extending over the lifetime of the building. Fortunately, there are IAQ management strategies that, if instituted during construction and before occupancy, will minimize potential problems (see Implementation).

ECONOMIC ISSUES

Consider the time and labour required to maintain a clean construction site. Protecting the ventilation system and isolating work that involves power equipment are critical methods to preventing the introduction of indoor air contaminants. Clean ventilation systems and building spaces can also extend the lifetime of the ventilation system and improve its efficiency, resulting in reduced energy use. Construction schedule disruption can be avoided through the proper sequencing of material installation, so as to reduce contamination and maintain the project schedule. Early coordination between the design team, contractor and subcontractors can minimize or eliminate scheduling delays.

CS

For some Core & Shell building types, ongoing construction may overlap with tenant space build-out—often when the building is fully enclosed and major building systems are in place. Core & Shell project teams should carefully consider coordinating the construction IAQ management plan with tenants' plans and, ideally, a tenant IAQ management plan.

2. RELATED CREDITS

Construction activities can affect the IAQ of the building long after occupancy. Successfully implementing a construction IAQ management plan, selecting low-emitting finish materials and furnishings, and isolating indoor pollutant sources will reduce levels of indoor contaminants. The following credits relate to IAQ management before occupancy:

- IEQ Credit 3.2: Construction Indoor Air Quality Management Plan—Before Occupancy
- IEQ Credit 4: Low-Emitting Materials
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control

IEQ	
NC	Credit 3.1
CS	Credit 3

CS

Core & Shell projects are eligible for exemplary performance under the Innovation in Design section when project teams enforce a construction indoor air quality management plan for 100% of the tenant spaces.

The following credits are therefore related when tenants pursue *LEED Canada for Commercial Interiors* Certification. It is important to note that there are a number of credit synergies between *LEED Canada for Core & Shell* and *LEED Canada for Commercial Interiors* rating systems. This is intentional to encourage tenants within a Core & Shell-certified project to pursue *LEED Canada for Commercial Interiors* certification.

- IEQ Credit 3.1: Construction IAQ Management Plan—During Construction
- IEQ Credit 3.2: Construction IAQ Management Plan—Before Occupancy
- IEQ Credit 4: Low-Emitting Materials
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control

3. SUMMARY OF REFERENCED STANDARDS

Sheet Metal and Air Conditioning Contractors National Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, 2nd edition, Chapter 3, November 2007
http://www.smacna.org
The Sheet Metal and Air Conditioning Contractors National Association (SMACNA) is an international organization that developed guidelines for maintaining healthful indoor air quality during demolitions, renovations, and construction. The full document covers air pollutant sources, control measures, IAQ process management, quality control and documentation, interpersonal communication, sample projects, tables, references, resources, and checklists.

American National Standards Institute (ANSI)/ASHRAE Standard 52.2–1999: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE
http://www.ashrae.org
This standard presents methods for testing air cleaners for 2 performance characteristics: the device's capacity for removing particles from the air stream and the device's resistance to airflow. The minimum efficiency reporting value (MERV) is based on 3 composite average particle size removal efficiency points. Consult the standard for a complete explanation of MERV calculations.

4. IMPLEMENTATION

Complete the construction IAQ management plan before construction begins. The plan should include agenda items to be discussed regularly at preconstruction and construction meetings. Continually educating subcontractors and field personnel and giving them the proper resources (e.g., collection bins, cleaning tools and materials) reinforce the importance of following the plan's procedures and encourage their compliance. The referenced SMACNA standard recommends control measures in 5 areas: HVAC protection, source control, pathway interruption, housekeeping, and scheduling. Review the applicability of each control measure and include those that apply in the final construction IAQ management plan. The control measures are as follows:

IEQ	
NC	Credit 3.1
CS	Credit 3

HVAC PROTECTION

Ideally during demolition and construction, the permanently installed HVAC systems should not be used because the systems can become contaminated and damaged. In most cases, using the HVAC system during construction activates the clock on the manufacturer's warranty, exposing the contractor to potential out-of-pocket costs if problems occur when the manufacturer's warranty has expired but the warranty for the building has not. Using temporary ventilation units is feasible, practical and generally not costly. Using temporary ventilation units is one strategy to meet the SMACNA control measure for HVAC protection. However, it does not satisfy all of the requirements of this credit on its own. Other strategies to mitigate contamination of both HVAC equipment and occupied spaces during construction are detailed below.

The contractor should protect all HVAC equipment from both dust and odours and seal all duct and equipment openings with plastic. If the system must be operated to maintain service to other occupied portions of the building or to protect finished work, the contractor should be sure to protect the return/negative pressure side of the system. If the returns cannot be closed, the construction team should install and maintain temporary filters over grilles and openings. To comply with the credit requirements, the filtration medium must have a rating of MERV 8 or better. If an unducted plenum over the construction zone must be used, the team should isolate it by having all ceiling tiles in place. The construction team should check for leaks in the return ducts and air handlers and make needed repairs promptly. The contractor should avoid using the mechanical rooms for construction storage.

The contractor should replace all filtration media just before occupancy, installing only a single set of final filtration media. Note that the requirement for MERV 13 rated filters has been moved to IEQ Credit 5: Indoor Chemical and Pollutant Source Control. This credit does not regulate the efficiency of the filters used for the long-term operation of the building.

SOURCE CONTROL

The architect or designer should specify finish materials such as paints, carpet, composite wood, adhesives and sealants that have low-toxicity levels or none at all. (Note that the selection of low-emitting materials is covered under IEQ Credit 4: Low-Emitting Materials). The Construction IAQ Management Plan should specify the control measures for materials containing VOCs. The construction team should recover, isolate and ventilate containers housing toxic materials. Finally, exhaust fumes from idling vehicles and gasoline-fuelled tools to the exterior of the building through the use of funnels or temporary piping.

PATHWAY INTERRUPTION

During construction, the contractor must isolate areas of work to prevent contamination of clean or occupied spaces. Depending on weather conditions, the contractor should ventilate using 100% outside air to exhaust contaminated air directly to the outside during installation of VOC-emitting materials. Depressurizing the work area will allow the air pressure differential between construction and clean areas to contain dust and odours. The contractor should provide temporary barriers that contain the construction area.

HOUSEKEEPING

The project and building maintenance teams should institute cleaning activities designed to control contaminants in building spaces during construction and before occupancy. The maintenance team should protect all porous building materials from exposure to moisture and

IEQ	
NC	Credit 3.1
CS	Credit 3

store them in a clean area before installation. The team should use vacuum cleaners with high-efficiency particulate filters, increase cleaning frequency and use wetting agents for dust.

SCHEDULING

The contractor and the project team should coordinate construction activities to minimize or eliminate disruption of operations in the occupied portions of the building. The contractor should sequence construction activities carefully over the duration of the project to minimize the impact on IAQ. It might be necessary to conduct activities with high pollution potential during off hours, such as weekends or evenings, to allow time for new materials to air out. The contractor should plan adequate time to conduct flush-out and IAQ test procedures before occupancy. Upon completion of construction, the contractor should replace all filtration media just before occupancy, and coordinate this activity with the activities and requirements addressed in IEQ Credit 3.2: Construction IAQ Management—Before Occupancy and IEQ Credit 5: Indoor Chemical and Pollution Source Control.

CS

While future tenant fit-outs are not addressed in *LEED Canada for Core & Shell*, minimizing cross contamination of existing tenant spaces as future tenants build out their spaces should also be considered. The Sheet Metal and Air Conditioning Contractors' National Association's (SMACNA's) IAQ Guidelines for Occupied Buildings under Construction details many measures to help improve the indoor air quality of occupied buildings under construction. One measure is to seal off the return air system from the construction site. Another measure is to exhaust contaminants directly from construction to the building's exterior. A comprehensive building IAQ management plan can help minimize health risks to existing tenants during construction of new tenant space.

5. TIMELINE AND TEAM

Scheduling aspects of this credit are related to the sequencing of demolition and construction procedures as well as the installation of finish materials. It is best to select low-emitting materials and install any products that emit VOCs before installing absorbent materials, such as ceiling tiles, gypsum wallboard, fabric furnishings, carpet, and insulation. If possible, store these materials in an isolated area to minimize contamination.

Give subcontractors and field personnel copies of the construction IAQ management plan prior to the initiation of work, and contractually require them to implement the applicable plan components. Post a copy of the plan in an obvious location on the job site and conduct periodic visual inspections to help enforce compliance.

6. CALCULATIONS

There are no calculations required for this credit.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the

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following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Create a written construction IAQ management plan for use during demolition and construction.
- Maintain a detailed photo log of the construction IAQ management plan practices followed during construction.

8. EXAMPLES

INDOOR AIR QUALITY MANAGEMENT PLAN (FACILITY ALTERATIONS)

1) Goals and Scope

To limit indoor air quality problems resulting from construction or renovation projects, (Building) must implement this Indoor Air Quality (IAQ) management plan to sustain the comfort and well-being of occupants and construction workers.

2) SMACNA Guidelines

The following is a list of example procedures. The project team should create a Construction IAQ Management Plan appropriate to the scope of work being completed.

The following Construction IAQ Management Plan measures must be implemented throughout the construction and occupancy phase of any project.

a) HVAC Protection: Provide project-specific measures to be employed.
   i) When possible, HVAC system should be shut down during construction.
b) Source Control: Provide project-specific measures to be employed.
   i) Product substitution: low emitting paints, adhesives, sealants, and carpets must be used when feasible.
c) Pathway Interruption: Provide project specific measures to be employed.
d) Housekeeping: Provide project-specific measures to be employed.
   i) Services must utilize best practices for minimizing IAQ problems, such as dust suppression, cleaning frequency, cleaning efficiency, water and spill cleanup, protection of on-site or installed absorptive and porous material.
e) Scheduling: Provide project specific measures to be employed.
   i) Building flush out: After construction ends and all interior finishes have been installed, new filtration media must be installed and a flush out of the construction area must be performed. The flush out must comply with the procedure listed within the LEED Rating System

3) Responsible Party

Teams and individuals involved in activities pertaining to the policy:
Facility Manager ____________________
General Contractor ____________________
Building Owner ____________________

4) Guidance for Resources and Implementation

a) Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, second edition, November 2007, Chapter 3

5) Quality Assurance and Quality Control Processes

During any construction or renovation project the following strategies must be utilized to ensure the implementation of this plan:

a) A list of filtration media utilized, including the manufacturer, model number, MERV rating, date of installation, and date of replacement.
b) Photographs documenting the IAQ control measures implemented at 3 time periods during the project (e.g., beginning, middle, and end). The photos will be labelled to highlight the approach taken.
c) Narrative documenting the flush-out procedure utilized, including airflow and duration.

IEQ	
NC	Credit 3.1
CS	Credit 3

9. EXEMPLARY PERFORMANCE

NC

This credit is not eligible for exemplary performance under the Innovation in Design section.

CS

Projects that require and enforce a construction indoor air quality management plan for 100% of tenant spaces (demonstrated through mandatory lease agreements) are eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations applicable to this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Provide the facility manager with a copy of the IAQ management plan used during construction to facilitate adoption of similar practices during future alterations or additions.

12. RESOURCES

WEBSITES

Controlling Pollutants and Sources
U.S. EPA
http://www.epa.gov/iaq/schooldesign/controlling.html

The EPA website provides information regarding typical sources of indoor and outdoor pollutants and methods for resolving indoor air quality concerns. Find detailed information on exhaust or spot ventilation practices during construction.

EPA Fact Sheet
http://www.epa.gov/iaq/pubs/ventilat.html

Ventilation and Air Quality in Offices: This EPA publication addresses IAQ issues for office buildings.

Indoor Air Pollution Report, July 2005
California Air Resources Board
http://www.arb.ca.gov/research/indoor/ab1173/finalreport.htm

This report, released in July 2005, covers the significant health effects caused by indoor air pollution, including respiratory illness and disease, asthma attacks, cancer, and premature death. The report describes the health effects, sources, and concentrations of indoor air pollutants; existing regulations, guidelines, and practices for indoor air pollution; and ways to prevent and reduce indoor air pollution.

IEQ	
NC	Credit 3.1
CS	Credit 3

Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA)
http://www.smacna.org

SMACNA is an international organization that developed guidelines for maintaining healthful indoor air quality during demolitions, renovations, and construction. The professional trade association publishes the referenced standard as well as Indoor Air Quality: A Systems Approach, a comprehensive document that covers air pollutant sources, control measures, IAQ process management, quality control and documentation, interpersonal communication, sample projects, tables, references, resources, and checklists.

PRINT MEDIA

Indoor Air Quality: A Facility Manager's Guide, published by the Construction Technology Centre Atlantic, is written as a comprehensive review of indoor air quality issues and solutions. Purchase the report online at http://ctca.unb.ca/CTCA/communication/IAQ/Order_IAQ.htm

13. DEFINITIONS

A **construction IAQ management plan** outlines measures to minimize contamination in a specific project building during construction and/or describes procedures to flush the building of contaminants prior to occupancy.

HVAC systems are equipment, distribution systems, and terminals that provide the processes of heating, ventilating, or air-conditioning. (ASHRAE 90.1–2007)

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Minimum efficiency reporting value (MERV) is a filter rating established by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE 52.2–1999, Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size). MERV categories range from 1 (very low efficiency) to 16 (very high).

IEQ	
NC	Credit 3.2
CS	NA

CONSTRUCTION IAQ MANAGEMENT PLAN: BEFORE OCCUPANCY

	NC	CS
Credit	IEQ Credit 3.2	NA
Points	1 point	NA

INTENT

To reduce indoor air quality (IAQ) problems resulting from the construction or renovation to promote the comfort and well-being of construction workers and building occupants.

REQUIREMENTS: NC

Develop an IAQ management plan and implement it after all finishes have been installed and the building has been completely cleaned before occupancy:

OPTION 1. FLUSH-OUT

PATH 1

After construction ends, prior to occupancy and with all interior finishes installed, install new filtration media and perform a building flush-out by supplying a total air volume of 4,300 cubic metres of outdoor air per square metre (14,000 cubic feet of outdoor air per square foot) of floor area while maintaining an internal temperature of at least 16ºC (60ºF) and relative humidity no higher than 60%.

OR

PATH 2

If occupancy is desired prior to completion of the flush-out, the space may be occupied following delivery of a minimum of 1,075 cubic metres of outdoor area per square metre (3,500 cubic feet of outdoor air per square foot) of floor area. Once a space is occupied, it must be ventilated at a minimum rate of 1.54 $L/s/m^2$ (0.30 cfm/ft^2) of outdoor air or the design minimum outdoor air rate determined in IEQ Prerequisite 1: Minimum Indoor Air Quality Performance, whichever is greater. During each day of the flush-out period, ventilation must begin a minimum of 3 hours prior to occupancy and continue during occupancy. These conditions must be maintained until a total of 4,300 cubic metres per square metre (14,000 cubic feet per square foot) of outdoor air has been delivered to the space. All finishes must be installed prior to flush out.

IEQ	
NC	Credit 3.2
CS	NA

OR

OPTION 2. AIR TESTING

Conduct baseline IAQ testing, after construction ends and prior to occupancy, using testing protocols consistent with the United States Environmental Protection Agency Compendium of Methods for the Determination of Air Pollutants in Indoor Air and as additionally detailed in the *LEED Canada Reference Guide for Green Building Design and Construction*.

Demonstrate that the contaminant maximum concentrations listed below are not exceeded.

CONTAMINANT	MAXIMUM CONCENTRATION
Formaldehyde	27 parts per billion
Particulates (PM10)	50 micrograms per cubic meter
Total Volatile Organic Compounds (TVOC)	500 micrograms per cubic meter
4-Phenylcyclohexene (4-PCH)*	6.5 micrograms per cubic meter
Carbon Monoxide (CO)	9 part per million and no greater than 2 parts per million above outdoor levels

**This test is only required if carpets and fabrics with styrene butadiene rubber (SBR) latex backing material are installed as part of the base building systems.*

For each sampling point where the maximum concentration limits are exceeded, conduct an additional flush-out with outdoor air and retest the noncompliant concentrations. Repeat until all requirements are met. When retesting noncompliant building areas, take samples from the same locations as in the first test, although it is not required.

Conduct the air sample testing as follows:

a. All measurements must be conducted prior to occupancy, but during normal occupied hours with the building ventilation system started at the normal daily start time and operated at the minimum outdoor air flow rate for the occupied mode throughout the test.

b. All interior finishes must be installed, including but not limited to millwork, doors, paint, carpet and acoustic tiles. Movable furnishings such as workstations and partitions should be in place for the testing, although it is not required.

c. The number of sampling locations will depend on the size of the building and number of ventilation systems. For each portion of the building served by a separate ventilation system, the number of sampling points must not be less than 1 per 2,300 square metres (25,000 square feet) or for each contiguous floor area, whichever is larger. Include areas with the least ventilation and greatest presumed source strength.

d. Air samples shall be collected between 0.9 and 1.8 metres (3 and 6 feet) from the floor to represent the breathing zone of occupants, and over a minimum 4-hour period.

IEQ	
NC	Credit 3.2
CS	NA

INTERPRETATIONS

A space may be excluded from the credit requirements provided it is rarely if ever occupied, can be excluded from ventilation requirements under ASHRAE 62, and is mechanically or physically separated from any occupied spaces.

LEASED TENANT SPACES (NC)

For NC certification, mandatory lease agreements must indicate to future tenants direction on the requirements of this credit. All options can be provided to the tenants. The option(s) selected by the tenant(s) do not need to be consistent with the option used on the base building and owner fit-up tenant spaces.

For spaces fit-up for certification that pursue the testing option, it is not necessary to repeat this testing for future fit-up provided that the untested spaces are built with similar indoor air quality features of the tested spaces. The mandatory lease agreement between the owner and future tenants should require fit-up of tenant spaces to match the *LEED Canada for New Construction* indoor air quality features of the tested spaces. For this strategy to succeed it is important that the fit-up area tested is representative of the air quality expected of the unoccupied untested tenant spaces.

IEQ	
NC	Credit 3.2
CS	NA

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Reducing contaminants inside buildings results in greater occupants comfort, lower absenteeism, and improved productivity. Construction inevitably introduces contaminants to building interiors. If unaddressed, contamination can result in poor IAQ extending over the lifetime of a building. Fortunately, there are IAQ management strategies that, if instituted during construction and before occupancy, will minimize potential problems (see Implementation).

ECONOMIC ISSUES

Additional time and labour may be required during construction to protect and clean ventilation systems and building spaces. These actions can extend the lifetime of ventilation systems and improve their efficiency, resulting in reduced energy use. The sequencing of material installation so as to reduce contamination may require additional time and could potentially delay occupancy. However, early coordination between the design team, contractor, and subcontractors can minimize or eliminate scheduling delays.

2. RELATED CREDITS

Comprehensive construction IAQ management consists of best practices both during construction and after construction prior to occupancy. These activities are typically governed by the same management plan. The following credit also requires development and implementation of a construction IAQ management plan:

- IEQ Credit 3.1: Construction IAQ Management Plan - During Construction

The materials that are specified and installed within the external moisture barrier of the building, as well as filtration, can directly affect air quality and influence the results for air quality testing. Refer also to the following credits:

- IEQ Credit 4: Low-Emitting Materials
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control

Dilution of indoor air contaminants can typically be achieved by introducing outdoor air. The following credit and prerequisite deal with ventilation rates:

- IEQ Prerequisite 1: Minimum Indoor Air Quality Performance
- IEQ Credit 2: Increased Ventilation

3. SUMMARY OF REFERENCED STANDARDS

U.S. Environmental Protection Agency Compendium of Methods for the Determination of Air Pollutants in Indoor Air

This standard is available from NTIS (800) 553-6847 with the ordering number PB90200288. According to the Compendium, the EPA created this document to "provide regional, state and local environmental regulatory agencies with step-by-step sampling and analysis procedures for the determination of selected pollutants in indoor air. Determination of pollutants in indoor air is a complex task, primarily because of the wide variety of compounds of interest and the lack of standardized sampling and analysis procedures. The Compendium has been prepared to provide a standardized format for such analytical procedures. A core set of 10 chapters with each chapter containing 1 or more methods are presented in the current document. Compendium covers a variety of active and passive sampling procedures, as well as several analytical techniques both on and off site…"

IEQ	
NC	Credit 3.2
CS	NA

4. IMPLEMENTATION

FLUSH-OUT PROCEDURE

This compliance path uses the building HVAC system to evacuate airborne contaminants. The flush-out can begin only after all construction work, including punch-list items, is completed. Finalize all cleaning, complete the final test and balancing of HVAC systems, and make sure the HVAC control is functional prior to the flush out. (This is especially important if the occupants will be moving in during the second phase of the flush-out.) Commissioning can occur during the flush-out if it does not introduce any additional contaminants into the building.

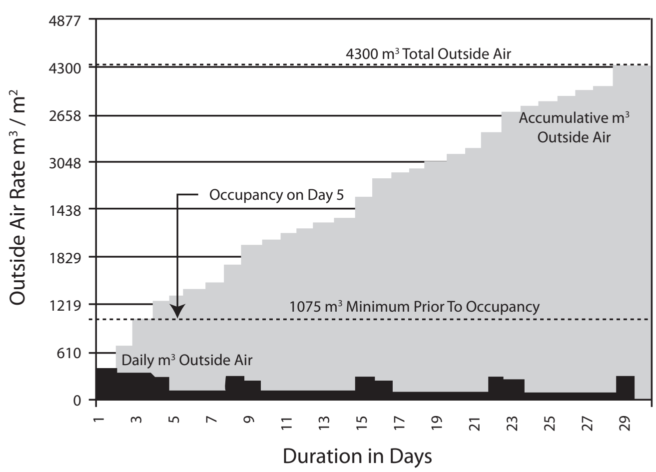
The flush-out procedure discussed below assumes that the building's HVAC system will be used, but alternatives are acceptable if they meet the air quantity, temperature, and humidity requirements.

One approach uses temporary supply and exhaust systems placed into windows or window openings. EPA's Indoor Air Quality for Schools website provides information on exhaust and spot ventilation during construction that can be helpful for design teams who are considering using this approach. Make sure that the airflow is not short-circuited, which could leave remote corners of the project spaces with inadequate circulation or cause unanticipated increases in other parts of the building (such as a stack effect up elevator shafts).

If the space's central HVAC system is used, remove any temporary filters and duct coverings installed as part of the construction IAQ management plan. Replace the HVAC filtration media with new media; if the system is configured to filter only outdoor air, the filters do not need to be replaced. New filters that meet the design specification and that were installed prior to the start of the flush-out will also satisfy the requirements of IEQ Credit 3.1, Construction IAQ Management Plan - During Construction.

Outdoor air is used to dilute and remove off-gassed contaminants. The quantity of outdoor air that must be introduced to the project space for the flush-out is 4,300 cubic metres of air per square metre (14,000 cubic feet of air per square foot) of floor area. Occupants may move in only after the initial flush-out phase, when 1,075 cubic metres of air per square metre (3,500 cubic feet of air per square foot) has been replaced (Figure 1). However, the initial flush-out phase does not signal the completion of the flush-out: A total of 4,300 cubic metres of outdoor air must be supplied per square metre (14,000 cubic feet per square foot) of floor area before the HVAC system is switched to its normal operational mode.

FIGURE 1. SAMPLE AIR QUANTITY FOR FLUSH-OUT



IEQ	
NC	Credit 3.2
CS	NA

Not all outdoor air is equal. Depending upon geography and season, outdoor air can be very cold or damp. Because of this, prudent limits have been set to ensure that no harm comes to the building and its occupants. The rate of outdoor air must not cause the interior temperature to drop below 16°C (60°F), and relative humidity must not exceed 60%.

During an occupied flush-out phase, a minimum ventilation rate must begin at least 3 hours before daily occupancy and continue while the space is occupied. The rate of outdoor air must be at least 1.54 L/s/m^2 (0.30 cfm/ft^2) or the design minimum outdoor air rate, whichever is greater. The design minimum outdoor air rate should be determined using ASHRAE 62.1–2007, the same criteria for IEQ Prerequisite 1, Minimum Indoor Air Quality Performance, or the applicable local code if it is more stringent. The 1.54 L/s/m^2 (0.30 cfm/ft^2) rate may be several times the ASHRAE 62.1–2007 requirement for a project's planned occupancy. As a result, consider the minimum flush-out rate during the early stages of HVAC design.

There are other thermal comfort, expense, and operational considerations to evaluate when preparing to occupy a space before the end of the flush-out. Check to make sure the HVAC system can maintain temperatures within a range that is comfortable for the occupants; opinions formed during this period may last long after the system is operating normally.

There are numerous expense and operational issues to consider, such as the rent or lease details or the existing HVAC system capacity to accommodate the flush-out criteria. Input from the entire project team will help determine the best approach. When completed, make the evaluation and the resulting flush-out strategy part of the IAQ management plan.

When there are multiple HVAC systems that can operate independently, it is acceptable to flush out portions of the building as they are completed, but no additional construction work can occur once the flush-out of an area begins. Isolate completed areas from those under construction per SMACNA IAQ Guidelines for Occupied Buildings under Construction.

AIR QUALITY TESTING

The baseline IAQ testing approach is meant to confirm that major contaminants are below recognized acceptable levels before occupancy. While the list included in the credit is not intended to be all-inclusive, it approximates the major forms of post-construction airborne constituents.

Testing results that meet the credit requirements indicate that the project has implemented a successful construction IAQ management plan; low-emitting materials have been specified; cleanup has been thorough; and the HVAC system is providing adequate ventilation. They can also mean that occupancy can potentially occur sooner than what might be possible if the flush-out compliance path had been followed. Ideally the groundwork should be laid for baseline testing during the design process by making sure the testing requirements are included in Division 1 of the project construction specifications. This credit does not establish qualifications for the laboratory or those conducting the sampling; however, the project team should evaluate the capabilities of the IAQ specialist, industrial hygienist, and testing facility being considered for field sampling of IAQ in buildings.

During construction, be vigilant about avoiding substitutions for the specified low-emitting materials. Use low-VOC cleaning supplies to prevent short-term high-VOC levels that may affect test results. Vacuum cleaners with HEPA filtration will help capture particulates.

Projects also following the requirements of IEQ Credit 3.1, Construction IAQ Management Plan - During Construction, should replace all filtration media after the final cleaning and complete the air test and balancing of the HVAC system before beginning the baseline IAQ testing. The IAQ maximum contaminant levels are dependent on the HVAC system operating under normal

IEQ	
NC	Credit 3.2
CS	NA

conditions with minimum outdoor airflow rates; that way, the air tested will be as similar as possible to what the occupants will be breathing. The protocols described in the referenced publication, EPA's Compendium of Methods for the Determination of Air Pollutants in Indoor Air, are recommended, but others may be used if valid justification is provided. Select the sampling locations carefully to find the concentrations in areas with the least ventilation and, potentially, the greatest presumed contaminant source strength. Take at least 1 sample per 2,300 square metres (25,000 square feet) in each portion of the building served by a separate ventilation system. For example, in a 1,858 square metre (20,000-square-foot) tenant space served by 3 rooftop units—1 each for the north and south elevations (general office area) and the third for a training room and conference rooms—take samples in at least 3 places, even though 2 units serve 1 general office area. Take the samples in the breathing zone, between 0.9 and 1.8 metres (3 and 6 feet) above the floor, during normal occupied hours with the HVAC system operating at normal daily start times and at the minimum outdoor airflow rate. Follow-up samples might be needed, so record the exact sample locations. If a test sample exceeds the maximum concentration level, flush out the space by increasing the rate of outdoor air. While the credit requirements do not prescribe the duration of the flush-out, those responsible for testing should make an evaluation based on the contaminant, its concentration, and the potential source. Off-gassing characteristics of sources differ; some deplete rapidly, while others emit at a steady rate over an extended period. Resample and confirm compliance before allowing occupancy. The retest may be limited to the chemical contaminants and locations that produced excessive chemical concentration levels in the initial test.

5. TIMELINE AND TEAM

During the design phase, include language requiring the general contractor to develop and implement a construction IAQ management plan that includes a flush-out procedure and/or air quality testing that meets the requirements of this credit.

After construction and installation of all finishes (including furniture and furnishings), conduct indoor air quality testing and/or a flush-out per the construction IAQ management plan and in accordance with the requirements of this credit.

Some additional time and labour may be required during and after construction to protect and clean ventilation systems. With early coordination for the sequencing of material installation and coordination between the contractor and subcontractors, the team can minimize or eliminate scheduling delays.

6. CALCULATIONS

If a building flush-out is performed before occupancy, the total quantity of outdoor air that must be delivered to the space is calculated as follows:

PHASED FLUSH-OUT:

Phase 1

Building Area (m^2) X 1,075 m^3/m^2 of Outdoor Air = Cubic Metres of Air Needed Prior to Occupancy

Phase 2

Building Area (m^2) X 3,225 m^3/m^2 of Outdoor Air = Cubic Metres of Air Needed to Complete Flush-Out

IEQ	
NC	Credit 3.2
CS	NA

NON-PHASED FLUSH-OUT:

Building Area (m^2) X 4,300 m^3/m^2 of Outdoor Air = Cubic Metres of Air Needed Prior to Occupancy

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Maintain a written construction IAQ management plan.
- For projects completing a flush-out procedure, record dates, occupancy, outdoor air delivery rates, internal temperature, and humidity, as well as any special considerations.
- For projects completing IAQ testing, maintain a copy of the testing report and verify that all required contaminants are accounted for and reported in the correct unit of measure.

8. EXAMPLES

TABLE 1. TIME FOR FLUSH-OUT OPTIONS

	SQUARE METRE OF OFFICE	OUTDOOR AIR REQUIRED FOR FLUSH-OUT (m^3/m^2)	VOLUME OF AIR REQUIRED BEFORE OCCUPANCY (m^3)	TIME BEFORE OCCUPANCY (DAYS)	MINIMUM OUTDOOR AIR DELIVERY RATE POST-OCCUPANCY (L/s)	TIME TO COMPLETE FLUSH-OUT @ MINIMUM DELIVERY RATE (DAYS)
Pre-Occupancy Option	5,000	4,300	21,500,000	32.3	0	0
Post-Occupancy Option	5,000	4,300	5,375,000	8.1	7,700	24.2
Note: Assuming the building has a 7,700 L/s air handler, capable of operating at 100% OA while maintaining 16° C and 60% RH 24 hr/day						

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

For projects that pursue this credit through the flush-out options in regions where there may be humid or cold outdoor air, maintain the indoor air temperature at or above 16°C (60°F) and maintain the relative humidity at or below 60%. When weather conditions may affect the ability to sufficiently heat, cool, or dehumidify the supply air, careful coordination between the project schedule and seasonal variations is crucial.

IEQ	
NC	Credit 3.2
CS	NA

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Minimize potential sources of indoor air contamination. If such sources must be introduced, consider flushing out the affected areas of the building before those areas are occupied.

Use periodic IAQ testing to verify safe, healthful conditions.

If applicable, provide building operators with information about the flush-out procedures used during construction to facilitate adoption of similar practices following future alterations or additions.

12. RESOURCES

WEBSITES

Controlling Pollutants and Sources, IAQ Design for Schools
U.S. EPA
http://www.epa.gov/iaq/schooldesign/controlling.html

This EPA website offers detailed information on exhaust or spot ventilation practices during construction activity.

EPA Protocol for Environmental Requirements, Testing for Indoor Air Quality, Baseline IAQ and Materials for Research Triangle Park Campus.
http://www.epa.gov/rtp/campus/environmental/s_01445.htm

This specification section was a part of the construction documents for the EPA's Research & Administration Facility at Research Triangle Park. Section 01445 addresses baseline indoor air quality testing and materials testing.

EPA Fact Sheet: Ventilation and Air Quality in Offices
http://www.epa.gov/iaq/pubs/ventilat.html

This EPA publication addresses IAQ issues for office buildings

Sheet Metal and Air Conditioning Contractors' National Association
http://www.smacna.org

SMACNA is an international organization that developed guidelines for maintaining healthful indoor air quality during demolitions, renovations, and construction. They publish Indoor Air Quality: A Systems Approach, which covers air pollutant sources, control measures, IAQ process management, quality control and documentation, interpersonal communication, sample projects, tables, references, resources, and checklists.

PRINT MEDIA

Indoor Air Quality: A Facility Manager's Guide, Construction Technology Centre Atlantic, is written as a comprehensive review of IAQ issues and solutions. Purchase the report online at http://ctca.unb.ca/CTCA/communication/IAQ/Order_IAQ.htm or call (506) 453-5000.

Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air, U.S. EPA This standard is available for purchase from NTIS. To order, call (800) 553-6847 and use order number PB90200288.

IEQ	
NC	Credit 3.2
CS	NA

13. DEFINITIONS

A **construction IAQ management plan** outlines measures to minimize contamination in a specific building during construction and/or to flush the building of contaminants before occupancy.

Building Flush-Out is a process that involves running a building's ventilation systems prior to or during building occupancy to facilitate the removal of contaminants and other harmful airborne particles.

Contaminants are unwanted airborne elements that may reduce air quality. (ASHRAE 62.1–2007)

HVAC systems are equipment, distribution systems, and terminals that provide the processes of heating, ventilating, or air-conditioning. (ASHRAE 90.1-2007)

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Off-gassing is the emission of volatile organic compounds (VOCs) from synthetic and natural products.

Outdoor air is the ambient air that enters a building through a ventilation system, either through intentional openings for natural ventilation or by infiltration. (ASHRAE 62.1–2007)

Thermal comfort exists when occupants express satisfaction with the thermal environment.

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space. (ASHRAE 62.1–2007).

IEQ	
NC	Credit 4.1
CS	Credit 4.1

LOW-EMITTING MATERIALS: ADHESIVES AND SEALANTS

	NC	CS
Credit	IEQ Credit 4.1	IEQ Credit 4.1
Points	1 point	1 point

INTENT

To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

REQUIREMENTS: NC & CS

All adhesives and sealants used on the interior of the building (i.e., inboard side of the weatherproofing system and applied on-site) must comply with the following requirements as applicable to the project scope:

- Adhesives, Sealants and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168. Volatile organic compounds (VOC) limits are listed in the table below and correspond to an effective date of July 1, 2005 and rule amendment date of January 7, 2005.

ARCHITECTURAL APPLICATIONS	VOC LIMIT [g/L LESS WATER]	SPECIALTY APPLICATIONS	VOC LIMIT [g/L LESS WATER]
Indoor Carpet Adhesives	50	PVC Welding	510
Carpet Pad Adhesives	50	CPVC Welding	490
Wood Flooring Adhesives	100	ABS Welding	325
Rubber Floor Adhesives	60	Plastic Cement Welding	250
Subfloor Adhesives	50	Adhesive Primer for Plastic	550
Ceramic Tile Adhesives	65	Contact Adhesive	80
VCT & Asphalt Adhesives	50	Special Purpose Contact Adhesive	250
Drywall & Panel Adhesives	50	Structural Wood Member Adhesive	140
Cove Base Adhesives	50	Sheet Applied Rubber Lining Operations	850
Multipurpose Construction Adhesives	70	Top & Trim Adhesive	250
Structural Glazing Adhesives	100		

SUBSTRATE SPECIFIC APPLICATIONS	VOC LIMIT [g/L LESS WATER]	SEALANTS	VOC LIMIT [g/L LESS WATER]
Metal to metal	30	Architectural	250
Plastic foams	50	Nonmembrane roof	300
Porous material (except wood)	50	Roadway	250
Wood	30	Single-ply roof membrane	450
Fibreglass	80	Other	420

SEALANT PRIMERS	VOC LIMIT [g/L LESS WATER]
Architectural, nonporous	250
Architectural, porous	775
Other	750

- Aerosol Adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000

AEROSOL ADHESIVES:	VOC WEIGHT [g/L MINUS WATER]
General Purpose mist spray	65% VOCs by weight
General Purpose web spray	55% VOCs by weight
Special purpose aerosol adhesives (all Types)	70% VOCs by weight

INTERPRETATIONS

All products applied to elements on the inboard side of the weatherproofing system are controlled by the IEQ Credit 4 credits, regardless of the project's stage of construction (i.e., prior to building close-in).

Adhesives and sealants that are applied at a manufacturing location are exempt from the credit requirements.

LEASED TENANT SPACES (NC)

If utilizing mandatory lease agreements to achieve NC certification, these agreements must indicate to future tenants direction on the required reference standards. It is recommended that the agreements include the required chemical limits information where applicable for ease of use of the tenants. Direction to specific product types is commendable but is not required as part of the mandatory lease agreement.

IEQ	
NC	Credit 4.1
CS	Credit 4.1

1. BENEFITS AND ISSUES TO CONSIDER

Many building products contain compounds that have a negative impact on indoor air quality (IAQ) and the Earth's atmosphere. The most prominent of these compounds—volatile organic compounds (VOCs)—contribute to smog generation and air pollution as well as adversely affect the well-being of building occupants. Low-emitting materials have a positive impact on both outdoor and indoor air quality.

ENVIRONMENTAL ISSUES

VOCs react with sunlight and nitrogen oxides (NO_x) in the atmosphere to form ground-level ozone, a chemical that has detrimental effects on human health, agricultural crops, forests, and ecosystems.[24] This ground-level ozone damages lung tissue, reduces lung function, and sensitizes the lungs to other irritants. Additionally, ground-level ozone is also a major component of smog.

ECONOMIC ISSUES

Healthy occupants are more productive and have less illness-related absenteeism. Materials with high-VOC content can threaten occupants' health and may decrease their productivity, increasing expenses and liability for building owners, operators, and insurance companies. Because of these issues, the construction market is driving product manufacturers to offer low-VOC alternatives to conventional building products. Costs for these products are generally competitive with conventional materials; however, some low-VOC materials are more expensive, particularly when the products are new to the marketplace. Low-VOC alternatives may also be difficult to obtain for some product types. These issues likely will fade as use of low-VOC products become more commonplace.

2. RELATED CREDITS

Because the intent of this credit is to reduce odorous, irritating, and/or harmful indoor air contaminants, the following other credits may be applicable:

- IEQ Credit 4.2: Low Emitting Materials—Paints and Coatings
- IEQ Credit 4.3: Low Emitting Materials—Flooring Systems
- IEQ Credit 4.4: Low Emitting Materials—Composite Wood and Agrifibre Products

Scheduling strategies and the use and tracking of building materials are also addressed in the contractor orientation training, covered under these 2 credits:

- IEQ Credit 3.1: Construction IAQ Management Plan During Construction
- IEQ Credit 3.2: Construction IAQ Management Plan Before Occupancy

Indoor air quality is affected by sources generated within the building itself and introduced into its spaces. Both sources are addressed in the following prerequisite and credit:

- IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control

3. SUMMARY OF REFERENCED STANDARDS

South Coast Air Quality Management District (SCAQMD) Amendment to South Coast Rule 1168, VOC Limits, effective January 7, 2005
South Coast Air Quality Management District

IEQ	
NC	Credit 4.1
CS	Credit 4.1

http://www.aqmd.gov/rules/reg/reg11/r1168.pdf
The South Coast Air Quality Management District is a governmental organization in southern California with the mission to maintain healthful air quality for its residents. The organization established source-specific standards to reduce air quality impacts.

Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule 1168. VOC limits listed in the table below correspond to an effective date of July 1, 2005, and rule amendment date of January 7, 2005.

TABLE 1. VOC LIMITS FOR ADHESIVES AND SEALANTS

ARCHITECTURAL APPLICATIONS	VOC LIMIT [g/L LESS WATER]	SPECIALTY APPLICATIONS	VOC LIMIT [g/L LESS WATER]
Indoor Carpet Adhesives	50	PVC Welding	510
Carpet Pad Adhesives	50	CPVC Welding	490
Wood Flooring Adhesives	100	ABS Welding	325
Rubber Floor Adhesives	60	Plastic Cement Welding	250
Subfloor Adhesives	50	Adhesive Primer for Plastic	550
Ceramic Tile Adhesives	65	Contact Adhesive	80
VCT & Asphalt Adhesives	50	Special Purpose Contact Adhesive	250
Drywall & Panel Adhesives	50	Structural Wood Member Adhesive	140
Cove Base Adhesives	50	Sheet Applied Rubber Lining Operations	850
Multipurpose Construction Adhesives	70	Top & Trim Adhesive	250
Structural Glazing Adhesives	100		
SUBSTRATE SPECIFIC APPLICATIONS	**VOC LIMIT [g/L LESS WATER]**	**SEALANTS**	**VOC LIMIT [g/L LESS WATER]**
Metal to metal	30	Architectural	250
Plastic foams	50	Nonmembrane roof	300
Porous material (except wood)	50	Roadway	250
Wood	30	Single-ply roof membrane	450
Fibreglass	80	Other	420
SEALANT PRIMERS	**VOC LIMIT [g/L LESS WATER]**		
Architectural, nonporous	250		
Architectural, porous	775		
Other	750		

Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS–36 requirements that went in effect on October 19, 2000.

IEQ	
NC	Credit 4.1
CS	Credit 4.1

Green Seal Standard 36 (GS–36), effective October 19, 2000
http://www.greenseal.org/certification/standards/commercial_adhesives_GS_36.cfm
Green Seal is an independent, nonprofit organization that strives to achieve a healthier and cleaner environment by identifying and promoting products and services that cause less toxic pollution and waste, conserve resources and habitats, and minimize global warming and ozone depletion. GS–36 sets VOC limits for commercial adhesives.

Green Seal Standard for Commercial Adhesives GS–36 requirements went into effect on October 19, 2000.

TABLE 2. VOC LIMITS FOR AEROSOL ADHESIVES

AEROSOL ADHESIVES	VOC LIMIT
General purpose mist spray	65% VOCs by weight
General purpose web spray	55% VOCs by weight
Special purpose aerosol adhesives (all types)	70% VOCs by weight

4. IMPLEMENTATION

The sections under IEQ Credit 4, Low-Emitting Materials, apply to products and installation processes that have the potential to adversely affect the IAQ of a project space and, subsequently, those occupants exposed to the off-gassing of contaminants from these materials.

COMPOSITION LIMITS

All materials covered by IEQ Credit 4 that emit contaminants that might enter the indoor air are considered indoor contaminant sources. Adhesives, sealants, primers, paints, coatings, flooring, and composite wood materials that are installed on the inboard side of the weatherproofing system or are in contact with ventilation supply or return air are considered potential indoor air contaminants and should comply with IEQ Credit 4. The threshold limits and content within a particular product are generally expressed in grams per litre (g/L). Three IEQ credits use this approach: 4.1, Low-Emitting Materials—Adhesives and Sealants; 4.2, Low-Emitting Materials—Paints and Coatings; and 4.3, Low-Emitting Materials—Flooring Systems. IEQ Credit 4.4, Low-Emitting Materials—Composite Wood and Agrifibre Products, also controls formulation by not allowing any added urea-formaldehyde resins.

CS

Because core and shell buildings do not have direct control over tenant spaces, the owner or developer has limited control over the building's overall indoor air quality through the selection of low-VOC materials and products. Core and shell building owners are encouraged to explain the benefits of low-VOC materials to their tenants through tenant design and construction guidelines. Consider exceeding the guidelines and mandating specific materials with proven VOC off-gassing performance as requirements for the build-out of all tenant spaces.

IEQ	
NC	Credit 4.1
CS	Credit 4.1

5. TIMELINE AND TEAM

The requirements for products and activities covered in IEQ Credit 4, Low-Emitting Materials, should be noted in the project specifications and, ideally, within the specific section applicable to a particular trade or supplier.

Clearly state the credit requirements in project specifications. Refer to the credit requirements in both Division 1 and in the technical divisions. Indicate what must be provided in the way of cut sheets, MSD sheets, certificates, and test reports. Consider making submittal of this compliance documentation a condition of product approval.

The requirements for IEQ Credit 4, Low-Emitting Materials, are not typical practice for all construction teams and suppliers. Consider asking the project owner to stress the importance of meeting the LEED requirements during pre-bid meetings and again at the time of contract award. During these sessions, have LEED Accredited Professionals available and ask for questions. Include requirements in subcontracts and purchase orders. Determine whether the VOC budget approach will be necessary and track materials accordingly.

Consider providing LEED project signage alongside the project safety signage. In progress meetings, address topics relevant to low-emitting materials and the LEED requirements. Finally, provide leadership and ensure compliance.

6. CALCULATIONS

VOC BUDGET METHODOLOGY

Determining a VOC budget is one way to achieve compliance under IEQ Credit 4.1, Low-Emitting Materials—Adhesives and Sealants, with sufficient justification. To demonstrate that the overall low-VOC performance has been attained for paints and adhesives separately, not in combination, compare the baseline case and the design case. When the design (or actual) is less than the baseline, the credit requirement is satisfied. The values used in the comparison calculation are the total VOCs contained in the products (e.g., sealants) used on the project. To determine total VOCs, multiply the volume of the product used by the threshold VOC level for the baseline case and actual product VOC level for the design case. The baseline application rate should not be greater than that used in the design case. Note that it is not necessary to show a complete budget for all products used but sufficient products to budget those products that are over the threshold VOC level.

The project team must provide justification for the use of non-compliant products in order to use the VOC budget. Examples of acceptable reasons for non-compliant product use include: inability of compliant products to meet reasonable performance requirements (e.g., cold weather application) and unavailability of compliant products on the market. Examples of unacceptable reasons for non-compliant product use include: compliant products requiring more frequent reapplication; "accidental" or unauthorized use, where the project team cannot provide evidence that a process was in place to prevent such accidental use, as well as actions taken to halt the use once it had taken place.

IEQ	
NC	Credit 4.1
CS	Credit 4.1

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Maintain a list of each indoor aerosol adhesive product, adhesives, sealants and sealant primers used on a project. Include the manufacturer's name, product name, and specific VOC data (g/L, less water) for each product, as well as the corresponding allowable VOC from the referenced standard.
- Track the amount of product used if the VOC budget approach is taken and track justification for its use.

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations for this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Use low-emitting materials during building operations and instruct building operators to use low-emitting products when performing repairs or alterations. Provide repair teams and contractors with a list of compliant products used during the initial construction process.

12. RESOURCES

WEBSITES

Certification Criteria, Environmental Choice EcoLogo Program
http://www.ecologo.org/en
The Environmental Choice Program presents a listing of products and services that are third-party verified and certified environmentally responsible. (Note that not all EcoLogo criteria for building products are as stringent as standards referenced by this Credit.)

Green Seal Standard 36 (GS–36)
http://www.greenseal.org/certification/standards/commercial_adhesives_GS_36.cfm
Green Seal is an independent, nonprofit organization that strives to achieve a healthier and cleaner environment by identifying and promoting products and services that cause less toxic pollution and waste, conserve resources and habitats, and minimize global warming and ozone depletion. GS–36 sets VOC limits for commercial adhesives.

South Coast Air Quality Management District (SCAQMD) Rule 1168
South Coast Air Quality Management District
http://www.aqmd.gov/rules/reg/reg11/r1168.pdf

IEQ	
NC	Credit 4.1
CS	Credit 4.1

Volatile Organic Compounds in Consumer and Commercial Products.
http://www.ec.gc.ca/cov-voc/default.asp?lang=En&n=BEE9D2C5-1
Site provides information on actions being taken by Environment Canada to address VOC emissions resulting from the use of consumer and commercial products in Canada.

13. DEFINITIONS

An **adhesive** is any substance that is used to bond 1 surface to another by attachment. Adhesives include bonding primers, adhesive primers, and adhesive primers for plastics. (SCAQMD Rule 1168).

Aerosol adhesive is an aerosol product in which the spray mechanism is permanently housed in a nonrefillable can. Designed for hand-held application, these products do not need ancillary hoses or spray equipment. Aerosol adhesives include special-purpose spray adhesives, mist spray adhesives, and web spray adhesives. (SCAQMD Rule 1168)

Architectural nonporous sealant primer is a substance used as a sealant primer on nonporous materials.

Architectural porous sealant primer is a substance used as a sealant on porous materials.

Contaminants are unwanted airborne elements that may reduce air quality (ASHRAE 62.1–2007).

Indoor adhesive, **sealant**, or **sealant primer** product is defined as an adhesive or sealant product applied on-site, inside the building's weatherproofing system.

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Interior of the Building is all space and materials located within the building's weatherproofing system.

Nonporous sealant is a substance used as a sealant on nonporous materials. Nonporous materials, such as plastic and metal, do not have openings in which fluids may be absorbed or discharged.

Occupants in a commercial building are workers who either have a permanent office or workstation in the building or typically spend a minimum of 10 hours per week in the building. In a residential building, occupants also include all persons who live in the building. In schools, occupants also include students, faculty, support staff, administration, and maintenance employees.

Off-gassing is the emission of volatile organic compounds (VOCs) from synthetic and natural products.

Ozone (O_3) is a gas composed of 3 oxygen atoms. It is not usually emitted directly into the air, but at ground-level is created by a chemical reaction between oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. Ozone has the same chemical structure whether it occurs miles above the earth or at ground-level and can have positive or negative effects, depending on its location in the atmosphere. (U.S. Environmental Protection Agency)

Porous materials have tiny openings, often microscopic, which can absorb or discharge fluids. Examples include wood, fabric, paper, corrugated paperboard, and plastic foam. (SCAQMD Rule 1168)

A **sealant** has adhesive properties and is formulated primarily to fill, seal, or waterproof gaps or joints between 2 surfaces. Sealants include sealant primers and caulks. (SCAQMD Rule 1168)

IEQ	
NC	Credit 4.1
CS	Credit 4.1

A **sealant primer** is applied to a substrate, prior to the application of a sealant, to enhance the bonding surface. (SCAQMD Rule 1168)

Volatile organic compounds (VOCs) are carbon compounds that participate in atmospheric photochemical reactions (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonates, and ammonium carbonate). The compounds vaporize at normal room temperatures.

A **Weatherproofing System** protects the building from the exterior environment (wind and water) and is defined as the air barrier within the wall and roof assemblies.

IEQ	
NC	Credit 4.2
CS	Credit 4.2

LOW-EMITTING MATERIALS: PAINTS AND COATINGS

	NC	CS
Credit	IEQ Credit 4.2	IEQ Credit 4.2
Points	1 point	1 point

INTENT

To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

REQUIREMENTS: NC & CS

Paints and coatings used on the interior of the building (i.e., inboard side of the weatherproofing system and applied on-site) must comply with the following criteria as applicable to the project scope:

- Architectural paints and coatings applied to interior walls and ceilings must not exceed the volatile organic compound (VOC) content limits established in Green Seal Standard GS-11, Paints, First Edition, May 20, 1993.
- Anti-corrosive and anti-rust paints applied to interior ferrous metal substrates must not exceed the VOC content limit of 250 g/L established in Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997.
- Clear wood finishes, floor coatings, stains, primers, and shellacs applied to interior elements must not exceed the VOC content limits established in South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004.

INTERPRETATIONS

All products applied to elements on the inboard side of the weatherproofing system are controlled by the IEQ Credit 4 credits, regardless of the project's stage of construction (i.e., prior to building close-in).

Paints and coatings that are applied at a manufacturing location are exempt from the credit requirements.

LEASED TENANT SPACES (NC)

If utilizing mandatory lease agreements to achieve NC certification, these agreements must indicate to future tenants direction on the required reference standards. It is recommended that the agreements include the required chemical limits information where applicable for ease of use of the tenants. Direction to specific product types is commendable but is not required as part of the mandatory lease agreement.

IEQ	
NC	Credit 4.2
CS	Credit 4.2

1. BENEFITS AND ISSUES TO CONSIDER

Refer to the Benefits and Issues section of IEQ Credit 4.1: Low-Emitting Materials—Adhesives and Sealants.

2. RELATED CREDITS

Because the intent of this credit is to reduce odorous, irritating, or harmful indoor air contaminants, the following other credits may be applicable:

- IEQ Credit 4.1: Low-Emitting Materials—Adhesives and Sealants
- IEQ Credit 4.3: Low-Emitting Materials—Flooring Systems
- IEQ Credit 4.4: Low-Emitting Materials—Composite Wood and Agrifibre Products

Scheduling strategies and the use and tracking of building materials are also addressed in the contractor orientation training, covered under these 2 credits:

- IEQ Credit 3.1: Construction IAQ Management Plan—During Construction
- IEQ Credit 3.2: Construction IAQ Management Plan—Before Occupancy

Indoor air quality is affected by sources generated within the building itself and introduced into its spaces. Both sources are addressed in the following prerequisite and credit:

- IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control

3. SUMMARY OF REFERENCED STANDARDS

Green Seal Standard GS–11
http://www.greenseal.org/certification/standards/paints_GS_11.pdf
Green Seal is an independent, nonprofit organization that strives to achieve a healthier and cleaner environment by identifying and promoting products and services that cause less toxic pollution and waste, conserve resources and habitats, and minimize global warming and ozone depletion. GS–11 sets VOC limits for commercial flat and nonflat paints. The GS-11 VOC limits applicable for this credit are summarized in Table 1. IEQc4.2 Applicable VOC Limits.

Green Seal Standard GC–03
http://www.greenseal.org/certification/standards/anti-corrosivepaints.pdf
GC–03 sets VOC limits for anti-corrosive and anti-rust paints. The GC-03 VOC limits applicable for this credit are summarized in Table 1. IEQc4.2 Applicable VOC Limits.

Chemical Component Limitations— VOC: the manufacturer shall demonstrate that the paint is not formulated to exceed the VOC concentrations listed below:

COATING TYPE	(g/L) MINUS WATER
Gloss	250
Semi-Gloss	250
Flat	250

IEQ	
NC	Credit 4.2
CS	Credit 4.2

South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings
http://www.aqmd.gov/rules/reg/reg11/r1113.pdf
The South Coast Air Quality Management District is a governmental organization in southern California with the mission to maintain healthful air quality for its residents. The organization established source-specific standards to reduce air quality impacts. The SCAQMD Rule 1113 VOC limits applicable for this credit are summarized in Table 1. IEQc4.2 Applicable VOC Limits.

TABLE 1. IEQC4.2 APPLICABLE VOC LIMITS

PRODUCT TYPE	REFERENCE STANDARD	VOC LIMIT (g/L MINUS WATER)
Interior Flat Coating or Primer	Green Seal GS-11, 1993	50
Interior Non-Flat Coating or Primer	Green Seal GS-11, 1993	150
Anti-Corrosive / Anti-Rust Paint	Green Seal GC-03, 2nd Edition, 1997	250
Clear Wood Finishes: Lacquer	SCAQMD Rule 1113, 2004	550
Clear Wood Finishes: Sanding Sealers	SCAQMD Rule 1113, 2004	350
Clear Wood Finishes: Varnish	SCAQMD Rule 1113, 2004	350
Clear Brushing Lacquer	SCAQMD Rule 1113, 2004	680
Floor Coatings	SCAQMD Rule 1113, 2004	100
Sealers and Undercoaters	SCAQMD Rule 1113, 2004	200
Shellac: Clear	SCAQMD Rule 1113, 2004	730
Shellac: Pigmented	SCAQMD Rule 1113, 2004	550
Stain	SCAQMD Rule 1113, 2004	250
Concrete-Curing Compounds	SCAQMD Rule 1113, 2004	350
Japans/Faux Finishing Coatings	SCAQMD Rule 1113, 2004	350
Magnesite Cement Coatings	SCAQMD Rule 1113, 2004	450
Pigmented Lacquer	SCAQMD Rule 1113, 2004	550
Waterproofing Sealers	SCAQMD Rule 1113, 2004	250
Waterproofing Concrete/ Masonry Sealers	SCAQMD Rule 1113, 2004	400
Wood Preservatives	SCAQMD Rule 1113, 2004	350
Low-Solids Coatings	SCAQMD Rule 1113, 2004	120*
Note: VOC levels for Low-Solids Coatings are measured in grams of VOC per litre of material, including water		

4. IMPLEMENTATION

Refer to the Implementation section of IEQ Credit 4.1, Low-Emitting Materials—Adhesives and Sealants.

5. TIMELINE AND TEAM

Refer to the Timeline and Team section of IEQ Credit 4.1, Low-Emitting Materials—Adhesives and Sealants.

IEQ	
NC	Credit 4.2
CS	Credit 4.2

6. CALCULATIONS

Refer to the Calculations section of IEQ Credit 4.1, Low-Emitting Materials—Adhesives and Sealants.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Maintain a list of each indoor paint and coating product used. Include the manufacturer's name, product name, and specific VOC data (in g/L, less water) for each product, as well as the corresponding allowable VOC from the referenced standard.
- Track the amount of product used if the VOC budget approach is taken and track justification for its use.

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations for this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Establish a sustainable purchasing policy for the continued use of low-emitting materials during the building's operation. Help building operators find low-emitting products for repairs or alterations by providing them with a list of compliant products. Provide maintenance personnel with information about original products to aid in color matching. Using fewer types of paint and coating products in the design makes maintenance easier.

12. RESOURCES

WEBSITES

Certification Criteria, Environmental Choice EcoLogo Program
http://www.ecologo.org/en

The Environmental Choice Program presents a listing of products and services that are third-party verified and certified environmentally responsible. (Note that not all EcoLogo criteria for building products are as stringent as standards referenced by this Credit.)

Green Seal
http://www.greenseal.org

Green Seal is an independent, nonprofit organization that strives to achieve a healthier and cleaner environment by identifying and promoting products and services that cause less toxic pollution and waste, conserve resources and habitats, and minimize global warming and ozone depletion.

IEQ	
NC	Credit 4.2
CS	Credit 4.2

Master Painters Institute's Environmental Issues Green Vision
www.paintinfo.com/green

South Coast Air Quality Management District
http://www.aqmd.gov

Volatile Organic Compounds in Consumer and Commercial Products
http://www.ec.gc.ca/cov-voc/default.asp?lang=En&n=BEE9D2C5-1

Site provides information on actions being taken by Environment Canada to address VOC emissions resulting from the use of consumer and commercial products in Canada.

Zero VOC Paint Manufacturers
http://www.aqmd.gov

A listing of paint manufacturers that offer products with no or low VOC content, provided by the South Coast Air Quality Management District.

13. DEFINITIONS

Anticorrosive paints are coatings formulated and recommended for use in preventing the corrosion of ferrous metal substrates.

A **coating** is applied to beautify, protect, or provide a barrier to a surface. (SCAQMD Rule 1113)

Contaminants are unwanted airborne elements that may reduce air quality. (ASHRAE 62.1–2007)

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Indoor paints or **coating products** are applied inside a building's weatherproofing system.

Interior of the Building is all space and materials located within the building's weatherproofing system.

Occupants in a commercial building are workers who either have a permanent office or workstation in the building or typically spend a minimum of 10 hours per week in the building. In a residential building, occupants also include all persons who live in the building. In schools, occupants also include students, faculty, support staff, administration, and maintenance employees.

Paint is a liquid, liquefiable, or mastic composition that is converted to a solid protective, decorative, or functional adherent film after application as a thin layer. These coatings are intended for application to interior or exterior surfaces of residential, commercial, institutional, or industrial buildings.

A **primer** is a material applied to a substrate to improve adhesion of subsequently applied coats.

Sealers are coatings applied to either block materials from penetrating into or leaching out of a substrate, to prevent subsequent coatings from being absorbed by the substrate, or to prevent harm to subsequent coatings by materials in the substrate.

Volatile organic compounds (VOCs) are carbon compounds that participate in atmospheric photochemical reactions (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonates, and ammonium carbonate). The compounds vaporize at normal room temperatures.

IEQ	
NC	Credit 4.2
CS	Credit 4.2

A **Weatherproofing System** protects the building from the exterior environment (wind and water) and is defined as the air barrier within the wall and roof assemblies.

IEQ	
NC	Credit 4.3
CS	Credit 4.3

LOW-EMITTING MATERIALS: FLOORING SYSTEMS

	NC	CS
Credit	IEQ Credit 4.3	IEQ Credit 4.3
Points	1 point	1 point

INTENT

To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

REQUIREMENTS: NC & CS

OPTION 1

All flooring must comply with the following as applicable to the project scope (a small amount of non-compliant flooring may be used for specialty areas provided it does not exceed 5% of floor area):

- All carpet installed in the building interior shall meet the testing and product requirements of the Carpet and Rug Institute's Green Label Plus program.
- All carpet cushion installed in the building interior shall meet the requirements of the Carpet and Rug Institute Green Label program.
- All carpet adhesive shall meet the requirements of IEQ Credit 4.1: Adhesives and Sealants, which includes a volatile organic compound (VOC) limit of 50 g/L.
- All hard surface flooring covered by the FloorScore standard must be certified as compliant with the standard (current as of the date of this rating system, or more stringent version) by an independent third-party. Flooring products covered by FloorScore include vinyl, linoleum, laminate flooring, engineered wood flooring, ceramic flooring, rubber flooring and wall base.
- All components of hard surface flooring systems (regardless of FloorScore requirement), including but not limited to, adhesives, sealants, and backing, must meet the requirements of IEQ Credit 4.1: Adhesives and Sealants.

IEQ	
NC	Credit 4.3
CS	Credit 4.3

- Concrete, wood, bamboo, and cork floor finishes such as sealers, stains, and finishes, must meet the requirements of South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004. VOC limits are listed below.
  - Clear wood finishes: varnish 350 g/L; lacquer 550 g/L
  - Floor coatings: 100 g/L
  - Sealers: waterproofing sealers 250 g/L; sanding sealers 350 g/L; all other sealers 200 g/L
  - Shellacs: Clear 730 g/L; pigmented 550 g/L
  - Stains: 250 g/L
- Tile setting adhesives and grout must meet South Coast Air Quality Management District (SCAQMD) Rule 1168. VOC limits are listed below and correspond to an effective date of July 1, 2005 and rule amendment date of January 7, 2005.
  - Ceramic tile adhesive: 65 g/L
  - Grout and mortar: 250 g/L

OR

OPTION 2

All flooring products installed in the building interior must meet the testing and product requirements of the California Department of Public Health Standard Practice for The Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.

A small amount of non-compliant flooring may be used for specialty areas provided it does not exceed 5% of floor area.

INTERPRETATIONS

Mineral-based finish flooring products such as tile, masonry, terrazzo, and cut stone without integral organic-based coatings and sealants and unfinished/untreated solid wood flooring qualify for this credit without any IAQ testing requirements. However, associated site-applied adhesives, grouts, finishes and sealers must be compliant for a mineral-based or unfinished/untreated solid wood flooring system to qualify for credit.

LEASED TENANT SPACES (NC)

If utilizing mandatory lease agreements to achieve NC certification, these agreements must indicate to future tenants direction on the required reference standards. It is recommended that the agreements include the required chemical limits information where applicable for ease of use of the tenants. Direction to specific product types is commendable but is not required as part of the mandatory lease agreement.

IEQ	
NC	Credit 4.3
CS	Credit 4.3

1. BENEFITS AND ISSUES TO CONSIDER

Refer to the Benefits and Issues section of IEQ Credit 4.1, Low-Emitting Materials—Adhesives and Sealants.

2. RELATED CREDITS

Because the intent of this credit is to reduce odorous, irritating, or harmful indoor air contaminants, the following other credits may be applicable:

- IEQ Credit 4.1: Low-Emitting Materials—Adhesives and Sealants
- IEQ Credit 4.2: Low-Emitting Materials—Paints and Coatings
- IEQ Credit 4.4: Low-Emitting Materials—Composite Wood and Agrifibre Products

Scheduling strategies and the use and tracking of building materials are also addressed in the contractor orientation training, covered under these 2 credits:

- IEQ Credit 3.1: Construction IAQ Management Plan During Construction
- IEQ Credit 3.2: Construction IAQ Management Plan Before Occupancy

Indoor air quality is affected by sources generated within the building itself and introduced into its spaces. Both sources are addressed in the following prerequisite and credit:

- IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control

3. SUMMARY OF REFERENCED STANDARDS

Carpet and Rug Institute (CRI) Green Label Plus Testing Program
Carpet and Rug Institute
http://www.carpet-rug.com
The Carpet and Rug Institute (CRI) is a trade organization representing the carpet and rug industry. Green Label Plus is an independent testing program that identifies carpets with very low VOC emissions. The CRI website describes the program and the associated VOC emission criteria in micrograms per square meter per hour. These criteria were developed by the Carpet and Rug Institute (CRI) in coordination with California's Sustainable Building Task Force and the California Department of Health Services (DHS). In the CRI "Green Label Plus Program," emission rates must be verified by annual tests. Approved certification numbers can be reviewed on the CRI website under Indoor Air Quality/Green Label Plus/Approved companies. Approved products are listed under the company heading.

California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda
California Department of Health Services
http://www.cal-iaq.org/VOC/Section01350_7_15_2004_FINAL_PLUS_ADDENDUM-2004-01.pdf
This practice applies to any newly manufactured material generally used within an enclosed indoor environment. However, the testing practice excludes all products that cannot be tested whole or by representative sample in small-scale environmental chambers.

The testing practice establishes the procedures for product sample collection, emissions testing, indoor concentration modeling, and documentation requirements associated with the analyzing the emissions of VOCs from various sources using small-scale environmental chambers. In addition, the testing practice lists target chemicals and their maximum allowable concentrations.

IEQ	
NC	Credit 4.3
CS	Credit 4.3

FloorScore™ Program
Resilient Floor Covering Institute
http://rfci.com/index.php?option=com_content&view=article&id=80&Itemid=79
According to its website, "The FloorScore program, developed by the Resilient Floor Covering Institute (RFCI) in conjunction with Scientific Certification Systems (SCS), tests and certifies flooring products for compliance with indoor air quality emission requirements adopted in California. Flooring products include vinyl, linoleum, laminate flooring, wood flooring, ceramic flooring, rubber flooring, wall base, and associated sundries."

South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings
http://www.aqmd.gov/rules/reg/reg11/r1113.pdf
The South Coast Air Quality Management District is a governmental organization in Southern California with the mission to maintain healthful air quality for its residents. The organization established source-specific standards to reduce air quality impacts. The South Coast Rule 1113 VOC limits for architectural coatings are summarized in Table 1, in IEQ Credit 4.1.

South Coast Air Quality Management District (SCAQMD) Rule 1168, VOC Limits
http://www.aqmd.gov/rules/reg/reg11/r1168.pdf
The South Coast Air Quality Management District is a governmental organization in southern California with the mission to maintain healthful air quality for its residents. The organization established source specific standards to reduce air quality impacts. The South Coast Rule 1168 VOC limits for adhesives are summarized in Table 1, in IEQ Credit 4.1.

State of California Standard 1350, Section 9, Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, Testing Criteria
http://www.dhs.ca.gov/ps/deodc/ehlb/iaq/VOCS/Section01350_7_15_2004_FINAL_PLUS_ADDENDUM-2004-01.pdfw
This standard practice document specifies testing criteria for carpet emissions that will satisfy the credit requirements.

According to the criteria, carpet must not exceed the maximum target emission factors used in the CRI Green Label program and follow the test protocol used by Green Label Plus. Test results submitted must be no more than 2 years old at the time of submission.

4. IMPLEMENTATION

Refer to the Implementation section of IEQ Credit 4.1, Low-Emitting Materials—Adhesives and Sealants.

5. TIMELINE AND TEAM

Refer to the Timeline and Team section of IEQ Credit 4.1, Low-Emitting Materials—Adhesives and Sealants.

6. CALCULATIONS

There are no calculations required for this credit.

IEQ	
NC	Credit 4.3
CS	Credit 4.3

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Maintain a list of each carpet, carpet cushion, and carpet adhesive installed in the building interior. Record the VOC content for each adhesive.
- Maintain a list of each hard surface flooring product, tile setting adhesive, finishes, and grout installed in the building interior. Record the VOC content for each tile setting adhesive and grout.

8. EXAMPLES

FIGURE 1. SAMPLE PRODUCT INFORMATION FOR CRI GREEN LABEL PLUS CARPETING

STYLE NUMBER 1111	
SPECIFICATIONS	
Construction	Textured loop pattern
Yarn content	Nylon with 25% recycled content
Dye method	Solution
Machine gauge	1/10 in (39.4 col/10 cm)
Stitch count	11 S.P.I. (43.3/10 cm)
Finished pile thickness	0.124 in (3.15 mm)
Average density	8,710
Yarn weight tufted	30 oz/yd^2 (1085 g/m^2)
Primary backing	Polypropylene
Secondary backing	Woven polypropylene with postconsumer recycled content
Width	12 ft (3.66 m)
Pattern repeat	0.40 in w x .047 in l (1.01 cm x 1.19 cm)
Total recycled content	2.43%
PERFORMANCE	
Flame resistance	Passes (Doc FF-1-70)
Flooring radiant panel	Class 1(ASTM E-662)
Smoke density	Less than 450 (ASTM E-662)
CRI Green Label Plus	Certification # GLP 0000
WARRANTIES	
Example nylon warranty	Lifetime carpet static warranty
Example nylon warranty	Lifetime carpet wear, limited warranty
Example nylon certification	Class III, extra heavy traffic
Example nylon content	Minimum 25% recycled content
Example nylon recycling	Available
ADDITIONAL INFORMATION	
Custom colors	Contact sales representative
Coordinating styles	Multiple

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

IEQ	
NC	Credit 4.3
CS	Credit 4.3

10. REGIONAL VARIATIONS

There are no regional variations for this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Establish a sustainable purchasing policy for the continued use of low-emitting materials during the building's operation. Help building operators find low-emitting products for repairs or alterations by providing a list of compliant products.

Use of carpet tiles saves materials over the life of the building because individual tiles can be replaced as the carpet wears. Using fewer flooring products in the design makes maintenance easier. If specialized flooring materials are specified, request maintenance information from product manufacturers or installers and give this information to the operations team.

12. RESOURCES

WEBSITES

Carpet and Rug Institute (CRI)
http://www.carpet-rug.org

Floorscore
http://rfci.com/index.php?option=com_content&view=article&id=80&Itemid=79
http://www.scscertified.com/gbc/floorscore.php

GreenGuard
http://www.greenguard.org/

Scientific Certification System, Inc.
http://www.scscertified.com/

South Coast Air Quality Management District
http://www.aqmd.gov/rules

13. DEFINITIONS

Contaminants are unwanted airborne elements that may reduce air quality. (ASHRAE 62.1–2007)

Hard surface flooring includes vinyl, linoleum, laminate flooring, wood flooring, rubber flooring, wall base, and associated sundries.

Indoor carpet systems are carpet, carpet adhesive, or carpet cushion products installed inside the building's weatherproofing system.

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Occupants in a commercial building are workers who either have a permanent office or workstation in the building or typically spend a minimum of 10 hours per week in the building. In a residential building, occupants also include all persons who live in the building.

Volatile organic compounds (VOCs) are carbon compounds that participate in atmospheric photochemical reactions (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonates, and ammonium carbonate). The compounds vaporize at normal room temperatures.

IEQ	
NC	Credit 4.3
CS	Credit 4.3

IEQ	
NC	Credit 4.4
CS	Credit 4.4

LOW-EMITTING MATERIALS: COMPOSITE WOOD AND AGRIFIBER PRODUCTS

	NC	CS
Credit	IEQ Credit 4.4	IEQ Credit 4.4
Points	1 point	1 point

INTENT

To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

REQUIREMENTS: NC & CS

Composite wood and agrifibre products used on the interior of the building (i.e., inboard side of the weatherproofing system and applied on-site) shall contain no added urea-formaldehyde resins. Laminating adhesives used to fabricate on-site and shop-applied composite wood and agrifibre assemblies must not contain added urea-formaldehyde resins.

Composite wood and agrifibre products are defined as particleboard, medium density fiberboard (MDF), plywood, wheatboard, strawboard, panel substrates and door cores. Materials considered fixtures, furniture, and equipment (FF&E) are not considered base building elements and are not included.

INTERPRETATIONS

LEASED TENANT SPACES (NC)

If utilizing mandatory lease agreements to achieve NC certification, these agreements must indicate to future tenants direction on the required reference standards. It is recommended that the agreements include the required chemical limits information where applicable for ease of use of the tenants. Direction to specific product types is commendable but is not required as part of the mandatory lease agreement.

IEQ	
NC	Credit 4.4
CS	Credit 4.4

1. BENEFITS AND ISSUES TO CONSIDER

Refer to the Benefits and Issues section of IEQ Credit 4.1, Low-Emitting Materials—Adhesives and Sealants.

2. RELATED CREDITS

Because the intent of this credit is to reduce odorous, irritating, or harmful indoor air contaminants, the following other credits may be applicable:

- IEQ Credit 4.1: Low-Emitting Materials—Adhesives and Sealants
- IEQ Credit 4.2: Low-Emitting Materials—Paints and Coatings
- IEQ Credit 4.3: Low-Emitting Materials—Flooring Systems

Scheduling strategies and the use and tracking of building materials are also addressed in the contractor orientation training, covered under these 2 credits:

- IEQ Credit 3.1: Construction IAQ Management Plan During Construction
- IEQ Credit 3.2: Construction IAQ Management Plan Before Occupancy

Indoor air quality is affected by sources generated within the building itself and introduced into its spaces. Both sources are addressed in the following prerequisite and credit:

- IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control

3. SUMMARY OF REFERENCED STANDARDS

There are no standards referenced for this credit.

4. IMPLEMENTATION

Refer to the Implementation section of IEQ Credit 4.1: Low-Emitting Materials—Adhesives and Sealants.

5. TIMELINE AND TEAM

Refer to the Timeline and Team section of IEQ Credit 4.1, Low-Emitting Materials—Adhesives and Sealants.

6. CALCULATIONS

There are no calculations required for this credit.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Maintain a list of each composite wood and agrifibre product installed in the building interior. Confirm that each product does not contain any added urea-formaldehyde.

IEQ	
NC	Credit 4.4
CS	Credit 4.4

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

There are no regional variations for this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Establish a sustainable purchasing policy for the continued use of low-emitting materials during the building's operation. Help building operators find low-emitting products for repairs or alterations by providing them with a list of compliant products.

If specialized composite wood or agrifibre materials are specified, request maintenance information from product manufacturers and installers and give this information to the operations team.

12. RESOURCES

WEBSITES

Certification Criteria, Environmental Choice EcoLogo Program
http://www.ecologo.org/en

The Environmental Choice Program presents a listing of products and services that are third-party verified and certified environmentally responsible. (Note that not all EcoLogo criteria for building products are as stringent as standards referenced by this Credit.)

GreenSpec
www.greenspec.com

Detailed listings for more than 2000 green building products, including environmental data, manufacturer information, and links to additional resources.

Ten Basic Concepts for Architects and Other Building Designers
www.buildinggreen.com/elists/halpaper.html

A primer on IAQ basics from Environmental Building News.

An Update on Formaldehyde
Consumer Product Safety Commission
http://www.cpsc.gov/CPSCPUB/PUBS/725.html

This informational document is from the Consumer Product Safety Commission.

Volatile Organic Compounds in Consumer and Commercial Products.
http://www.ec.gc.ca/cov-voc/default.asp?lang=En&n=BEE9D2C5-1

Site provides information on actions being taken by Environment Canada to address VOC emissions resulting from the use of consumer and commercial products in Canada.

13. DEFINITIONS

IEQ	
NC	Credit 4.4
CS	Credit 4.4

Agrifibre board is a composite panel product derived from recovered agricultural waste fibre from sources cereal straw, sugarcane bagasse, sunflower husk, walnut shells, coconut husks, and agricultural prunings. The raw fibres are processed and mixed with resins to produce panel products with characteristics similar to those derived from wood fibre. The following conditions describe which products must comply with the requirements:

1. The product is inside the building's waterproofing system.
2. Composite components used in assemblies are to be included (e.g., door cores, panel substrates).
3. The product is part of the base building systems.

Composite wood consists of wood or plant particles or fibres bonded together by a synthetic resin or binder. Examples include plywood, particle-board, oriented-strand board (OSB), medium-density fiberboard (MDF), and composite door cores. The following conditions describe which products must comply with the credit requirements:

1. The product is inside the building's waterproofing system.
2. Composite wood components used in assemblies are included (e.g., door cores, panel substrates, plywood sections of I-beams).
3. The product is part of the base building systems.

Contaminants are unwanted airborne elements that may reduce air quality. (ASHRAE 62.1–2007)

Formaldehyde is a naturally occurring VOC found in small amounts in animals and plants, but is carcinogenic and an irritant to most people when present in high concentrations, causing headaches, dizziness, mental impairment, and other symptoms. When present in the air at levels above 0.1 ppm parts of air, it can cause watery eyes, burning sensations in the eyes, nose and throat; nausea, coughing, chest tightness, wheezing, skin rashes, and asthmatic and allergic reactions.

Indoor composite wood or **agrifibre** is a product installed inside the building's weatherproofing system.

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Interior of the Building is all space and materials located within the building's weatherproofing system.

Laminate adhesive is used in wood or agrifibre products (veneered panels, composite wood products contained in engineered lumber, door assemblies, etc.).

Off-gassing is the emission of volatile organic compounds (VOCs) from synthetic and natural products.

Portable Furniture is all furniture not affixed to the building.

Urea-formaldehyde is a combination of urea and formaldehyde that is used in some glues and may emit formaldehyde at room temperature.

Pheno-formaldehyde, which off-gasses only at high temperature, is used for exterior products, although many of those products are suitable for interior applications.

IEQ	
NC	Credit 4.4
CS	Credit 4.4

A **Weatherproofing System** protects the building from the exterior environment (wind and water) and is defined as the air barrier within the wall and roof assemblies.

IEQ	
NC	Credit 4.4
CS	Credit 4.4

14. CASE STUDY

SOUTHBROOK VINEYARDS HOSPITALITY PAVILION

LEED Canada-NC 1.0 Gold, 7 November 2008

Location: Niagara-on-the-Lake, Ontario
Building Type: Retail
Owner Type: Commercial
Building Size: 850m^2
Owner Name: Southbrook Vineyards (owner)
LEED Consultant: Enermodal Engineering Ltd.
Responsible Firm (for this credit): Diamond + Schmitt Architects (architect), Merit Contractors Niagara (Contractor)
Photo Credit: Diamond + Schmitt Architects/Tom Arban and Southbrook Vineyards

Located in the famed Niagara wine region, the Southbrook Vineyards Hospitality Pavilion provides office space, retail, a tasting room, and banquet/event space. In addition to obtaining LEED certification, Southbrook Vineyards accomplished its goal of engaging both "mouths and minds" in sustainable wine making through the achievement of biodynamic agriculture and organic designations.

Early in the design process, Southbrook's owners stressed the importance of having the indoor air stream protected from harmful products used during and after construction – ensuring the taste and smell of the wine are not impacted by materials in the building. The design and construction teams paid special attention to use only low VOC adhesives, sealants, paints, and coatings in the building. This commitment also included all wood products and finishes – from doors and millwork to counters and bottle storage – where only products with no-added urea-formaldehyde were specified.

Lessons learned:

- The LEED consultant should make it a priority early in the design and construction process to build an open relationship with the construction team to ensure all installation and IAQ goals are met.

IEQ	
NC	Credit 5
CS	Credit 5

INDOOR CHEMICAL AND POLLUTANT SOURCE CONTROL

	NC	CS
Credit	IEQ Credit 5	IEQ Credit 5
Points	1 point	1 point

INTENT

To minimize building occupant exposure to potentially hazardous particulates and chemical pollutants.

REQUIREMENTS: NC & CS

Design to minimize and control the entry of pollutants into buildings and later cross-contamination of regularly occupied areas through the following strategies:

- Employ permanent entryway systems at least 3 metres (10 feet) long in the primary direction of travel to capture dirt and particulates entering the building at regularly used entrances that are directly connected to the outdoors or other contaminant generating spaces. Permanently installed grates, grilles, or slotted systems that allow for cleaning underneath must comprise at least 1 metre (3 feet) of the 3 metre (10 feet) requirement. Walk-off/Roll-out mats are acceptable for the remainder of the length only when maintained on a weekly basis by a contracted service. Entrances from adjacent areas where outdoor dirt is reduced, such as from covered parking structures, need not have permanently installed grates, grilles, or slotted systems if they are equipped with portable walk-off mats that total at least 3 metres (10 feet) long, with a weekly cleaning and maintenance program in place. Core and Shell projects that do not have entryway systems cannot achieve this credit.
- Sufficiently exhaust each space where hazardous gases or chemicals may be present or used (e.g., garages, housekeeping and laundry areas, science laboratories, prep rooms, art rooms, shops of any kind, and copying and printing rooms) to create negative pressure with respect to adjacent spaces when the doors to the room are closed. For each of these spaces, provide self-closing doors and deck-to-deck partitions or a hard-lid ceiling. The exhaust rate must be at least 2.5 $L/s/m^2$ (0.50 cfm/ft^2), with no air recirculation. The pressure differential with the surrounding spaces must be at least 5 Pascals (Pa) (0.02 inches of water gauge) on average and 1 Pa (0.004 inches of water) at a minimum when the doors to the rooms are closed.

IEQ	
NC	Credit 5
CS	Credit 5

- Provide containment (i.e., a closed container for storage for off-site disposal in a regulatory compliant storage area, preferably outside the building) for appropriate disposal of hazardous liquid wastes in places where water and chemical concentrate mixing occurs (e.g., housekeeping, janitorial and science laboratories).
- In mechanically ventilated buildings, install new air filtration media in regularly occupied areas prior to occupancy for all air handling equipment with a maximum flow rate of more than 283 L/s (600 cfm); these filters must provide a minimum efficiency reporting value (MERV) 13 or higher. Air handlers with a maximum supply volume of 283 L/s (600 cfm) or less are exempt from the filtration requirements provided they are equipped with the highest supply air filtration level commercially available for the specific equipment. Filtration should be applied to process both return and outside air that is to be delivered as supply air.
- For residential projects, install carbon monoxide (CO) alarms in dwelling units and common spaces that contain or are adjacent to combustion equipment.

INTERPRETATIONS

Terminal air handling equipment such as fan coils, fan-powered VAV boxes, or heat pumps, are exempt from the filtration requirements provided that the primary air or ventilation air handlers are equipped with MERV 13 filtration of supply air as above, and that the terminal devices are equipped with the highest air filtration level commercially available for the specific equipment under consideration.

Fan units that provide no outdoor air or serve only a single zone are exempt from filtration requirements (e.g., unit heaters and vestibule heaters).

LEASED TENANT SPACES (NC)

For NC certification, mandatory lease agreements for tenant space not fit up at the time of certification must indicate to future tenants the requirements of this credit including the requirement that filtration media must be replaced immediately prior to occupancy and note the minimum efficiency reporting value (MERV) required.

IEQ	
NC	Credit 5
CS	Credit 5

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

This credit recognizes projects that reduce or mitigate human contact with airborne chemicals and particles. Although additional materials and energy may be required to provide entryway systems and isolated chemical-use areas, proper management of hazardous chemicals used for building operations and maintenance is important. With proper maintenance, harmful chemical spills and accidents can be avoided.

ECONOMIC ISSUES

Additional sinks, drains, room separations, and separate exhaust systems for copying and housekeeping areas can increase the project's overall initial cost. Dedicated ventilation and exhaust systems may require additional ductwork and associated installation costs. Clean air can promote occupants' productivity, increasing profitability for the company. Reducing the potential for spills can avoid costly environmental cleanups. An environmentally sound building also supports the well¬being of occupants, which may contribute to lower health insurance rates and health care costs.

CS

The level of control a building owner or developer has over different spaces in a multiuse building varies. For example, a commercial office building may have a retail component at the ground level. The final location of each tenant's entry will be determined by their needs and demands, outside the direct control of the Core & Shell owner. Even in these cases, the project team is required to install permanent entryway systems and/or properly maintained walk-off mats to comply with the credit. As is the case for all *LEED Canada Core & Shell* credits, the requirements of a credit exclude the fit-out of tenant spaces. Tenant space activities such as use of copiers, fax machines, and printers are not considered within the scope of the *LEED Canada Core & Shell* program; however, consider including compliance specifications in tenant design and construction guidelines. Because the decisions of 1 tenant can affect the indoor environmental quality of other tenants, *LEED Canada Core & Shell* projects should include the requirements of tenant lease agreements.

2. RELATED CREDITS

Filtration media can remove contaminants from the air during construction as well as during operation. To ensure that the systems will accommodate high-efficiency filtration, refer to these credits:

- IEQ Credit 3.1: Construction IAQ Management Plan During Construction
- IEQ Credit 3.2: Construction IAQ Management Plan Before Occupancy

Exhausting indoor air in areas where chemicals are used is important to maintaining acceptable indoor air quality but can require additional fan energy. These exhaust systems will require commissioning, relating to the credits below:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Prerequisite 2: Minimum Energy Performance

IEQ	
NC	Credit 5
CS	Credit 5

- EA Credit 1: Optimized Energy Performance
- EA Credit 3: Enhanced Commissioning

Ventilation systems must be capable of accommodating the filtration media required for credit compliance. Refer to the following prerequisite and credit:

- IEQ Prerequisite 1: Minimum Indoor Air Quality Performance
- IEQ Credit 1: Outdoor Air Delivery Monitoring

3. SUMMARY OF REFERENCED STANDARDS

American National Standards Institute (ANSI)/ASHRAE Standard 52.2–1999: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE
www.ashrae.org
This standard presents methods for testing air cleaners for 2 performance characteristics: the device's capacity for removing particles from the air stream and the device's resistance to airflow. The minimum efficiency reporting value (MERV) is based on 3 composite average particle size removal efficiency points. Consult the standard for a complete explanation of MERV calculations. Table 1 summarizes the requirements for a MERV value of 13.

TABLE 1. REQUIREMENTS FOR MERV 13

COMPOSITE AVERAGE PARTICLE SIZE EFFICIENCY (%)				MINIMUM FINAL RESISTANCE (in. of water)
0.30 - 0.10 µm	1.0 - 3.0 µm	3.0 - 10.0 µm	(Pa)	
<75%	≥90%	≥90%	350	1.4

4. IMPLEMENTATION

The indoor air quality (IAQ) of buildings can be adversely affected by daily occupancy and operations. Occupants and building visitors contribute to indoor IAQ issues by introducing contaminants via shoes and clothing. Daily copier, fax, and printer operations add contaminants to the building's interior environment; in addition, the storage, mixing and disposal of housekeeping liquids may adversely affect human health. This credit seeks to improve a building's IAQ and limit the amount of particulate, chemical, and biological contaminants that occupants are exposed to.

ENTRYWAY SYSTEMS

Incorporate permanent entryway systems at all high-traffic exterior to interior access points to reduce the amount of contaminants tracked into the occupied space. The entryway systems should be designed to capture and remove particles from shoes without allowing build-up of contaminants.

High-traffic exterior access points will always include, but may not be limited to, the main building entry. Building entrances from structured parking areas will be used frequently. In some instances, these entry points are inside a parking garage. While a covered garage does provide protection from the elements, it is also a source of possible contaminants, and it functions as a direct connection to the outdoors. Buildings that have distinct employee and visitor entry points should include permanent entryway systems in these locations as well. Evaluate all building entry points to determine whether permanent entryway systems should be incorporated.

IEQ	
NC	Credit 5
CS	Credit 5

Equip all exterior to interior entrances with entryway systems (e.g., grilles, grates, or mats) to catch and hold dirt particles and prevent contamination of the building interior. Entryway systems must extend 3 metres (10 feet) from the building entrance into the building interior. Open grates and grilles or other entryway systems that have a recessed collection area are generally thought to be most effective.

Mat systems should be appropriate for the climate. For example, durable coarse mats with large open loops are appropriate for capturing sand, mud, or snow and should have a Class I fire-retardant rating.

High void volume within mat fibres provides space for trapping dirt below the mat surface and enables water to spread to a larger area for improved drying. This inhibits dirt retracing and mould and mildew growth. High-void-volume mats are also easier to vacuum or shake out. Fibre height provides maximum scraping surface at the shoe and mat interface and improves vacuuming efficiency.

Entryway mats with solid backings capture dirt and moisture and help to prevent dirt from collecting underneath. A nonporous backing inhibits mould and mildew growth. The use of mould- and mildew-resistant materials in the mat construction can also prevent mould and mildew growth within the materials. Other recommended performance features in an entryway system include the following:

- Fire-retardant ratings that exceed DOC-FF-1-70, such as U.S. National Fire Protection Association (NFPA) -253 Class I and II, which can reduce insurance costs
- Electrostatic propensity levels of less than 2.5 kV, which means that the mat should not produce an electrical discharge when a user touches other people or objects

Entryway systems constructed with recycled content and rubber backings are preferable.

HAZARDOUS CHEMICAL AREAS

Locate high-volume copy, print, and fax equipment in enclosed rooms away from regularly occupied spaces. In order to effectively remove airborne contaminants generated by this type of equipment, the rooms must be physically separated from adjacent spaces. This may be accomplished through installation of deck-to-deck partitions or sealed gypsum board enclosures. Rooms with large openings but no doors will not meet the credit requirement. Installation of a self-closing door is an option for such spaces. To remove airborne contaminants and prevent cross-contamination of nearby occupied spaces, equip the copy, print, and fax rooms with a dedicated exhaust system that creates negative pressure within the room to meet the requirements of this credit. If possible, convenience copier and printer use should be minimized. Although encouraged, designing exhaust systems that account for convenience copier and printer use is not required for this credit.

Chemical storage and mixing areas, such as janitor's closets and photo labs, should be located away from occupant work areas. Additionally, these rooms must be physically separated from adjacent spaces via installation of deck-to-deck partitions or sealed gypsum board enclosures. Rooms must be equipped with a dedicated exhaust system that creates the required negative pressurization to ensure that nearby occupied spaces will not be cross-contaminated. Drywall ceilings may be used in place of full-height partitions, but acoustical lay-in ceilings are not adequate.

The definition of convenience printers and copiers, which are not required to be segregated in a chemical use area, is left to the discretion of the design team; convenience machines are generally smaller units shared by many office personnel for short print and copy jobs.

IEQ	
NC	Credit 5
CS	Credit 5

Battery banks used to provide temporary back-up power must be segregated to satisfy this credit's requirements.

Housekeeping facilities that are part of a common laundry room in residential or hospitality buildings must meet the chemical storage requirements.

Rooms where chemicals are mixed and disposed of should be isolated. These rooms should include sinks and/or drains in appropriate locations to ensure that chemicals are disposed of properly and are not dumped into inadequate spaces (e.g., restrooms). Local codes requiring separate drain lines must be followed.

Additional ventilation systems to mitigate contaminating adjacent spaces can affect building energy performance; in these situations, the building may require additional commissioning, measurement, and verification to earn this credit. Ventilation system design must ensure that installed systems are capable of accommodating the filtration media that is required for this credit. Low-capacity packaged air handling systems, 283 L/s (600 cfm) or less, are exempt from the MERV 13 filtration requirement of this credit; however, they must be equipped with the highest supply air filtration level commercially available for the specific equipment. The selected space layout may prohibit deck-to-deck separation and separate ventilation systems for chemical use areas. Storage areas for recyclable materials may also be considered contaminant sources, depending on the items recycled. Poorly chosen janitorial supplies can negatively affect IAQ.

Give special consideration to the design and installation of containment drains to ensure that hazardous waste is disposed of properly and to prevent environmental damage or contamination of water systems.

In addition, sources of outdoor air pollution (such as trash dumpsters or areas where vehicles tend to idle) should be located away from outdoor ventilation air intakes.

Carbon monoxide (CO) alarms are required in spaces susceptible to combustion gas spillage. Potential sources of CO include boilers, furnaces, vehicles, and fuel-burning appliances.

5. TIMELINE AND TEAM

During the early planning stage of a project, the design team should document the client's equipment requirements and usage patterns. This information will be critical in determining whether dedicated, isolated rooms will be required to house copy, fax, and print equipment.

During the design phase, the architect should consider the location and type of entryway systems and allow adequate space for entryway systems. During the schematic design phase, the team should confirm the locations of areas where chemicals and high-volume copy, fax, and print equipment will be used. It may be possible to locate such rooms above or adjacent to one another to make individual exhaust systems unnecessary and minimize exhaust ductwork and drainage piping. Also confirm that chemical and equipment rooms are properly isolated from adjacent spaces. The mechanical engineer should incorporate MERV 13 filters, dedicated exhaust systems, and separate drainage piping into the drawings and specifications; these elements will affect the fan sizing, shaft layout, and underground coordination.

Install and then commission the space exhaust systems to ensure that they meet the owner's requirements and the design intent.

IEQ	
NC	Credit 5
CS	Credit 5

6. CALCULATIONS

There are no calculations required for this credit.

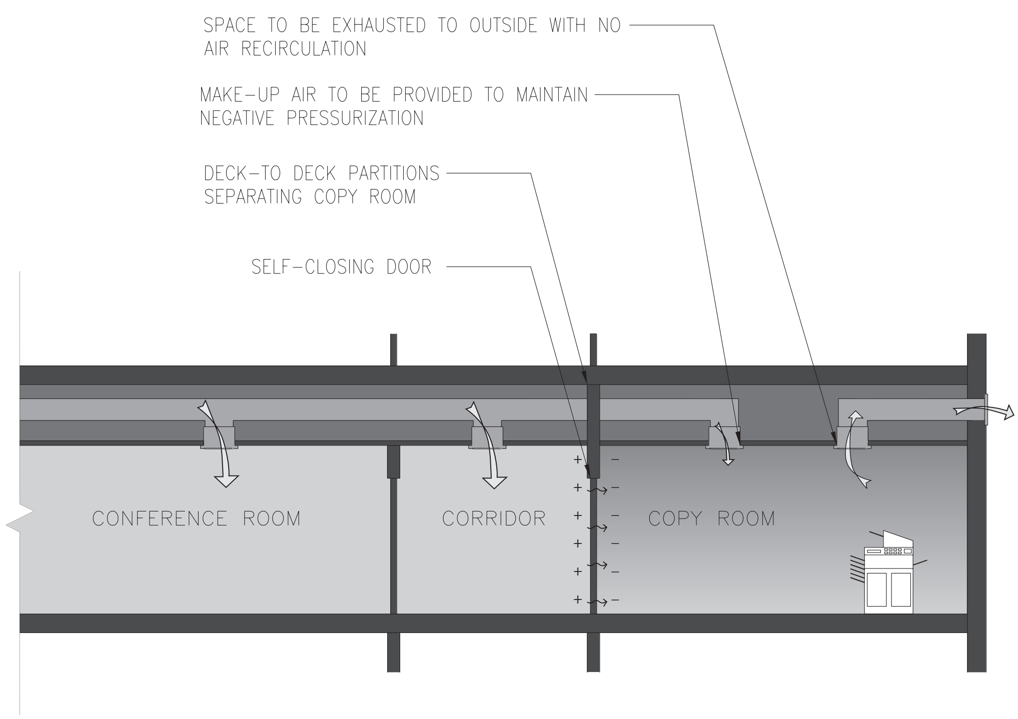
7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Retain visual documentation of the location and size of all permanent entryway systems and walk-off mats.
- Create a table listing entryway systems.
- Create a building maintenance plan that includes a description of cleaning and maintenance for permanent entryway systems and walk-off mats necessary to manage contaminants brought into the building.
- Create a list of rooms or areas that require separation.
- Detail deck-to-deck partitions or hard-lid conditions at rooms known to have contaminants.
- As the project evolves, review negative pressure calculations at hazardous chemical areas to assure proper depressurization.
- Maintain product literature (such as Mechanical schedules) for MERV 13, or higher filters.

8. EXAMPLES

FIGURE 1. REQUIREMENTS FOR ISOLATION AREAS FOR HAZARDOUS GASES OR CHEMICALS



IEQ	
NC	Credit 5
CS	Credit 5

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Local weather conditions should be factored into determining the location and type of entryway systems. For example, in areas that receive heavy rain or snow, it may be prudent to locate entryway systems in an enclosed vestibule or inside the building. A floor drain to remove collected moisture may also be necessary.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Establish procedures and schedules for replacing filtration media and testing and maintaining exhaust systems and include them in the building's preventive maintenance plan.

Systems that require regular maintenance should be designed to be easily accessible to operations staff. Ensure that protocols for selecting, storing, and handling hazardous waste are clearly communicated to building operators.

Develop, document, and record entryway maintenance practices in accordance with the manufacturer's specifications. These practices should specify cleaning strategies for the exterior and interior of entryways, general maintenance of entryway systems, and cleaning during inclement weather. Operations staff can reduce maintenance and replacement needs for entryway systems by keeping exterior walkways clean and using high-quality mats. Cleaning mats frequently can prolong the life of carpets and other flooring materials.

12. RESOURCES

WEBSITES

CBD-110. Ventilation and Air Quality, Canadian Building Digest
http://www.nrc-cnrc.gc.ca/eng/ibp/irc/cbd/building-digest-110.html

Institute for Research in Construction, National Research Council Canada. This document provides basic principles of ventilation to maintain an acceptable level of air quality.

Environmentally Preferable Purchasing Information
U.S. EPA
http://www.epa.gov/opptintr/epp/

This page includes a database of environmental information on more than 600 products, including janitorial and pest control products.

Green Seal
http://www.greenseal.org/findaproduct/index.cfm

Green Seal is an independent, nonprofit organization that strives to achieve a healthier and cleaner environment by identifying and promoting products and services that cause less toxic pollution and waste, conserve resources and habitats, and minimize global warming and ozone depletion.

IEQ	
NC	Credit 5
CS	Credit 5

Indoor Air Quality
Health Canada
http://www.hc-sc.gc.ca/ewh-semt/pubs/air/index-eng.php

This site provides a wide variety of air quality documents, including ambient air quality objectives for pollutants related to human activity, building materials and furnishings, and a Technical Guide on indoor air quality in office buildings.

Janitorial Products Pollution Prevention Project
http://www.westp2net.org/janitorial/jp4.cfm

The Janitorial Products Pollution Prevention Project is a governmental and nonprofit project that provides fact sheets, tools, and links.

Maintaining Acceptable Air Quality in Office Buildings through Ventilation
http://www.nrc-cnrc.gc.ca/eng/ibp/irc/ctus/ctus-n3.html

Construction Technology Updates. Institute for Research in Construction, National Research Council Canada. This document describes the role of a flushing cycle to expel contaminants especially off-gassed chemicals.

Study of Workstation Emissions Offers Insight into Indoor Air Quality Indoor Environment
http://www.nrc-cnrc.gc.ca/eng/ibp/irc/ci/volume-2-n3-10.html

Construction Innovation. Vol. 2, Number 3, Winter 1997. Institute for Research in Construction, National Research Council Canada. This document describes a study of workstation emissions that is crucial to efforts of improving indoor air quality.

Using Ventilation to Control Contaminant Build-up in Office Buildings
Construction Innovation
http://irc.nrc-cnrc.gc.ca/pubs/ci/v3no3/v3no3_10_e.html

Vol. 3, Number 3, Spring 1998. Institute for Research in Construction, National Research Council Canada. This document provides the principles for the use of ventilation to flush out VOC emissions from building materials, furnishings and equipment in office buildings.

13. DEFINITIONS

Air-handling units are mechanically indirect heating, ventilating, or air conditioning systems in which air is treated or handled by equipment located outside the space served, and conveyed to and from the space by means of a fan and duct system. (NEEB 1997 edition)

Entryway systems can be open floor grates or grilles with a recessed area designed to capture dirt and other debris from people entering the building.

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Minimum efficiency reporting value (MERV) is a filter rating established by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE 52.2–1999, Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size). MERV categories range from 1 (very low efficiency) to 16 (very high).

IEQ	
NC	Credit 5
CS	Credit 5

Regularly occupied spaces in commercial buildings are areas where people sit or stand as they work. In residential applications these spaces include all living and family rooms and exclude bathrooms, closets, or other storage or utility areas. In schools, they are areas where students, teachers, or administrators are seated or standing as they work or study.

Walk-off mats or roll-out mats are placed inside building entrances to capture dirt, water, and other materials tracked inside by people and equipment.

IEQ	
NC	Credit 6.1
CS	NA

CONTROLLABILITY OF SYSTEMS: LIGHTING

	NC	CS
Credit	IEQ Credit 6.1	NA
Points	1 point	NA

INTENT

To provide a high level of lighting system control by individual occupants or groups in multi-occupant spaces (e.g., classrooms and conference areas) and promote their productivity, comfort and well-being.

REQUIREMENTS: NC

Provide individual lighting controls for 90% (minimum) of the building occupants to enable adjustments to suit individual task needs and preferences.

Provide lighting system controls for all shared multi-occupant spaces that complies with ASHRAE/IESNA Standard 90.1-2007 section 9.4.1.2 (Lighting) (with errata but without addenda[a]), to enable adjustments that meet group needs and preferences.

INTERPRETATIONS

LEASED TENANT SPACES (NC)

For NC certification, mandatory lease agreements for leased tenant space not fit-up at the time of certification must indicate to future tenants the requirements of this credit.

[a] Project teams wishing to use ASHRAE approved addenda for the purposes of this credit may do so at their discretion. Addenda must be applied consistently across all LEED credits.

IEQ	
NC	Credit 6.1
CS	NA

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Providing individual controls for lighting increases occupants' comfort by enabling them to adjust the workspace to their individual needs. Individual controls also allow for multiple lighting possibilities—lighting for specific tasks, general overhead lighting, lighting with consideration for A/V needs, and lecture style lighting with emphasis on the learning walls or presentation screens, for example. By balancing ambient light levels and providing user-controlled, flexible, task-appropriate lighting, project teams can reduce the overall lighting energy consumption and the heat loads associated with unnecessarily high or uneven levels of indoor lighting.

Effective lighting is important to human comfort, productivity, and communication. In classroom and presentation settings, building occupants must be able to see material on which they are working, as well as material that is presented on white boards and projected onto screens.

ECONOMIC ISSUES

Additional task lights and lighting controls might increase initial costs for the project. These costs are generally offset by a reduced heat load and may enable designers to minimize ambient light levels as well as the number of installed fixtures and lamps. It is important to educate occupants on the design and function of system controls, because abuse of personal controls, such as leaving task lights on when not in classrooms or offices, has the potential to increase energy costs. Integrating individual controls with occupancy sensors provides project teams with an opportunity to reduce the overall energy cost. Integrating light-reflecting (or light-absorbing) surface materials with lighting design may create opportunities to reduce the number of installed luminaries, resulting in potential energy savings.

2. RELATED CREDITS

Lighting systems are affected by window placement, glazing selection for daylight and views, and zoning strategies employed for thermal comfort controllability. Lighting systems in turn affect energy performance: Giving occupants the ability to turn down or turn off lights when they are not needed can reduce electricity use. As with all control systems, the lighting controls need to be included within the scope of commissioning. For all these reasons, lighting is related to the following credits and prerequisites:

- EA Prerequisite 1: Fundamental Commissioning of the Building Energy Systems
- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance
- EA Credit 3: Enhanced Commissioning
- IEQ Credit 6.2: Controllability of Systems—Thermal Comfort
- IEQ Credit 8: Daylight and Views

3. SUMMARY OF REFERENCED STANDARDS

ANSI/ASHRAE/IESNA Standard 90.1–2007, Energy Standard for Buildings Except Low-Rise Residential Lighting, Section 9 (without amendments)
American Society of Heating Refrigeration, and Air-Conditioning Engineers
http://www.ashrae.org
Standard 90.1–2007 was developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), under an American National Standards Institute (ANSI)

IEQ	
NC	Credit 6.1
CS	NA

consensus process. The Illuminating Engineering Society of North America (IESNA) is a joint sponsor of the standard. Standard 90.1 establishes minimum requirements for the energy-efficient design of buildings, except those that are low-rise residential.

Section 9 of the standard provides requirements for the lighting of buildings. Only the lighting requirements outlined in Section 9.4.1.2 (Lighting) apply to this credit.

4. IMPLEMENTATION

Many conventional buildings have only fixed-intensity general lighting systems that illuminate indoor spaces without consideration for specific tasks and individual occupant comfort or needs. A better approach provides uniform general ambient lighting, augmented with individually controlled task fixtures.

To comply with ANSI/ASHRAE/IESNA 90.1–2007, task lighting must be included in the lighting allowance. Daylighting can be integrated with this credit by using technologies and strategies to compensate for the reduced illuminance levels, as detailed in IEQ Credit 8. It is important to determine if any installed lighting systems or controls will require special calibration, commissioning, or occupant training.

Task lights come in several varieties, from desk-top lamps to fixtures that are permanently attached to workstations or laboratory benches. Ideally these task lights will have multiple lighting levels and automatic shutoff switching. Task lighting does not need to be hardwired to meet the requirements of this credit: outlet-powered task lighting provides a simple and effective way to add control.

To ensure maintenance of adequate light levels, consider strategies to address output depreciation and address relamping programs with the owner. Internal sensors may be available to make small adjustments to a light fixture as lamp output diminishes over time.

Remember that the operation of automatic occupancy sensors, daylight sensors, and other lighting controls might be adversely affected by items such as office equipment and furnishings that are installed during and after construction. Coordinate the final calibration of these items with the installer and commissioning agent early in the construction phase to ensure that the system operates as intended and provides lighting controls to 90% of occupants. Lighting system designs should comply with average illumination levels recommended by the Illuminating Engineering Society of North America (IESNA).

Increased uniformity will reduce the perception of decreased light levels in open spaces by minimizing high-contrast areas. Designers should investigate the benefits of direct/indirect or pendant mounted systems paired with high-reflectance ceiling surfaces and finishes. Integration of surface materials selection and lighting design may create opportunities to reduce the number of installed lighting fixtures and could result in saving energy.

Document the anticipated space uses, as well as any special needs or preferences regarding illuminance levels of the expected building users, give them to the lighting designer. This will enable the designer to allow all users to be able to match the light levels to their needs and desires.

5. TIMELINE AND TEAM

During design, the layout of lighting and controls is the responsibility of the architect or lighting designer in consultation with the owner. Consider occupants' lighting needs and desires. Document the tasks specific to each space and the tools and equipment that occupants will use on a daily basis. A large open space, such as a 24-hour data center, might have special design

IEQ	
NC	Credit 6.1
CS	NA

needs because of round-the-clock use. Ensuring consistent, ergonomic, and operable lighting is a fundamental part of design decision making and project infrastructure.

In design development, project teams should involve electrical engineers and coordinate power and circuitry requirements. Design should include lighting professionals and electrical engineers to ensure white boards and screens are free from glare. Improperly lit surfaces can prevent participants from seeing important information. Lighting for audiovisual presentations should be dark enough that images are clearly visible on the screen but not so dark that the audience cannot take notes.

Once fixtures have been installed, coordinate the final calibration of the lighting controls with the installer and commissioning agent to ensure that the system operates as intended.

During building operation, the owner should provide training for building maintenance staff in calibration of systems and relamping. Property management and building engineers should periodically review lighting systems, as well as conduct surveys to ensure that occupants' needs are met and that lighting is working according to design.

Design should include lighting professionals and electrical engineers to ensure that material presented on white boards or on screens is free of glare. White boards and video displays can create glare if improperly lighted, preventing participants in some parts of the room from easily viewing the information presented on them. Lighting during A/V presentations should be dark enough to view images clearly on the screen but not so dark as to prevent building occupants from taking notes, if necessary.

6. CALCULATIONS

ADJUSTABLE TASK LIGHTING

Identify workstation locations intended for individual use. Include every individual workspace (e.g., private offices, open plan workstations, reception stations, ticket booths). Confirm that 90% or more of the occupants of these spaces have task lighting that enables adjustment to suit individual needs. At a minimum, the occupant must be able to turn the fixture on and off. Ideally, the occupant can easily reposition the fixture and have multiple light levels. The fixture should be appropriate for the task.

SHARED MULTI-OCCUPANT SPACES

In conference rooms, classrooms, lounges, and indoor spaces used for presentations and training, the group should have access to adequate controls to suit their activities. Specific types or numbers of controls are not listed in the credit requirements to allow for flexibility in designing to the specific uses of each project. Meeting spaces must be designed so that occupants have control of their individual area; subdivide these spaces with movable walls or partitions. In residential applications, switched receptacles are appropriate to provide a variety of lighting options within the space. When daylighting is used as a component of an ambient lighting scheme in either type of space, provide glare control, lighting level controls, and room-darkening shades if appropriate.

OFFICES AND OTHER REGULARLY OCCUPIED SPACES

Count the workstations intended for individual use. The office and equipment layout should be carefully analyzed to ensure that 90% or more of these occupants have individual lighting controls that enable adjustment to suit individual needs. At a minimum, occupants must be able to turn the fixture on and off.

IEQ	
NC	Credit 6.1
CS	NA

Many types of luminaires are available; select those with a high level of flexibility and control. One effective way to meet the requirement is to use suspended luminaries that have 2 compartments, 1 for downlighting and 1 for general illumination, with separate switches for each. Occupants can quickly switch from 1 lighting scenario to the other without using dimmers, and 1 light is automatically turned off when the other is turned on. Dimming controls provide the greatest flexibility with the least disruption. Audiovisual rooms require a lower light level and should be easy to adjust to maintain optimum contrast levels on projection screens.

Ceilings should be white or light in color and extend at least 2.9 metres (9 1/2 feet) from the floor. If acoustical tiles or paint are used, select materials with 90% or greater reflectivity.

When using daylighting strategies in these spaces, install window treatments that provide appropriate light levels for audiovisual uses.

INDIVIDUAL WORKSTATION LIGHTING CONTROLS

Include private offices and cubicles when counting workstations for the following calculation:

$$\text{Workstations with Controls (\%)} = \frac{\text{Individual Workstations with Lighting Controls}}{\text{Total Individual Workstations}}$$

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Maintain a floor plan that indicates the location, zoning, and type of lighting controls. The floor plan should include furniture layout, indicating individual and shared work areas.
- Retain design information on task lighting, sensors, and lighting controls.

IEQ	
NC	Credit 6.1
CS	NA

8. EXAMPLES

FIGURE 1. WORKSTATIONS WITH INDIVIDUALLY ADJUSTABLE TASK LIGHTING

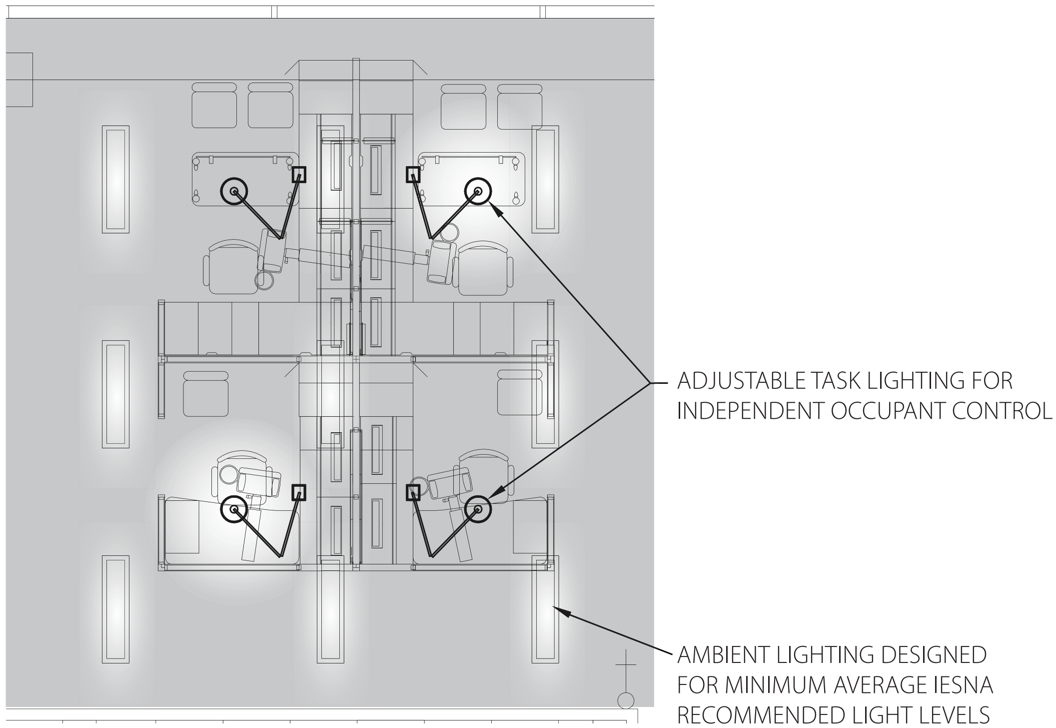
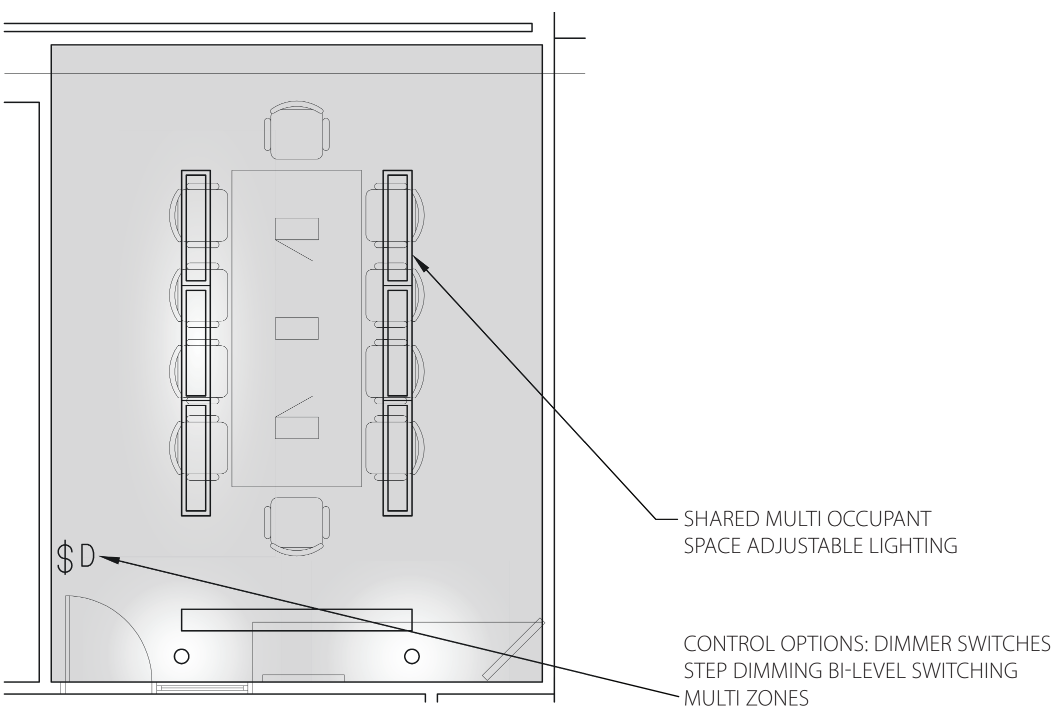


FIGURE 2. SHARED MULTI-OCCUPANT SPACE WITH ACCESS TO LIGHTING CONTROL



IEQ	
NC	Credit 6.1
CS	NA

Daylight harvesting and lighting control have been linked to higher productivity and lower energy bills. A lighting control system that either is remotely programmed or uses occupancy sensors (with a delay) to turn lamps on and off can save energy when areas are not in use.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Buildings in regions with strong sunlight may use less artificial lighting by day but require greater controllability in their lighting systems. Because daylight levels may range from low to intense during the course of a day, building occupants may experience discomfort if light levels fluctuate widely. Project teams in these regions should consider incorporating passive design strategies, such as good building orientation and the use of light-shielding devices like canopies, to control daylight. Daylight sensors that automatically adjust artificial lighting to compensate are also effective.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Building owners and architects should specify for lighting engineers and operators the number and type of lighting controls installed.

For automatic controls, provide appropriate setpoints and schedules in the facility's building operation plan. Establish procedures and schedules for recalibrating sensors, based on the manufacturer's requirements, and include them in the building's preventive maintenance plan.

When specifying automatic controls, consider the intended space use, and choose an option suited to expected conditions. A utility room, for example, may have moving parts that can falsely trigger motion-based sensors.

12. RESOURCES

WEBSITES

Center for the Built Environment
http://www.cbe.berkeley.edu

This University of California, Berkeley research center provides information on underfloor air distribution technologies and other topics. See the publications page for articles such as "A Field Study of PEM (Personal Environmental Module) Performance in Bank of America's San Francisco Office Buildings."

Cost-Effective Open-Plan Environment (COPE) Research Reports
Institute for Research in Construction, National Research Council and COPE Consortium.
http://www.nrc-cnrc.gc.ca/eng/projects/irc/cope/reports.html

In depth studies of open-plan office design variables and their effect on occupant satisfaction, including workstation design, indoor air quality and thermal comfort, lighting and acoustics. Studies include field and literature reviews, mock-up office experiments, and simulations to investigate the many elements of the open-plan office. (Some reports are not yet available.)

IEQ	
NC	Credit 6.1
CS	NA

Reports include:

- Environmental Satisfaction in Open-Plan Environments: 2. Effects of Workstation Size, Partition Height and Windows
- Office Air Distribution Systems and Environmental Satisfaction
- A Literature Review on the Relationship between Outdoor Ventilation Rates in Offices and Occupant Satisfaction
- Investigation of Air and Thermal Environments in a Mock-up Open Plan Office: Measurements and CFD Simulations
- The Effect of Office Design on Workstation Lighting: Simulation Results
- Effects of Office Design on the Annual Daylight Availability

Do Green Buildings Enhance the Well-being of Workers? Yes
Environmental Design + Construction
http://www.edcmag.com/Articles/Cover_Story/fb077b7338697010VgnVCM100000f932a8c0

This article by Judith Heerwagen in the July/August 2000 edition of Environmental Design + Construction quantifies the effects of green building environments on productivity.

PRINT MEDIA

Controls and Automation for Facilities Managers: Applications Engineering, by Viktor Boed (CRC Press, 1998).

Advanced Lighting Guidelines, 2003 edition, by New Buildings Institute (NBI, 2003).

Collaborative for High Performance Schools Best Practices Manual, 2006 edition
http://www.chps.net/dev/Drupal/node/288 manual/index.htm.

IESNA Lighting for Educational Facilities, by Illuminating Engineering Society of North America (IESNA, 2006): Document ID RP-3-00 at http://www.iesna.org.

IESNA Lighting Handbook, 9th edition, by Illuminating Engineering Society of North America (IESNA, 2000): Document ID # HB-9-00at http://www.iesna.org.

13. DEFINITIONS

Audiovisual (A/V) media are slides, film, video, sound recordings, and other such devices used to present information.

Commissioning (Cx) is the process of verifying and documenting that a building and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's operating requirements.

Controls are operating mechanisms that enable a person to turn on or off devices (e.g., lights, heaters) or adjust systems within a range (e.g., lighting, temperature).

Daylighting is the controlled admission of natural light into a space, used to reduce or eliminate electric lighting.

Glare is any excessively bright source of light within the visual field that creates discomfort or loss in visibility.

Group multi-occupant spaces include conference rooms, classrooms, and other indoor spaces used as places of congregation.

In **individual occupant spaces**, workers use standard workstations to conduct individual tasks. Examples are private offices and open office areas with multiple workers.

IEQ	
NC	Credit 6.1
CS	NA

Luminaire is a lighting fixture assembly, including lamp, housing, reflector, and ballast (if applicable).

Nonoccupied spaces include all rooms used by maintenance personnel that are not open for use by occupants. Examples are closets and janitorial, storage, and equipment rooms.

Outdoor air is the ambient air that enters a building through a ventilation system, either through intentional openings for natural ventilation or by infiltration. (ASHRAE 62.1–2007)

Sensors are devices that undergo a measurable change in response to environmental changes and communicate this to the appropriate equipment or control system.

IEQ	
NC	Credit 6.1
CS	NA

14. CASE STUDY

EXPANSION OF DINOSAUR PROVINCIAL PARK VISITOR CENTRE AND TYRRELL FIELD STATION

LEED Canada-NC 1.0 Gold, 4 October 2007

Location: Dinosaur Provincial Park, Alberta
Building Type: Conservation Centre
Owner Type: Government (provincial)
Building Size: 1,300m^2
Owner Name: Alberta Infrastructure and Transportation
LEED Consultant: Designworks Architecture
Responsible Firm (for this credit): Designworks Architecture
Photo Credit: Alberta Tourism Parks Recreation and Culture

Dinosaur Provincial Park is a UNESCO World Heritage Site situated in a unique and powerful landscape formed by erosion. The project comprised a 50% expansion to the existing Visitor Centre and Field Station to accommodate increased visitation within a modest budget.

The building design optimizes daylight access through the use of either north facing glazing or glazing that is protected from direct sun through steep hills immediately east of the building. Strategic placement of high level clerestory glazing allows daylight into floor areas further from the building perimeter and contributes daylight from two directions in some areas. Abundant daylight with glare protection allows for significant durations of natural daylighting with minimal or no electric lighting.

When adequate daylight is available, or when rooms are empty, daylight and occupancy sensors automatically switch off electric lighting. In the exhibit hall, which has a deeper room profile relative to the primary daylighting glazing, lighting controls allow electric lighting to be shut down by rows that are progressively further from the perimeter. This strategy provides a balanced distribution of lighting and blending of daylighting and electric lighting.

Interior surfaces, particularly walls and ceilings, have light-coloured finishes to provide greater reflectivity of daylight and to help balance daylight distribution. The lighting controls, in the form of daylighting and occupancy sensors are provided per the credit requirement. The controls allow for manual on, auto-off (if adequate daylight or no occupancy), and an option to manually override the auto-off.

IEQ	
NC	Credit 6.1
CS	NA

Lessons learned:

- Consultant should provide occupant education on how the controls work and the intent of the controls and daylighting strategies.
- Placement and design of furnishings is important. Tall merchandize displays in the gift shop have reduced daylight distribution resulting in occupants overriding the daylighting controls. Exhibits in the central hall were designed and oriented to work with the daylighting and natural ventilation strategies.

IEQ	
NC	Credit 6.2
CS	Credit 6

CONTROLLABILITY OF SYSTEMS: THERMAL COMFORT

	NC	CS
Credit	IEQ Credit 6.2	IEQ Credit 6
Points	1 point	1 point

INTENT

To provide a high level of thermal comfort system control by individual occupants or groups in multi-occupant spaces (e.g., classrooms or conference areas) to promote their productivity, comfort and well-being.

REQUIREMENTS: NC & CS

Provide individual comfort controls for 50% (minimum) of the building occupants to enable adjustments to meet individual needs and preferences. Operable windows may be used in lieu of controls for occupants located 6 metres (20 feet) inside and 3 metres (10 feet) to either side of the operable part of the window. The areas of operable window must meet the requirements of ASHRAE Standard 62.1-2007-Ventilation for Acceptable Indoor Air Quality, paragraph 5.1 Natural Ventilation (with errata but without addenda[a]).

Provide comfort system controls for all shared multi-occupant spaces to enable adjustments that meet group needs and preferences.

Conditions for thermal comfort are described in ASHRAE Standard 55-2004-Thermal Environmental Conditions for Human Occupancy (with errata but without addenda) to include the primary factors of air temperature, radiant temperature, air speed and humidity.

CS ADDITIONAL REQUIREMENT:

Core and shell projects that do not purchase and/or install the mechanical system or operable windows (or a combination of both) have not met the intent of this credit.

See Appendix 1 — Default Occupancy Counts for occupancy count requirements and guidance.

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[a] Project teams wishing to use ASHRAE approved addenda for the purposes of this credit may do so at their discretion. Addenda must be applied consistently across all LEED credits.

IEQ	
NC	Credit 6.2
CS	Credit 6

INTERPRETATIONS

Skylights are an acceptable alternative to operable windows provided that the operable area they provide meets the area requirements of ASHRAE Standard 62.1-2007- Ventilation for Acceptable Indoor Air Quality. Skylights must also have easily accessible controls for building occupants.

LEASED TENANT SPACES (NC & CS)

For spaces not fit-up at time of application, the applicant must identify regularly occupied areas for the future tenants and provide sufficient controls in these areas. See Appendix 1 - Default Occupancy Counts.

MURBS

In residential units, provide individual comfort controls for each regularly occupied space to enable adjustments to meet individual needs and preferences. Operable windows can be used as comfort controls for each room. The areas of operable window must meet the requirements of ASHRAE Standard 62.1-2007-Ventilation for Acceptable Indoor Air Quality, paragraph 5.1 Natural Ventilation.

For residential projects, sliding glass and other doors leading to exterior balconies can be treated as "operable windows" for this credit, provided there are no security issues that would preclude their regular use for thermal comfort control.

Kitchen exhaust fans in MURBs do not qualify as an airflow control for the purposes of this credit.

IEQ	
NC	Credit 6.2
CS	Credit 6

1. BENEFITS AND ISSUES TO CONSIDER

Providing temperature controls for individuals and spaces will increase occupant comfort while simultaneously saving energy.

ECONOMIC ISSUES

Occupant complaints frequently include thermal discomfort. Greater thermal comfort may increase occupant performance and attendance and, at least, will reduce complaints. As noted in a report published by the Center for the Built Environment,[25] studies have shown that individual occupant controls can potentially increase occupant satisfaction and productivity. The financial implications of such improvements can be extremely large. Additional controllability may add to a project's initial costs, however, these costs are generally offset by energy savings from lower-conditioned temperatures, automatic occupancy detectors, natural ventilation, and shading devices. Conversely, abuse of personal controls, such as setting thermostats too high or leaving windows open during nonworking hours, increases energy costs. Therefore, it is important to educate occupants on the design and function of system controls. Alteration of ventilation and temperature schemes may change the energy performance of a building and may require commissioning and measurement and verification attention.

CS

Core & Shell HVAC duct design for tenant spaces are typically incomplete. The intent of this credit in *LEED Canada Core & Shell* is to provide building HVAC systems that can be expanded to allow for a high degree of occupant control. Some system types make this credit easier to achieve and document than others. An underfloor air system that allows tenants to use individual diffusers can offer a high degree of tenant controllability. Buildings that use an overhead variable air volume system will have to demonstrate that it is possible for the system to provide enough control points for 50% of the occupants.

2. RELATED CREDITS

The intent of this credit is to enable individuals and, in multi-occupant spaces, groups to control their thermal comfort. The following prerequisites and credits also address building occupants' ability to control systems, maintenance, and other factors:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance
- EA Credit 3: Enhanced Commissioning
- EA Credit 5: Measurement and Verification
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control
- IEQ Credit 6.1: Controllability of Systems—Lighting (NC only)
- IEQ Credit 8: Daylight and Views

IEQ	
NC	Credit 6.2
CS	Credit 6

3. SUMMARY OF REFERENCED STANDARDS

American National Standards Institute (ANSI)/ASHRAE Standard 62.1–2007: Ventilation for Acceptable Indoor Air Quality
ASHRAE
http://www.ashrae.org
Section 5.1 of the standard provides minimum requirements for operable openings. The portion of the window that can be opened must be 4% of the net inhabitable floor area. Building occupants must have ready access to the means of opening the windows.

American National Standards Institute ANSI/ASHRAE Standard 55–2004: Thermal Environmental Conditions for Human Occupancy
ASHRAE 55–2004 identifies the factors of thermal comfort and the process for developing comfort criteria for a building space and its occupants. ASHRAE states, "this standard specifies the combinations of indoor space environment and personal factors that will produce thermal environmental conditions acceptable to 80% or more of the occupants within a space. The environmental factors addressed are temperature, thermal radiation, humidity and air speed; the personal factors are those of activity and clothing."

4. IMPLEMENTATION

Many conventional buildings are built as sealed spaces in which the occupants have no control over thermal conditions. A better approach gives individuals the controls to adjust thermal conditions for a more comfortable environment. Individual thermal comfort can depend on air velocity, the direction and temperature of indoor air, and moisture content. The design team should determine the level of individual control desired, and should design the building with comfort controls to suit both individual needs and those of groups in shared spaces.

Consider including designs with operable windows, hybrid designs incorporating operable windows and mechanical systems, or mechanical systems alone. Individual control of comfort with mechanical systems may be integrated into the overall systems design by enabling individual adjustment of selected comfort parameters, such as individual thermostats, individual diffusers (located at the floor, desk, or overhead level) and individual radiant panels. Occupancy sensors can also be integrated in the design to automatically turn down the thermostat and reduce airflow when occupants are away, helping reduce energy use.

Educate occupants on their individual control of their environment. Additionally, train key maintenance staff in the operations of the HVAC equipment and any installed controls. Provide at least 1 thermal control per residential unit to be eligible for this credit. Common areas in residential projects are considered multi-occupant spaces and are subject to the same requirement as other projects.

INDIVIDUAL THERMAL COMFORT

To satisfy this portion of the requirement, start by identifying workstation locations that are intended for individual use, including private offices, open plan workstations, reception stations, ticket booths, etc. Confirm that 50% or more of individuals occupying these locations have at least 1 means of individual control over thermal comfort.

Operable windows may be used in lieu of individual controls for those occupants located within 6 metres (20 feet) of the exterior wall and within 3 metres (10 feet) of either side of the operable part of the window. The operable portion of the window will need to comply with the free-opening size criteria of ANSI/ ASHRAE 62.1–2007 section 5.1. The minimum area of the window opening may

IEQ	
NC	Credit 6.2
CS	Credit 6

be 4% of the net occupiable area for ventilation purposes; however, larger opening areas may be required for thermal comfort under a wide range of outside conditions. For example, in an area 6 metres by 6 metres, the opening size per window would need to be 1.44 square metres to meet the limits used in this credit.

MULTI-OCCUPANT SPACES

Start by identifying areas where groups occasionally congregate, such as conference rooms, break rooms, and lecture halls. Specific types or numbers of controls are not listed in the credit requirements to allow for flexibility in designing to the unique uses of each project. Confirm that there is at least 1 accessible means of control over thermal comfort in the space. Meeting spaces that can be subdivided, as with a movable wall in a convention hall, must be designed so that occupants in each area have control of their individual area.

5. TIMELINE AND TEAM

During schematic design, building designers should evaluate the building's orientation and consider how heat gain or loss will affect the occupants. Designers should also consider whether site-specific conditions, such as wind, sound, and odours, may affect the location of operable windows. During design development, locate the thermal comfort controls with electrical and mechanical engineers as well as the construction or development manager. Consider thermal comfort needs as they pertain to ANSI/ASHRAE 55–2004 requirements; survey future occupants' desires. Evaluate the controls for each space, considering the specific tools and equipment that occupants will use on a daily basis. When evaluating shared occupant spaces, consider the occupancy schedule.

Post installation commissioning of all thermal comfort systems will ensure proper operation. During building operation, the owner should provide training for building maintenance staff in using the controls. Property management and building engineers should periodically review of comfort control systems to ensure that occupants' needs are met and that controls are working according to design.

6. CALCULATIONS

INDIVIDUAL THERMAL COMFORT

Identify workstations intended for individual use, such as private offices, open-plan workstations, reception stations, and ticket booths. Confirm that 50% or more of individuals occupying these locations have at least 1 means of individual control over thermal comfort.

Operable windows may be used in lieu of individual controls for occupants located within 6 metres (20 feet) of the exterior wall and within 3 metres (10 feet) of either side of the operable part of the window. The operable portion of the window must comply with the free-opening size criterion of ANSI/ASHRAE 62.1– 2007, Section 5.1; the minimum area of the window that may be opened is 4% of the net floor area. For the limits used in this credit [i.e., an area 6 metres (20 feet) by 6 metres (20 feet) per window], the opening size would need to be 1.44 square metres (16 square feet).

SHARED MULTI-OCCUPANT SPACES

For conference rooms and lecture halls, confirm that there is at least 1 accessible means of control over thermal comfort. For meeting spaces that can be subdivided, such as a convention hall with a movable wall, occupants in each area should have control of their individual area.

IEQ	
NC	Credit 6.2
CS	Credit 6

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

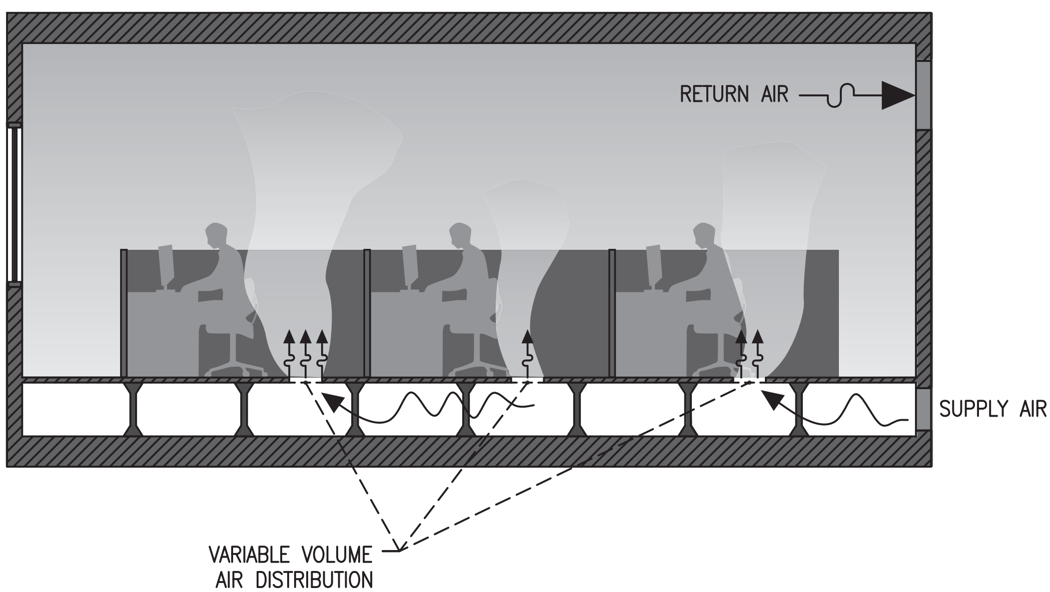
- For individual workstation controls, maintain a list of the total number of individual workstations and thermal controls.
- For shared multi-occupant space control, maintain a list of a project's group multi-occupant spaces and a description of the installed thermal controls.
- Show thermal controls on drawings.

CS

- Record the number of expected occupants on a floor-by-floor basis. See Appendix 1 for the default occupancy counts. State which systems serve each floor.

8. EXAMPLES

FIGURE 1 . UNDERFLOOR AIR DISTRIBUTION SYSTEM WITH INDIVIDUAL CONTROLS FOR AIR VELOCITY AND TEMPERATURE



Some examples to help achieve thermal comfort for building occupants include thermostat controls; local diffusers at the floor, desk, or overhead levels; or control of individual radiant panels. Radiant heating may be a good option to pursue. More specifically, room thermostats, natural ventilation actuators, and ceiling fans can have the capability for local occupant override or bypass.

IEQ	
NC	Credit 6.2
CS	Credit 6

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Local weather and ambient air conditions must be considered when determining the feasibility of operable windows for projects. For example, in areas that are prone to extreme temperatures for a majority of the year, or urban areas where traffic and air pollution are problematic, operable windows may not be an appropriate addition to a building.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Inform building operators about the number and type of thermal comfort controls installed.

Include the default setpoints and schedules in the facility's building operation plan. Establish procedures and schedules for recalibrating controls, based on the manufacturer's recommendations, and include them in the building's preventive maintenance plan. Train building operators in using and maintaining specialty equipment. Maintenance staff should plan to clean or replace HVAC filters more frequently if building occupants use operable windows.

12. RESOURCES

WEBSITES

Center for the Built Environment
http://www.cbe.berkeley.edu

This University of California, Berkeley research center provides information on underfloor air distribution technologies and other topics. See the publications page for articles such as A Field Study of Personal Environmental Module (PEM) Performance in Bank of America's San Francisco Office Buildings.

Do Green Buildings Enhance the Well-Being of Workers? Yes
Environmental Design + Construction
http://www.edcmag.com/Articles/Cover_Story/fb077b7338697010VgnVCM100000f932a8c0

An article by Judith Heerwagen, in the July/August 2000 edition, of Environmental Design + Construction quantifies the effects of green building environments on productivity.

PRINT MEDIA

Controls and Automation for Facilities Managers: Applications Engineering, by Viktor Boed (CRC Press, 1998).

Giving Occupants What They Want: Guidelines for Implementing Personal Environmental Control in Your Building, by Fred S. Bauman(Center for the Built Environment, 1999).

Using Advanced Office Technology to Increase Productivity: The Impact of Environmentally Responsive Workstations (ERWs) on Productivity and Worker Attitude, by W. Kroner, J. Stark-Martin, and T. Willemain (Rensselaer Polytechnic Institute, 1992).

IEQ	
NC	Credit 6.2
CS	Credit 6

13. DEFINITIONS

The **building envelope**, or shell, is the exterior surface of a building's construction—the walls, windows, roof, and floor.

Comfort criteria are the specific original design conditions that at minimum include temperature, humidity, and air speed as well as outdoor temperature design conditions, outdoor humidity design conditions, clothing, and expected activity. (ASHRAE 55–2004)

Commissioning (Cx) is the process of verifying and documenting that a building and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's operating requirements.

Controls are operating mechanisms that enable a person to turn on or off devices (e.g., lights, heaters) or adjust systems within a range (e.g., lighting, temperature).

Daylighting is the controlled admission of natural light into a space, used to reduce or eliminate electric lighting.

HVAC systems are equipment, distribution systems, and terminals that provide the processes of heating, ventilating, or air-conditioning. (ASHRAE 90.1–2007)

In **individual occupant spaces**, workers use standard workstations to conduct individual tasks. Examples are private offices and open office areas with multiple workers.

Natural ventilation is provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building. (ASHRAE 62.1–2007)

Non-occupied spaces include all rooms used by maintenance personnel that are not open for use by occupants. Examples are closets and janitorial, storage, and equipment rooms.

Outdoor air is the ambient air that enters a building through a ventilation system, either through intentional openings for natural ventilation or by infiltration (ASHRAE 62.1–2007).

Regularly occupied spaces in commercial buildings are areas where people sit or stand as they work. In residential applications these spaces include all living and family rooms and exclude bathrooms, closets, or other storage or utility areas. In schools, they are areas where students, teachers, or administrators are seated or standing as they work or study.

Group multi-occupant spaces include conference rooms, classrooms, and other indoor spaces used as places of congregation.

Sensors are devices that undergo a measurable change in response to environmental changes and communicate this to the appropriate equipment or control system.

Thermal comfort exists when occupants express satisfaction with the thermal environment.

IEQ	
NC	Credit 7.1
CS	Credit 7

THERMAL COMFORT: DESIGN

	NC	CS
Credit	IEQ Credit 7.1	IEQ Credit 7
Points	1 point	1 point

INTENT

To provide a comfortable thermal environment that promotes occupant productivity and well-being.

REQUIREMENTS: NC & CS

Design heating, ventilation and air conditioning (HVAC) systems and the building envelope to meet the requirements of ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy (with errata but without addenda[a]). Demonstrate design compliance in accordance with the Section 6.1.1 documentation.

CS ADDITIONAL REQUIREMENT:

The core and shell base building mechanical system must allow for the tenant build-out to meet the requirements of this credit. Project teams that design their project for mechanical ventilation that do not purchase or install the mechanical system are not eligible to achieve this credit.

See Appendix 1 — Default Occupancy Counts for occupancy count requirements and guidance.

INTERPRETATIONS

In accordance with the ASHRAE Standard 55-2004, it is acceptable to exclude areas that are primarily used by people at high metabolic rates. For the spaces to be excluded, the project must provide a description of the space(s), the intended use(s), the referenced metabolic rates from ASHRAE Standard 55-2004, and the rationale for excluding the space. All non-excluded areas must meet the credit requirements.

[a] Project teams wishing to use ASHRAE approved addenda for the purposes of this credit may do so at their discretion. Addenda must be applied consistently across all LEED credits.

IEQ	
NC	Credit 7.1
CS	Credit 7

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Maintaining an acceptable level of thermal comfort for building occupants should be considered a necessity for any building or space with regular occupancy. Studies have shown that people who are comfortable are more productive and generally happier. In a work environment, increases in productivity can reduce the amount of time and energy required for an individual task. Over the course of a year, that can translate to fewer hours running equipment such as computers or task lighting, resulting in energy savings that reduce the strain on the environment.

ECONOMIC ISSUES

Generally, HVAC and building envelope systems that do not adequately address the thermal comfort of occupants are less energy efficient than their more robust counterparts—with the exception of passive or naturally ventilated spaces. Mechanical systems relying on natural ventilation typically have lower capital and construction costs and use less energy than mechanically ventilated systems. In climates with extreme seasonal temperature swings, occupants' comfort can suffer in a naturally ventilated building, but a well-designed building envelope and HVAC system can help compensate. Buildings with poor envelopes might struggle to maintain a comfortable environment for occupants near the building perimeter. The building HVAC system will expend more energy trying to maintain a comfortable environment for those occupants on the perimeter, increasing the annual energy cost of the building.

HVAC systems with poorly located or inadequate numbers of thermostats or control zones can significantly affect occupants' comfort. Occupants using areas that could otherwise have been provided individual temperature controls may have to share a thermostat or may use space heaters, which can increase energy use. When spaces have not been properly thermally zoned, occupants may try to heat and cool the same area at the same time, potentially resulting in greater energy use and additional costs to operate the building.

2. RELATED CREDITS

The thermal comfort of building occupants is affected by environmental conditions (air temperature, radiant temperature, relative humidity, and air speed), personal factors (metabolic rate and clothing), and personal preferences. Thermal comfort can be controlled through both active (HVAC) and passive systems (natural ventilation). The best results are often achieved through a combination of the 2 systems: Using both can help reduce the building's energy consumption, as well as achieve optimum comfort levels. For all these reasons, this credit is related to the following other prerequisites and credits:

- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance
- EA Credit 5: Measurement and Verification

To address the issue of commissioning thermal comfort features, refer to the following prerequisite and credit:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Credit 3: Enhanced Commissioning

IEQ	
NC	Credit 7.1
CS	Credit 7

The following prerequisite and credits also pertain to occupants' comfort:

- IEQ Prerequisite 1: Minimum Indoor Air Quality Performance
- IEQ Credit 2: Increased Ventilation
- IEQ Credit 6.2: Controllability of Systems—Thermal Comfort
- IEQ Credit 7.2: Thermal Comfort—Verification

3. SUMMARY OF REFERENCED STANDARDS

American National Standards Institute (ANSI)/ ASHRAE Standard 55–2004, Thermal Comfort Conditions for Human Occupancy
ASHRAE
http://www.ashrae.org
According to ASHRAE, this standard "specifies the combinations of indoor space environment and personal factors that will produce thermal environmental conditions acceptable to 80% or more of the occupants within a space. The environmental factors addressed are temperature, thermal radiation, humidity and air speed; the personal factors are those of activity and clothing."

Chartered Institute of Building Services Engineers (CIBSE) Applications Manual 10–2005, Natural Ventilation in Non-Domestic Buildings
CIBSE, London
http://www.cibse.org
CIBSE Applications Manual 10–2005 provides guidance for implementing natural ventilation in non-residential buildings. It provides detailed information on how to adopt natural ventilation as the sole servicing strategy for a building or as an element in a mixed mode design. According to the publisher, this manual "is a major revision of the Applications Manual (AM) first published in 1997. At the time, there was a significant expansion of interest in the application of engineered natural ventilation to the design of non-domestic buildings. The original AM10 sought to capture the state of knowledge as it existed in the mid-90s and present it in a form suited to the needs of every member of the design team. Some 10 years on from the time when the initial manual was conceived, the state of knowledge has increased, and experience in the design and operation of naturally ventilated buildings has grown. This revision of AM10 is therefore a timely opportunity to update and enhance the guidance offered to designers and users of naturally ventilated buildings."

4. IMPLEMENTATION

A green building should provide its occupants with comfortable indoor conditions that support their productivity and well-being. Although often associated only with air temperature, thermal comfort is a complex issue, affected by environmental conditions (e.g., air temperature, radiant temperature, humidity, and air speed) and personal factors (e.g., metabolic rate. clothing, and preferences). There are 3 basic approaches to providing thermal comfort within a project space:

- mechanical ventilation (i.e., active ventilation);
- natural ventilation (i.e., passive ventilation); and
- mixed-mode ventilation (i.e., both mechanical and natural ventilation).

The owner and project team should make a decision as to which of the conditioning approaches are appropriate for the building. ASHRAE 55–2004 provides thermal comfort standards, with an optional alternate approach specifically for naturally ventilated spaces.

ASHRAE 55–2004 is based on the predicted mean vote (PMV) comfort model, which incorporates heat balance principles to relate the personal and environmental thermal comfort factors based

IEQ	
NC	Credit 7.1
CS	Credit 7

on the thermal sensation scale that shows 7 levels ranging from +3 (hot) to -3 (cold). The model is applicable to air speeds not greater than 0.20 m/s (40 fpm).

For naturally ventilated spaces, field experiments have shown that occupants' thermal responses depend in part on the outdoor climate and may differ from thermal responses in buildings with centralized HVAC systems. This is primarily because of the different thermal experiences, changes in clothing, availability of control, and shifts in occupant expectations. The standard provides an optional method of compliance that is intended for naturally ventilated spaces. This optional method (section 5.3 of the standard) provides broad indoor temperature ranges as a function of mean monthly outdoor temperatures, assuming light and sedentary activity but independent of humidity, air speed, and clothing considerations.

ASHRAE 55-2004 also addresses factors that can cause local discomfort. The ASHRAE Standard 55-2004 sections pertaining to these issues are listed below. Design teams should refer to the standard for details.

- 5.2.1 Operative Temperature
- 5.2.2 Humidity Limits
- 5.2.3 Elevated Air Speed
- 5.2.4 Local Thermal Discomfort
- 5.2.5 Temperature Variations with Time

5. TIMELINE AND TEAM

Using ASHRAE 55–2004, the design team and the owner should determine how to achieve the desired thermal comfort in the project space and identify the appropriate conditioning systems (whether active or passive). This decision might be influenced by the local climate, the size and type of the proposed building, and the nature of the operations it will host.

There are many well-established HVAC load calculation methods to assist designers in sizing and selecting HVAC equipment to provide thermal comfort conditions. Lighting and other internal HVAC loads are integrated into the calculations to enable adequate system capacity and meet thermal comfort criteria without oversizing the HVAC system.

A natural ventilation approach may be more difficult to evaluate in design and require more intensive analysis and/or reliance on experience and precedents. For naturally ventilated buildings, CIBSE AM10 presents design strategies to maintain comfort and health.

For mechanical conditioning, the operating setpoints and parameters of the HVAC system will largely determine thermal comfort conditions. Many facility operators in mechanically air-conditioned spaces spend significant effort and time adjusting thermostat setpoints and other operational parameters to limit complaints associated with poor thermal comfort. Giving individual occupants some control over temperature and/or air movement reduces thermal comfort complaints.

The maxim "passive buildings, active occupants" fits the natural ventilation model well. Occupants generally take a primary role in managing thermal comfort conditions in naturally ventilated buildings by opening and closing windows as necessary and appropriate. Thermal comfort in naturally conditioned buildings is also somewhat more variable than in mechanically conditioned buildings, where systems are often designed to maintain relatively consistent conditions through all periods of occupancy.

IEQ	
NC	Credit 7.1
CS	Credit 7

6. CALCULATIONS

Project teams should be able to describe how thermal comfort conditions were established for the project and how the design of conditioning systems addresses the thermal comfort design. Project teams need to provide predicted mean vote and predicted percentage of dissatisfied (PMV/PPD) calculations for major zones for each operating season using ASHRAE comfort tools or similar procedures. If any of the local discomfort conditions described in the ASHRAE Standard 55-2004 exists, the project team must provide supporting calculations and/or a description of how the issue is addressed.

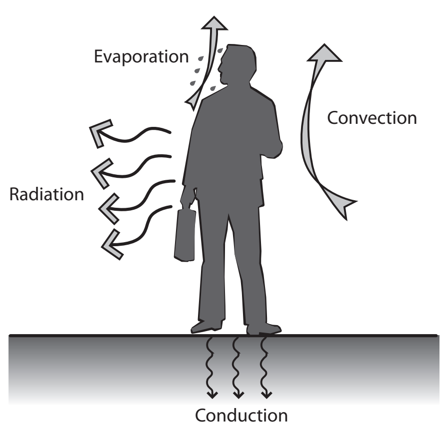
7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Document the owner's project requirements. This should indicate the intended comfort criteria for the building and state assumptions regarding activity level and occupant clothing.
- Summarize operational procedures for building systems, including building controls and other environmental control systems. Teams should also include general information, seasonal set point recommendations, changeover schedules, maintenance and operation instructions, and a maintenance and inspection schedule.
- Document the mechanical designer's basis of design; include design assumptions, including diversity considerations, and HVAC load calculations.
- Maintain documentation (e.g., design plans, lists) of all registers and terminal units that includes the type and flow, or radiant value. Additionally, include any elements that significantly affect thermal comfort, indication of spaces outside comfort-controlled areas, and locations of all occupant-adjustable controls.
- Generate supporting calculations that address local discomfort where specific comfort conditions exist.

8. EXAMPLES

FIGURE 1. THERMAL TRANSFER BETWEEN PERSON AND ENVIRONMENT



IEQ	
NC	Credit 7.1
CS	Credit 7

FIGURE 2. SIX PRIMARY COMFORT FACTORS (ASHRAE 55–2004)

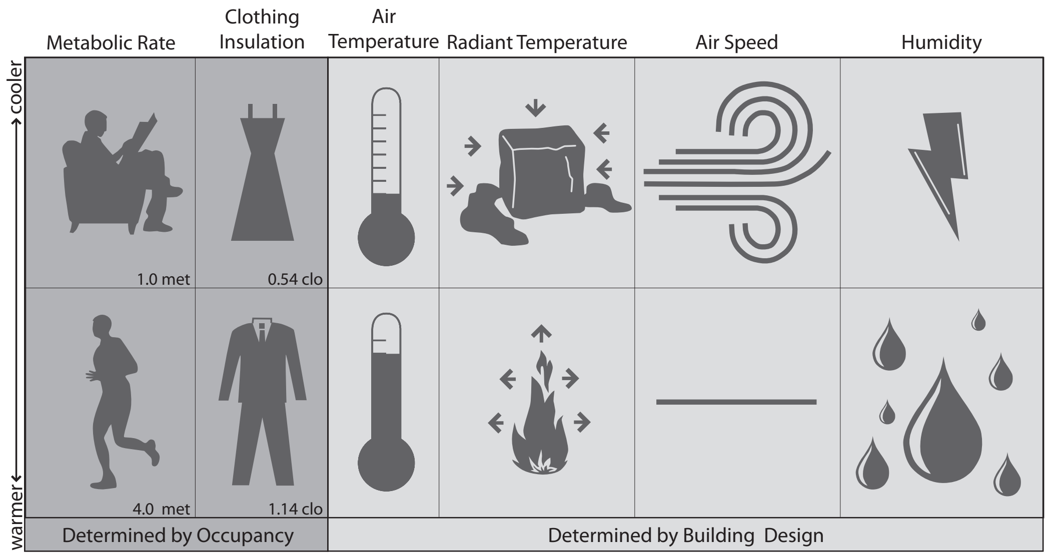
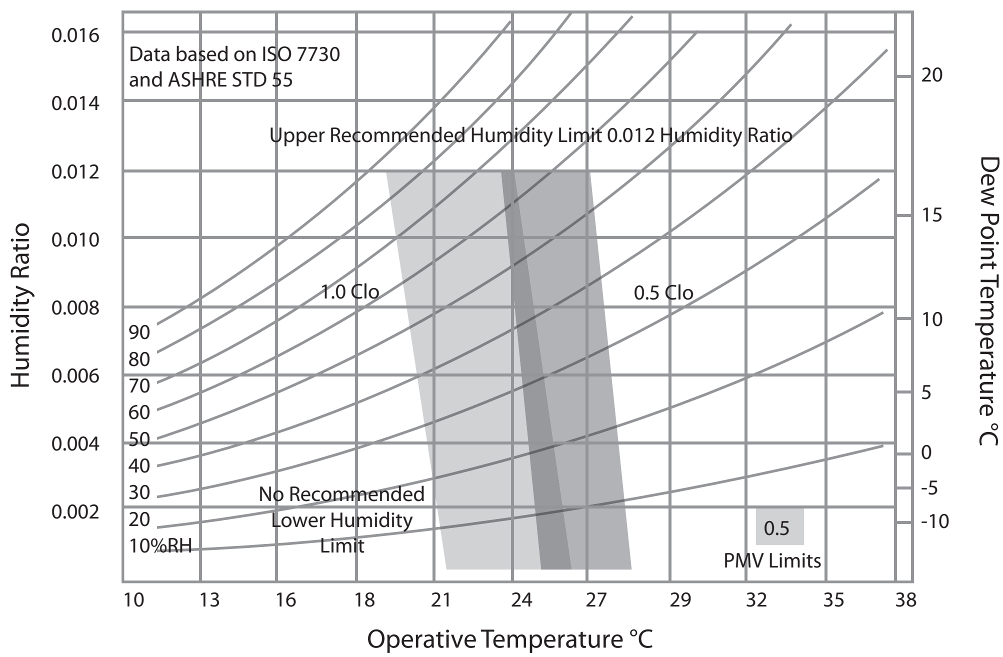


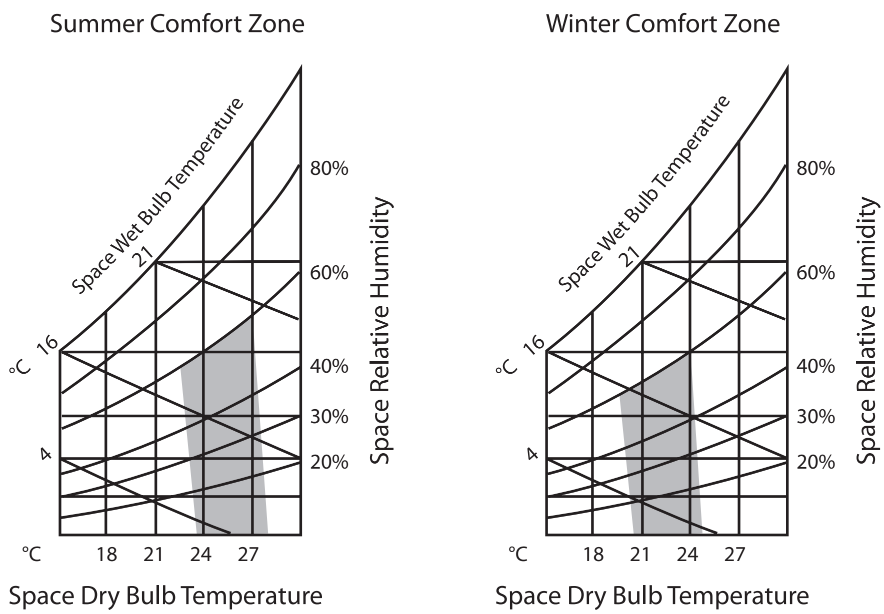
FIGURE 3. ACCEPTABLE OPERATIVE TEMPERATURE AND HUMIDITY RATIO (ASHRAE 55-2004)



The charts take temperature and humidity into consideration and are most applicable to occupants who are appropriately dressed and involved in light work (e.g., office workers). Variations are based on the assumption that occupants are dressed according to the seasons.

IEQ	
NC	Credit 7.1
CS	Credit 7

FIGURE 4 . COMFORT ZONES (ASHRAE 55-2004)



Use Figure 4 to identify optimum interior comfort levels as well as deviations in thermal comfort that are specific to the building, the occupants, and the type of work they do.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

When considering occupant comfort, anticipate how climate and seasonal variations will affect thermal comfort levels. Climate variations play an important role in passively ventilated buildings because of the introduction of unconditioned outside air. In mechanically ventilated buildings, regional variations have an impact on the temperature range that an occupant considers comfortable. Warmer climates typically have higher design temperatures than colder climates to match the conditions that would normally be considered comfortable.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Provide the building owner, maintenance personnel, and occupants with the information needed to understand, maintain, and adjust the HVAC system for thermal comfort. Establish appropriate setpoints and control sequences, as well as recommendations for typical corrective actions, and include them in the building operating plan and sequence of operations document.

Establish procedures and schedules for inspecting and recalibrating sensors and controls, based on the manufacturer's recommendations, and include them in the building's preventive maintenance plan.

IEQ	
NC	Credit 7.1
CS	Credit 7

12. RESOURCES

WEBSITES

EnergyPlus
http://www.eere.energy.gov/buildings/energyplus/

A building energy simulation program for modeling building heating, cooling, lighting, ventilating, and other energy flows. It builds on the most popular features and capabilities of BLAST and DOE-2 but also includes many innovative simulation capabilities such as time steps of less than an hour, modular systems and plant integrated with heat balance based zone simulation, multizone air flow, thermal comfort, and photovoltaic systems.

ESP-r
http://www.esru.strath.ac.uk/Programs/ESP-r.htm

An integrated modeling tool for the simulation of the thermal, visual and acoustic performance of buildings and the assessment of the energy use and gaseous emissions associated with the environmental control systems and constructional materials. In undertaking its assessments, the system is equipped to model heat, air, moisture and electrical power flows at user determined resolution. The system is designed for the Unix operating system, with supported implementations for Solaris and Linux, and is made available at no cost under an Open Source license. ESPr has a variety of possible applications including consultancy, research and teaching.

NIST Multizone Modeling Software
http://www.bfrl.nist.gov/IAQanalysis/software/index.htm

The National Institute of Standards and Technology provides software such as CONTAMW, a multizone indoor air quality and ventilation analysis computer program designed to predict airflows and contaminant concentrations.

TAS
http://www.edsl.net/main

A "suite of software products, which simulate the dynamic thermal performance of buildings and their systems. The main module is TAS Building Designer, which performs dynamic building simulation with integrated natural and forced airflow. It has 3D graphics based geometry input that includes a CAD link. TAS Systems is a HVAC systems/controls simulator, which may be directly coupled with the building simulator. It performs automatic airflow and plant sizing and total energy demand. The third module, TAS Ambiens, is a robust and simple to use 2D CFD package which produces a cross section of micro climate variation in a space."

The Whole Building Design Guide, Enhance IEQ
http://www.wbdg.org/design/ieq.php

The IEQ section provides a wealth of resources including definitions, fundamentals, materials, and tools.

PRINT MEDIA

ASHRAE 62.1 –2007: Ventilation for Acceptable Indoor Air Quality (ASHRAE, 2007).

Humidity Control Design Guide, by L. Harriman, G.W. Brundett, and R. Kittler (ASHRAE, 2000).

The Impact of Part-Load Air-Conditioner Operation on Dehumidification Performance: Validating a Latent Capacity Degradation Model by Hugh Henderson, Conference Proceedings IAQ and Energy 98, ASHRAE, 1998.

IEQ	
NC	Credit 7.1
CS	Credit 7

13. DEFINITIONS

Comfort criteria are the specific original design conditions that at a minimum include temperature, humidity, and air speed as well as outdoor temperature design conditions, outdoor humidity design conditions, clothing, and expected activity. (ASHRAE 55-2004)

Commissioning is the process of verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's operating requirements.

Mechanical ventilation is provided by mechanically powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows (ASHRAE 62.1-2007).

Mixed-mode ventilation combines mechanical and natural ventilation methods.

Natural ventilation is provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building. (ASHRAE 62.1–2007)

Occupants in a commercial building are workers who either have a permanent office or workstation in the building or typically spend a minimum of 10 hours per week in the building. In a residential building, occupants also include all persons who live in the building.

Predicted mean vote is an empirical equation for predicting the mean vote on a rating scale of thermal comfort of a large population of people exposed to a certain environment.

Relative humidity is the ratio of partial density of airborne water vapour to the saturation density of water vapour at the same temperature and total pressure.

Thermal comfort exists when occupants express satisfaction with the thermal environment.

IEQ	
NC	Credit 7.2
CS	NA

THERMAL COMFORT: VERIFICATION

	NC	CS
Credit	IEQ Credit 7.2	NA
Points	1 point*	NA

*1 point in addition to IEQ Credit 7.1.

INTENT

To provide for the assessment of building occupants' thermal comfort over time.

REQUIREMENTS: NC

CASE 1. ALL BUILDINGS

Achieve IEQ Credit 7.1: Thermal Comfort – Design.

Agree to conduct a thermal comfort survey of building occupants within 6 to 18 months after occupancy. This survey should collect anonymous responses about thermal comfort in the building, including an assessment of overall satisfaction with thermal performance and identification of thermal comfort problems. Agree to develop a plan for corrective action if the survey results indicate that more than 20% of occupants are dissatisfied with thermal comfort in the building. This plan should include measurement of relevant environmental variables in problem areas in accordance with ASHRAE Standard 55-2004, Thermal Environmental Conditions for Human Occupancy, (with errata but without addenda[a]).

Provide a permanent monitoring system to verify that building performance meets the desired comfort criteria as determined by IEQ Credit 7.1: Thermal Comfort – Design.

[a] Project teams wishing to use ASHRAE approved addenda for the purposes of this credit may do so at their discretion. Addenda must be applied consistently across all LEED credits.

IEQ	
NC	Credit 7.2
CS	NA

CASE 2. RESIDENTIAL BUILDINGS ONLY

Achieve IEQ Credit 7.1: Thermal Comfort – Design.

Provide permanent monitoring of the central and in-suite equipment to verify that building performance meets the desired comfort criteria as determined by IEQ Credit 7.1: Thermal Comfort – Design. Where the occupant has control over the dwelling unit temperature, it is acceptable to have standalone displays of temperature and humidity within the dwelling unit. Provide instructions, permanently installed within the dwelling unit, to advise the occupants on steps they can take to maintain temperature and humidity within comfort criteria.

INTERPRETATIONS

There are no interpretations for this credit.

IEQ	
NC	Credit 7.2
CS	NA

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

For many facilities, the HVAC systems that maintain indoor thermal comfort are the largest energy users. A successful green building should minimize the energy use associated with building conditioning—along with the associated energy cost, fuel consumption and air emissions—while maintaining thermal comfort conditions that enhance occupant well-being.

ECONOMIC ISSUES

Monitoring, managing, and maintaining thermal comfort conditions in a building might increase or decrease operating costs slightly. Thermal comfort complaints are among the most prevalent from occupants. Maintaining thermal comfort could help operations and maintenance staff to focus on other facility issues by reducing the need to respond to such complaints.

2. RELATED CREDITS

The thermal comfort of building occupants is affected by factors such as environmental conditions (air temperature, radiant temperature, relative humidity, and air speed), personal factors (metabolic rate and clothing), and personal preference. Refer to the following related prerequisites and credits:

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Credit 3: Enhanced Commissioning
- EA Credit 5: Measurement and Verification

The following prerequisite and credits also pertain to occupants' comfort:

- IEQ Prerequisite 1: Minimum IAQ Performance
- IEQ Credit 2: Increased Ventilation
- IEQ Credit 6.2: Controllability of Systems—Thermal Comfort
- IEQ Credit 7.1: Thermal Comfort—Design

3. SUMMARY OF REFERENCED STANDARDS

American National Standards Institute (ANSI)/ ASHRAE Standard 55–2004, Thermal Comfort Conditions for Human Occupancy
ASHRAE
http://www.ashrae.org
According to ASHRAE, "This standard specifies the combinations of indoor space environment and personal factors that will produce thermal environmental conditions acceptable to 80% or more of the occupants within a space. The environmental factors addressed are temperature, thermal radiation, humidity and air speed; the personal factors are those of activity and clothing."

4. IMPLEMENTATION

IEQ Credit 7.2, Thermal Comfort—Verification, is contingent on achieving IEQ Credit 7.1, Thermal Comfort—Design.

Poor thermal comfort is the main occupant complaint in many facilities. A well-managed and responsive green building should have systems in place to determine if occupant comfort is being maintained or can be improved.

IEQ	
NC	Credit 7.2
CS	NA

Since thermal comfort is inherently subjective and is psychological as much as physiological, surveying occupants regularly is the best way to determine whether a facility is comfortable. Sporadic occupant complaints about thermal comfort may not be an appropriate indicator of overall thermal comfort, but it might indicate local or personal dissatisfaction. Providing a systematic process and mechanism for all occupants to provide feedback about their thermal comfort will help building operators adjust and maintain thermal comfort in their buildings. Temperature, humidity, and other environmental monitoring systems provide facility operators with objective data to determine if the building space conditions meet the design intent and if they are being consistently maintained.

PLANNING AND DESIGN PHASE

Once the project has identified appropriate thermal comfort criteria (as part of compliance with IEQ Credit 7.1: Thermal Comfort—Design) and determined the appropriate conditioning system to meet the criteria, identify the key areas of focus for the occupant survey. Anticipate provisions for the analysis of environmental variables if the survey identifies problems.

SURVEY OCCUPANTS

Facility operators or outside consultants should develop procedures to survey building occupants about thermal comfort conditions. The main parameter to be measured in the occupant survey is satisfaction with thermal environment (e.g., "How satisfied are you with the temperature in your workspace?"). The answer is rated according to a 7-point scale format from very satisfied (+3) to very dissatisfied (-3) with the center (0) signifying the neutral point. Survey respondents identify their approximate location by building nominal zone and can specify their exact location voluntarily. The survey must include follow-up questions that are asked if the respondent indicates dissatisfaction, to identify the nature and cause of the problem. Sources of sample surveys include, but are not limited to, the Center for the Built Environment and the Usable Buildings Trust (see Resources).

This survey may be administered in person, over the phone, over networked computers, or on paper, but should be consistently applied and available for participation by all regular occupants. Percent dissatisfied will be the percentage of respondents who answer "dissatisfied" (any of the lower 3 points of the 7-point scale).

The survey may encompass other indoor environmental quality considerations (such as lighting or acoustics), although their inclusion is not required for this credit.

PLAN FOR CORRECTIVE ACTION

The survey responses will identify the nature and location of any thermal environmental problems. Use respondent suggestions to help guide corrective actions. Corrective actions typically include control adjustments (e.g., temperature setpoints, schedules, operating modes), diffuser airflow adjustments, and solar control.

Thermal discomfort in buildings is often caused by local variations in the thermal environment. It is impractical to have monitoring systems in every workstation capable of monitoring and diagnosing thermal comfort problems. The design team and facility operations and maintenance staff can use their discretion to decide how to resolve performance failure. Short-term monitoring and spot measurements of environmental variables with temporary equipment should be done once problem areas have been identified through the occupant survey.

IEQ	
NC	Credit 7.2
CS	NA

RESIDENTIAL BUILDINGS

For projects pursuing the residential compliance path, HVAC operating instructions must be permanently installed in the suites (e.g., on the inside of a cabinet door). Instructions should cover how to operate the HVAC systems and steps the occupant can take to ensure the room temperature and humidity conditions stay within the comfort zone. Steps to maintain temperature and humidity in these ranges will vary by system type, location and building operations.

5. TIMELINE AND TEAM

The design team is primarily responsible for achieving this credit, which is based on the requirements of ASHRAE Standard 55–2004. Additionally, a member of the building operations team, an owner agent, or a commissioning authority should administer the post-occupancy survey to meet the requirements of this credit.

6. CALCULATIONS

There are no calculations associated with this credit.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Create a written plan for corrective action if 20% or more of building occupants are dissatisfied with thermal comfort in the building.
- Create a thermal comfort survey to administer to building occupants.
- For residential projects, create instructions to advise building occupants on maintaining comfort conditions.

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. REGIONAL VARIATIONS

Regional climate and seasonal variations significantly affect the thermal comfort of occupants. Climate variations play an important role in passively ventilated buildings because of the introduction of unconditioned outside air. In mechanically ventilated buildings, regional variations affect the temperature range that an occupant considers comfortable. Warmer climates typically have higher design temperatures than colder climates, matching the conditions that would normally be considered comfortable for the occupants.

IEQ	
NC	Credit 7.2
CS	NA

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Provide the building owner, maintenance personnel, and occupants with the information needed to understand, maintain, and adjust the HVAC system for thermal comfort. Establish appropriate setpoints and control sequences, as well as recommendations for typical corrective actions, and include them in the building operating plan and sequence of operations document.

Establish procedures and schedules for inspecting and recalibrating sensors and controls, based on the manufacturer's recommendations, and include them in the building's preventive maintenance plan.

12. RESOURCES

WEBSITES

Center for the Built Environment
http://www.cbesurvey.org

This University of California, Berkeley, research center provides information on underfloor air distribution technologies and other topics. This website serves as an introduction to CBE's online IEQ survey.

The Usable Buildings Trust
http://www.usablebuildings.co.uk/

The Usable Buildings Trust promotes better buildings through the effective use of feedback. As the home of the Post-Occupancy Review of Buildings and Their Engineering (PROBE) studies, it includes an occupant survey that addresses thermal comfort and other IEQ issues.

PRINT MEDIA

Unplanned Airflows and Moisture Problems, by T. Brennan, J. Cummings, and J. Lstiburek, ASHRAE Journal (November 2000).

Federal Facilities Council, Technical Report 145: Learning From our Buildings: A State-of-the-Practice Summary of Post-Occupancy Evaluation, (National Academy Press, 2001).

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Mixed-mode ventilation combines mechanical and natural ventilation methods.

Natural ventilation is provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building. (ASHRAE 62.1-2007)

IEQ	
NC	Credit 7.2
CS	NA

Occupants in a commercial building are workers who either have a permanent office or workstation in the building or typically spend a minimum of 10 hours per week in the building. In a residential building, occupants also include all persons who live in the building.

Predicted mean vote is an empirical equation for predicting the mean vote on a rating scale of thermal comfort of a large population of people exposed to a certain environment.

Relative humidity is the ratio of partial density of airborne water vapour to the saturation density of water vapour at the same temperature and total pressure.

Thermal comfort exists when occupants express satisfaction with the thermal environment.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

DAYLIGHT AND VIEWS: DAYLIGHT

	NC	CS
Credit	IEQ Credit 8.1	IEQ Credit 8.1
Points	1 point	1 point

INTENT

To provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

REQUIREMENTS: NC & CS

Through 1 of the 4 options achieve daylighting in at least 75% of the regularly occupied spaces.

OPTION 1. SIMULATION

Demonstrate through computer simulations that 75% or more of all regularly occupied spaces achieve daylight illuminance levels of a minimum of 250 Lux (25 footcandles) and a maximum of 5,000 Lux (500 footcandles) in a clear sky condition on March 21 or September 21 at 9.00 am and 3.00 pm; areas with illuminance levels below or above the range do not comply. However, designs that incorporate view-preserving automated shades for glare control may demonstrate compliance for only the minimum 250 Lux (25 footcandles) illuminance level.

OR

OPTION 2. PRESCRIPTIVE

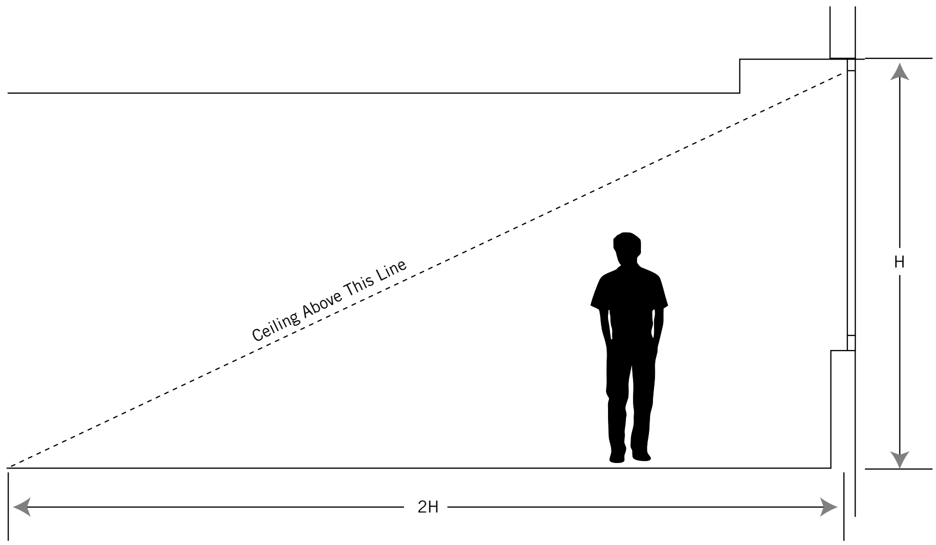
For the Side-lighting daylight zone (see diagram below):

- Achieve a value, calculated as the product of the visible light transmittance (VLT) and window-to-floor area ratio (WFR) of daylight zone between 0.150 and 0.180. The window area included in the calculation must be at least 0.76 metres (30 inches) above the floor.

  $0.150 < VLT \times WFR < 0.180$

- The ceiling must not obstruct a line in section that joins the window-head to a line on the floor that is parallel to the plane of the window; is twice the height of the window-head above the floor in, distance from the plane of the glass as measured perpendicular to the plane of the glass.
- Provide sunlight redirection and/or glare control devices to ensure daylight effectiveness.

IEQ	
NC	Credit 8.1
CS	Credit 8.1



For Top-lighting Daylight Zone (see diagram below):

- The daylit zone under a skylight is the outline of the opening beneath the skylight, plus in each direction the lesser of:

  a. 70% of the ceiling height,

  OR

  b. 1/2 of the distance to the edge of the nearest skylight,

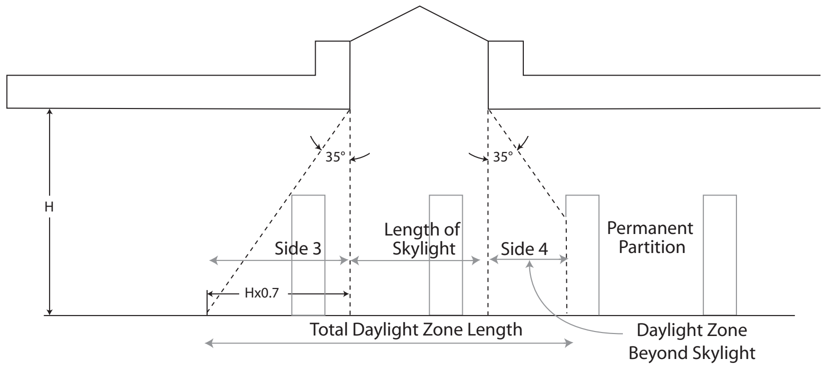
  OR

  c. The distance to any permanent opaque partition (if transparent show VLT) that is farther than 70% of the distance between the top of the partition and the ceiling.

- Achieve a skylight roof coverage that is between 3% and 6% of the roof area with a minimum 0.5 visible light transmittance (VLT).
- The distance between the skylights must not be more than 1.4 times the ceiling height.
- Skylight diffuser, if used, must have a measured haze value of greater than 90% when tested according to ASTM D1003. Avoid direct line of sight to the skylight diffuser.

Exceptions for areas where tasks would be hindered by the use of daylight will be considered on their merits.

IEQ	
NC	Credit 8.1
CS	Credit 8.1



OR

OPTION 3. MEASUREMENT

Demonstrate, through records of indoor light measurements, that a minimum daylight illumination level of 250 Lux (25 footcandles) has been achieved in at least 75% of all regularly occupied areas. Measurements must be taken on a 3 metre (10-foot) grid for all occupied spaces and must be recorded on building floor plans.

Only the floor area associated with the portions of rooms or spaces meeting the minimum illumination requirements may be counted in the calculations.

For all projects pursuing this option, provide daylight redirection and/or glare control devices to avoid high-contrast situations that could impede visual tasks. Exceptions for areas where tasks would be hindered by daylight will be considered on their merits.

OR

OPTION 4. COMBINATION

Any of the above calculation methods may be combined to document the minimum daylight illumination in at least 75% of all regularly occupied spaces. The different methods used in each space must be clearly recorded on all building plans.

In all cases, only the floor area associated with the portions of rooms or spaces meeting the requirements can be applied toward the total area calculation required to qualify for this credit.

In all cases, provide glare control devices to avoid high-contrast situations that could impede visual tasks. Exceptions for areas where tasks would be hindered by the use of daylight will be considered on their merits.

INTERPRETATIONS

For all spaces, furniture systems are not considered. The daylight analysis must be completed for each unique floor plate in the building.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

1. BENEFITS AND ISSUES TO CONSIDER

This credit addresses the availability of daylight to a building's occupants. When designing for maximum daylight, designers must evaluate and balance a number of environmental factors, such as heat gain and loss, glare control, visual quality, and variations in daylight availability.

ENVIRONMENTAL ISSUES

Buildings emphasizing daylighting may need larger daylighting apertures. Daylighting reduces the need for electric lighting of building interiors, which, if integrated into the overall approach to lighting, can result in decreased energy use. A well-designed daylit building is estimated to reduce lighting energy use by 50% to 80%.[26] This conserves natural resources and reduces air pollution impacts due to energy production and consumption.

Daylighting design involves a careful balance of heat gain and loss, glare control, visual quality, and variations in daylight availability. Shading devices, light shelves, courtyards, atriums, and window glazing are all strategies employed in daylighting design. Important considerations include the selected building's orientation, window size and spacing, glass selection, reflectance of interior finishes, and locations of interior walls.

Large expanses of unfragmented or untreated glazing can give the illusion of transparency or reflect sky and habitat, causing birds in flight to collide into the windows. See the Implementation sections for measures to reduce bird collisions.

ECONOMIC ISSUES

Specialized glazing can increase initial costs for a project and can lead to excessive heat gain if not designed properly. Glazing provides less insulating effects compared to standard walls, resulting in higher energy use and requiring additional maintenance. However, offices with sufficient natural daylight and a visual connection to outdoor environments have been proven to increase occupant productivity and comfort, leading to better employee retention. In most cases, employee compensation significantly outweighs the initial costs of incorporating daylighting measures into a building design.

2. RELATED CREDITS

Increasing the area of vision glazing is likely to provide greater access to views from the building interior, which is covered under the following credit:

- IEQ Credit 8.2: Daylight and Views - Views

The increased window-to-wall ratio in a design can alter energy performance and has a direct correlation to lighting design strategies to conserve energy. The interior lighting design can be used to maximize the energy savings by providing daylighting controls. Refer to the following:

- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance
- IEQ Credit 6: Controllability of Systems

IEQ	
NC	Credit 8.1
CS	Credit 8.1

3. SUMMARY OF REFERENCED STANDARDS

ASTM D1003 - 07e1, Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics
http://www.astm.org
This test method covers the evaluation of specific light-transmitting and wide-angle-light-scattering properties of planar sections of materials such as essentially transparent plastic.

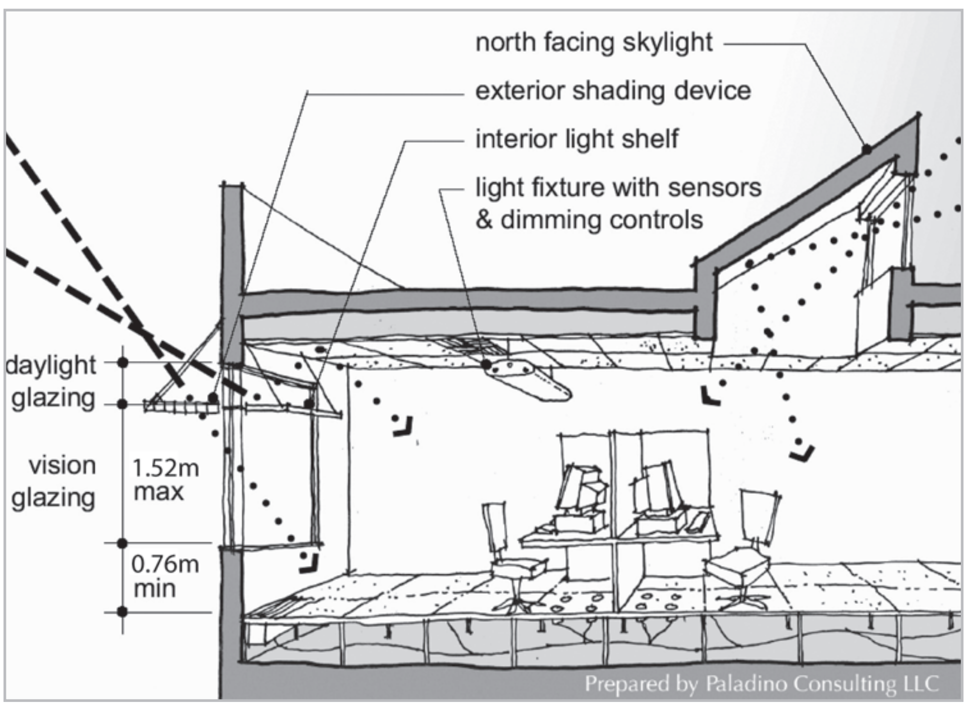
4. IMPLEMENTATION

A building may have limited daylighting potential because of site constraints that restrict the orientation of the building and limit the number and size of building openings. Vertical site elements, such as neighbouring buildings and trees, might reduce the potential for daylighting. The design of the exterior envelope and the depth of the floor plate can allow more daylight into the building, and are critical for credit achievement.

Evaluate the impact of the selected building's orientation on possible daylighting options, and opt for designs with shallow floor plates, courtyards, atriums, clerestory windows, or skylights. Consider adding interior light shelves, exterior fins, louvers, and adjustable blinds if possible. See Figure 1, which illustrates several daylighting strategies.

Attention to daylight should also be addressed during the design phase of the building. Furniture systems, wall partitions, surface colour, and texture all have the ability to reflect daylight into the space. Reflective surfaces should also be considered, as they can either hinder or enhance occupants' thermal and visual comfort.

FIGURE 1. DAYLIGHTING STRATEGIES



IEQ	
NC	Credit 8.1
CS	Credit 8.1

The desired amount of daylight will differ depending on how each space is used. Daylit buildings often have several daylight zones with differing target light levels. In addition to light levels, daylighting strategies should address interior colour schemes, direct beam penetration, and integration with the electric lighting system. Glare control is perhaps the most common failure in daylighting strategies. Large windows provide generous amounts of daylight. If not controlled, properly, this daylight can produce unwanted glare and affect interior lighting quality. Measures to control glare include light shelves, louvers, blinds, fins, and shades. Typically, low-luminance ratios and lighting primary surfaces will enhance visual quality. Glare control is required for each window.

Computer modeling software can be used to simulate daylighting conditions and can provide valuable input into the development of an effective, integrated daylighting strategy. Daylighting software simulates the daylighting conditions of interior spaces at various times during the day and shows the combined effects of multiple windows within a daylit space.

Photo-responsive controls for electric lighting can be incorporated into daylighting strategies to maintain consistent light levels and to minimize occupant perception of the transition from natural light to artificial light. These controls help save energy by reducing electric lighting in high-daylight conditions while preserving Lux (footcandle) levels on the task surface. These types of automatic controls require commissioning, as well as measurement and verification attention.

Despite the known benefits of views in buildings, 1 clear downside is the increased likelihood that birds may fly into the windows. Perhaps as many as 1 billion birds die in this way each year. Larger areas of unfragmented or untreated glazing increase the risk. To reduce these collisions, consider treating the window glazing. Use exterior shading devices, introduce etched or fritt patterns, and/or create appropriate visual markers, such as differentiated planes, materials, textures, colours, opacity, or other features that help fragment glass reflections and reduce apparent overall transparency and reflectivity. (For further guidance on bird-safe designs and resources see SS Credit 5 - Site Development.)

To control glare, use any of the following common strategies:

- Fixed exterior shading devices
- Exterior light shelves
- Interior light shelves
- Interior blinds and louvers
- Operable draperies and blinds
- Fritted glazing
- Electronic blackout glazing

CS

The decisions of the Core & Shell project design team may affect the ability of future tenants to optimize the daylighting of their spaces. Decisions made by the team designing the core and shell can, in some cases, preclude the tenant from achieving this credit in *LEED Canada for Commercial Interiors*.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

5. TIMELINE AND TEAM

During the predesign stage, the owner, architect, and engineers should discuss general lighting design and the goals for occupants' work environment. Specific daylighting performance criteria should be included in the owner's project requirements.

During schematic design, the architect, civil engineer, and landscape architect should orient the building on its site to allow for passive solar strategies. Daylighting simulations should be run early to ensure effective daylighting while minimizing potential for glare and any undesirable window and building solar exposure. Consider the preservation of existing topography and landscape features that shade the building and minimize glare. Also consider proximity to neighbouring buildings and their effect on the daylighting approach. Determine how best to allocate the interior building spaces and consider locating regularly used spaces at the building perimeter, toward sources of daylight. The architect and engineers should evaluate the building footprint, the structural floor to floor height, and finished ceiling clearances to ensure an adequate ratio of window to floor area. Consider strategies to increase the amount of daylight glazing when designing the massing of the building, and carefully weigh the effects of the envelope design on energy efficiency. In addition, identify initial glare control strategies.

During the preparation of construction documents, the LEED calculations and/or computer simulation model should be developed in greater detail to inform the design decisions and verify compliance of the design. Refer again to the owner's project requirements. Use preliminary calculations to guide specifications for glare control devices. Once the design is complete, finalize the LEED calculations and supporting documentation.

During construction, the design and construction team should confirm that the submitted products and systems meet the owner's project requirements, the design performance specifications, and the original design intent.

During building operations, the owner should verify that occupants are not subject to glare and ensure that the installed glare control devices are performing as intended. Facility managers should be advised on proper maintenance of interior and exterior light shelves and other shading devices to ensure performance.

6. CALCULATIONS

To calculate the daylighting zone percentage, divide the aggregate of all daylit regularly occupied spaces by the aggregate area of all regularly occupied spaces in the project, both daylit and noncompliant areas.

CALCULATING REGULARLY OCCUPIED AREAS

Identify all regularly occupied spaces within the project and calculate their associated floor areas. For veterinary, boarding, or animal shelter facilities, include the area regularly occupied by the animals. Any spaces dedicated to tasks that would be compromised or hindered by the inclusion of daylighting should be identified and the reason for their exclusion should be explained, for documentation purposes, in a supporting narrative. Any exclusion must be based solely on the basis of the task performed in the space, not the length of time an occupant will spend there. In addition, exceptions to the requirement are solely based on visual considerations, not based on sound.

For consistency across LEED projects, the regularly occupied spaces and total area calculated for this credit should be consistent with the regularly occupied areas identified in other credits, such as

IEQ	
NC	Credit 8.1
CS	Credit 8.1

IEQ Credit 8.2. However, exceptions for specialized areas dedicated to tasks that would be hindered by the use of daylight will be considered on their merits.

CALCULATING DAYLIGHTING PERFORMANCE

The requirement can be met even if 100% of each room does not meet the minimum 250 Lux (25 footcandle) requirement when using the daylight simulation and/or measurement methodologies. The portion of the room with a 250 Lux (25 footcandle) minimum illumination counts toward the percentage of compliant area, and the portion of the space not meeting the illumination criterion is included in the calculation of total area. For the calculation spreadsheet, enter the space portion that meets the illumination criterion and the space portion that does not. The floor area of all compliant spaces is tallied and then divided by the total floor area of all regularly occupied spaces. If the percentage is 75% or more, then the project qualifies for 1 point under this credit.

OPTION 1. SIMULATION

- Create a daylight simulation model for the building, or each regularly occupied space with glazing. The model should include approximate glazing properties, as well as representative surface reflectance settings for interior finishes.
- For each applicable area, include a horizontal calculation grid at 0.76 metres (30 inches) above the floor, or measured at the appropriate desk or work height level for the intended use of the space. This represents the typical work plane height. The calculation grid should be set at a maximum of 1.5 metre (5-foot) intervals to provide a detailed illumination diagram for each area.
- Calculate the daylight illumination for each applicable space using the following daylight criterion: clear-sky conditions at both 9:00 a.m. and 3:00 p.m. on the equinox (March 21 or September 21) for the project's geographic location. Figure 5 illustrates a sample daylight analysis for an office space.
- Identify all regularly occupied rooms or areas. Determine the floor area of each space using construction documents and enter the information on a spreadsheet. Provide illumination levels (in Lux), determined through the simulation model, for each space.
- If the illumination for a room/area is a minimum of 250 Lux (25 footcandles) and a maximum of 5,000 Lux (500 footcandles), the floor area of the space counts toward the credit. If the project uses automated shades, the maximum Lux requirement does not apply.
- Dedicated theatre spaces (not multipurpose rooms) must meet an illuminance of 100 Lux (10 footcandles), as recommended in the IESNA Lighting Handbook Reference and Application.
- Multipurpose rooms must be included in the credit calculations. Because some activities in these spaces may be hindered by daylight, effective shades and lighting controls should be included in the design.
- Sum the floor area of all daylit rooms or areas and divide by the total floor area of all applicable spaces. If this percentage is 75% or more, the project qualifies for 1 point under this credit.
- Note that glare control is also required for each window. Create another spreadsheet entry that identifies the type of glare control applied to each window type. The type of glare control selected for each window does not affect the daylight calculations. See the list of common glare control strategies in the Implementation section.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

OPTION 2. PRESCRIPTIVE

SIDE LIGHTING

This option provides a relatively simple method of determining whether the daylighting requirements are met. It is applicable to many standard building designs, primarily rectangular floor plates with a central core. The project team needs the following basic information to determine compliance:

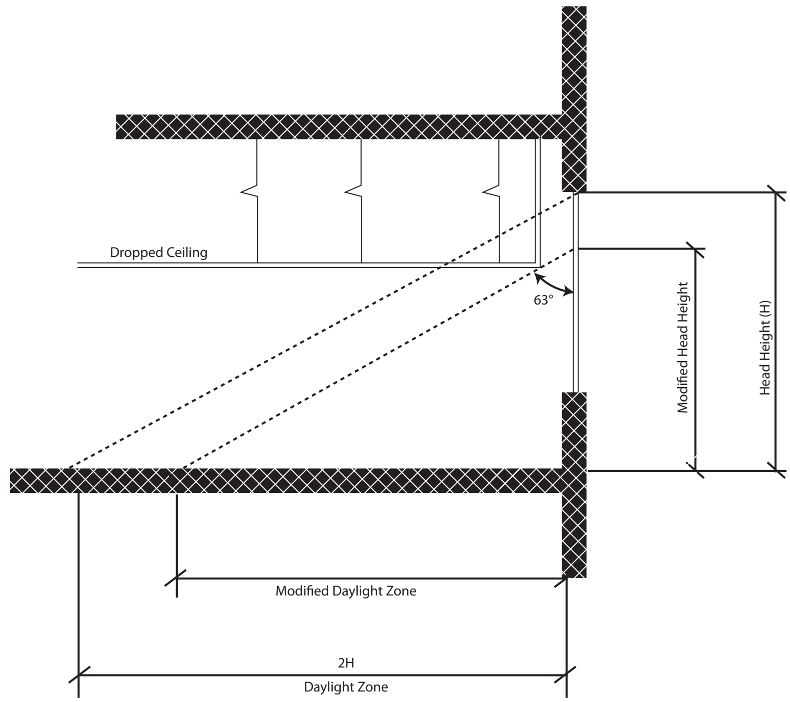
- Window head height
- Window sill height
- Window width (per bay)
- Bay width
- Bay depth to core
- Visible light transmittance (T_{vis})
- Floor area (per bay)

Perform the following calculation for each bay condition in the building (north-south, east-west, and corner):

- Determine the window area (WA) for the bay. This is the window head height less the window sill height 0.76 metres (30 inches) or more above the floor, multiplied by the window width(s) per bay.
- Determine whether the window head height can contribute to this credit, or if an adjusted head height must be used. Draw a 63-degree angle from the vertical, in section, from the window head to the floor. If the ceiling obstructs this line, a modified head height must be used. Draw a 63-degree angle from the vertical, in section, using the ceiling corner that obstructed the previous line as a starting point. The point at which this line intersects the window is the modified head height. See Figure 2.
- Determine the floor area (FA) for the typical bay—that is, the bay width multiplied by the bay depth to core.
- Determine the ratio of the window area to the floor area (WFR)—that is, WA/FA.
- Determine the product of visible light transmittance to window to floor area—that is, (T_{vis}) (WFR).
- If the result is between 0.150 and 0.180, the bay counts toward meeting the requirement.
- Each bay condition in the building must meet this requirement.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

FIGURE 2. SAMPLE MODIFIED WINDOW HEAD HEIGHT AND DAYLIGHT ZONE



An example of this calculation is shown in Table 2.

TABLE 2. SAMPLE PRESCRIPTIVE CALCULATION

	N/S BAY	E/W BAY	CORNER BAY
Window head height (m)	3	3	3
Window sill height (m)	0.76	0.76	0.76
Window Width (per bay) (m)	5.8	5.8	23.8
Bay width (m)	6	6	12
Bay depth to core (m)	12	12	12
VLT (T_{vis})	0.86	0.86	0.45
WA			
Window daylight height (m)	2.24	2.24	2.24
Window area (WA) (m^2)	13.0	13.0	53.3
FA			
Floor area (FA) (m^2)	72	72	144
WFR=(WA/FA)	0.1805556	0.1805556	
(VLT) (WFR)	0.1552778	0.1552778	

IEQ	
NC	Credit 8.1
CS	Credit 8.1

AREA EFFECTED BY GLARE			
	North façade Nov/ Dec mornings	East façade all morning	Refer to N/S/E/W notes
	South façade almost entire day	West façade all afternoon	
GLARE CONTROL MEASURE			
(refer to wall section details)	North façade - interior adjustable blinds specified for all windows facing north		
	South façade - exterior light shelves and interior adjustable blinds at full length of façade		
	East façade - interior adjustable blinds specified for all windows facing east		
	West façade - exterior light shelves and interior adjustable blinds at full length of façade		

TOP-LIGHTING DAYLIGHT ZONE

This method is applicable for many standard building designs and might be particularly useful for single-floor retail developments. The project team needs the following basic information to determine compliance:

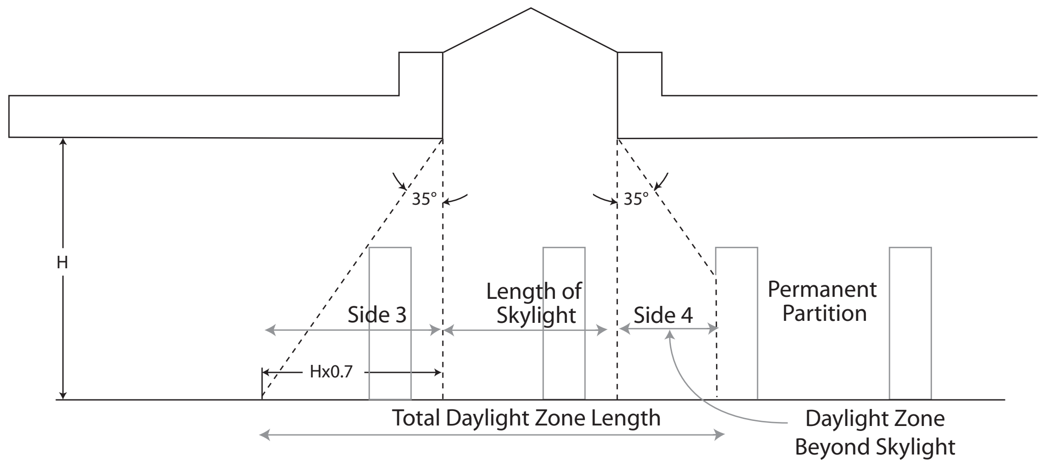
- Area of skylights (SA)
- VLT (T_{vis}) of skylights
- Roof area (TA)
- Distance between skylights
- Measured haze value of skylight diffuser

Perform the following calculation for a typical building condition:

- Determine the skylight roof coverage, which is the ratio of area of skylights to area of roof—that is, (SA/RA) (100).
- Confirm that the skylight diffuser is greater than 90%.
- Determine the daylight zone(s) in square metres below the skylight, based on the prescriptive criteria.
- Evaluate the total area (in square metres) of the daylight zone(s). If this total area is 75% or more of the area of the regularly occupied spaces in the building, the requirement has been met.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

FIGURE 3. TOP-LIGHTING DAYLIGHT ZONE



COMBINED SIDE-LIGHTING AND TOP-LIGHTING DAYLIGHT ZONE

For buildings that have both side-lighting and top-lighting conditions, a combination of the above 2 methodologies can be utilized to demonstrate compliance.

OPTION 3. MEASUREMENT

Only the floor area associated with the portions of rooms or spaces meeting the minimum illumination requirements may be counted in the calculations.

Projects pursuing this option must provide daylight redirection and/or glare control devices to avoid high-contrast situations that could impede visual tasks. Exceptions for areas where tasks would be hindered by daylight will be considered on their merits.

- Create a spreadsheet that identifies all regularly occupied rooms or areas. Determine the floor area of each space using construction documents.
- Take field measurements of Lux levels at 0.76 metres (30 inches) above the floor within all regularly occupied areas, or measured at the appropriate desk or work height level for the intended use of the space.
- Record indoor light measurements of all regularly occupied spaces on a maximum 3 metre (10 foot) grid on project floor plans. Include room identification labels and/or notes regarding intended uses on the plans to match the spaces listed on the spreadsheet.
- Enter the illumination level (in Lux), determined using the field measurements for each space. Areas with a minimum 250 Lux (25-footcandle) illumination contribute toward credit compliance. See Table 3.
- Sum the floor area of all daylit spaces and divide by the total floor area of all regularly occupied spaces. If this percentage is 75% or more, the project qualifies for 1 point under this credit.
- Glare control is also required for each window. Create another spreadsheet entry that identifies the type of glare control applied to each window type. The type of glare control selected for each window does not affect the daylight factor calculations.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

Dedicated theatre spaces (not multipurpose rooms) must meet an illuminance of 100 Lux (10 footcandles), as recommended in the IESNA Lighting Handbook Reference and Application.

Include multipurpose rooms in the credit calculations. Because some activities in these spaces may be hindered by daylight, effective shades and lighting controls should be included in the design.

TABLE 3. SAMPLE DAYLIGHTING MEASUREMENT

	m^2 WITHIN GRID	LUX	COMPLIANT (m^2)
Room 101			
point 1	10	600	10
point 2	10	600	10
point 3	7.0	340	7.0
point 4	3.5	240	0
Room 102			
point 1	10	550	10
point 2	5.5	210	0
point 3	10	250	10
Total	56		47
			84%

OPTION 4. COMBINATION

The above calculation methods may be combined to document the minimum daylight illumination in at least 75% of all regularly occupied spaces. For all projects using this option, only the floor area of the compliant portions of rooms or spaces applies toward the 75% minimum. The methods used in each space must be clearly recorded on a minimum 3 metre (10-foot) grid on all building plans.

Provide glare control devices to avoid high-contrast situations that could impede visual tasks. Exceptions for areas where tasks would be hindered by the use of daylight will be considered on their merits.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Develop documentation—such as floor plans, sections, and elevations—showing the glare control methods used on the project.
- Maintain documentation—such as floor plans, sections, and elevations—showing the location of regularly occupied spaces with a qualifying amount of daylight.
- To account for changes in design, develop a spreadsheet documenting the daylight factors outlined in the Calculations section.
- If using daylight simulation, update the computer model as the design progresses.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

8. EXAMPLES

To optimize daylighting, select glazing with a high visible transmittance (T_{vis}). See Figure 4 for glass characteristics.

FIGURE 4. GLASS CHARACTERISTICS

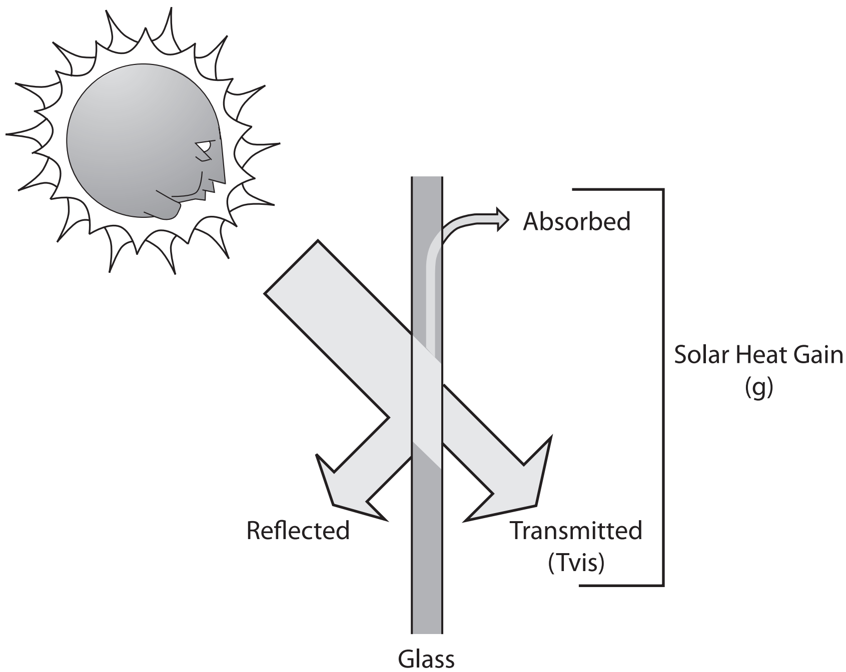
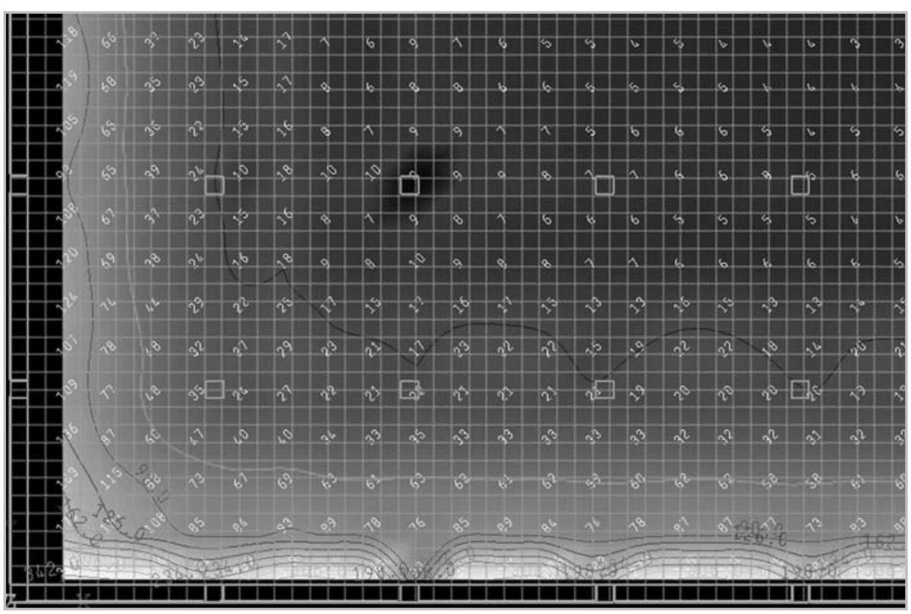


Figure 5 provides an example of a daylight simulation model.

FIGURE 5. SAMPLE DAYLIGHT SIMULATION MODEL OUTPUT (IN FOOTCANDLES)



IEQ	
NC	Credit 8.1
CS	Credit 8.1

9. EXEMPLARY PERFORMANCE

This credit may be eligible for exemplary performance under the Innovation in Design section if the project achieves 95% daylighting based on the credit requirements and guidelines.

10. REGIONAL VARIATIONS

The building site orientation and its specific regional location will directly influence the available daylight throughout the day and during the year. For instance, in northern latitudes, winter days are short, and building occupants might spend the entire period of daylight inside. Seasonal variances in the sun's daily path should be evaluated during the project design development to minimize the potential for glare inside the building while maximizing the use of functional daylighting. The consistent availability of adequate daylight at a particular project site will also affect the potential for reduction in lighting power demand through the use of daylighting strategies, such as incorporation of photoresponsive controls for perimeter lighting zones. When selecting glazing systems, balance the visible light transmittance with overall building energy performance goals to minimize undesirable heat loss and/or gain through the glazing.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Glazing and shading systems should be regularly cleaned and maintained. Windows and skylights require periodic sealant and flashing inspections to ensure water tightness.

Alterations or additions, both interior and exterior, can directly affect the daylight that reaches the building interior. Care should be taken during tenant build out to minimize obstruction of daylight.

12. RESOURCES

WEBSITES

American Bird Conservancy (ABC)
http://www.abcbirds.org

ABC is a national leader in reducing human effects on birds and wildlife. ABC's bird collision program supports national efforts to reduce bird mortality through education and advocacy.

The Art of Daylighting
http://www.edcmag.com/Articles/Feature_Article/10e5869a47697010VgnVCM100000f932a8c0

This Environmental Design + Construction article provides a solid introduction to daylighting.

City of Chicago, Department of Environment
http://www.cityofchicago.org/Environment/BirdMigration/sub/main.html

In 1 of the first cities to implement a mandatory lights-out program, Chicago's Department of Environment has many resources for bird-friendly design.

Fatal Light Awareness Program (FLAP)
http://www.flap.org

Initiated the Bird-Friendly Building Development Program for the City of Toronto, FLAP monitors and promotes bird-friendly design.

New York City Audubon
http://www.nycaudubon.org

IEQ	
NC	Credit 8.1
CS	Credit 8.1

This Audubon chapter takes a leadership role in reducing bird collisions with buildings. The chapter publishes Bird-Safe Building Guidelines, conducts monitoring, and, through its Project Safe Flight, promotes bird-friendly design.

Radiance Software
http://radsite.lbl.gov/radiance/

This site offers free daylighting simulation software from the Lawrence Berkeley National Laboratory.

Whole Building Design Guide, Daylighting
http://www.wbdg.org/resources/daylighting.php

Whole Building Design Guide, Electric Lighting Controls
http://www.wbdg.org/resources/electriclighting.php?r=school_library

The Daylighting and Electric Lighting Controls sections provide a wealth of resources including definitions, fundamentals, materials, and tools.

PRINT MEDIA

Architectural Lighting, second edition by M. David Eganand Victor Olgyay(McGraw-Hill, 2002).

Daylighting Design, by Benjamin Evans, Time-Saver Standards for Architectural Design Data, (McGraw-Hill, Inc., 1997).

Daylighting Performance and Design, by Gregg D. Ander (John Wiley & Sons, 1997).

Daylighting for Sustainable Design, by Mary Guzowski (McGraw-Hill, Inc., 1999).

Sustainable Building Technical Manual, Public Technology Institute (Public Technology Institute, (1996): http://www.pti.org.

Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life, by Kellert, Heerwagen, and Mador (John Wiley & Sons, 2008).

Avian Collisions at Communication Towers, second edition, by Joelle Gehring and Paul Kerlinger (Curry & Kerlinger, 2007).

Bird Density and Mortality at Windows, by Stephen B. Hager, Heidi Trudell, Kelly J. McKay, Stephanie M. Crandall, and Lance Mayer, Wilson Journal of Ornithology 120(3) (2008): 550-564.

13. DEFINITIONS

A **bay** is a component of a standard, rectilinear building design. It is the open area defined by a building element such as columns or a window. Typically, there are multiple identical bays in succession.

Daylighting is the controlled admission of natural light into a space, used to reduce or eliminate electric lighting.

Daylight illuminance levels are the lighting levels achieve through the use of daylight alone.

Daylighting zone is the total floor area that meets the performance requirements for daylighting.

Glare is any excessively bright source of light within the visual field that creates discomfort or loss in visibility.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

Regularly occupied spaces in commercial buildings are areas where people sit or stand as they work. In residential applications these spaces include all living and family rooms and exclude bathrooms, closets, or other storage or utility areas. In schools, they are areas where students, teachers, or administrators are seated or standing as they work or study.

Side-lighting is illumination from light entering the building through the sides (e.g. windows).

Top-lighting is illumination from light entering the building through the roof (e.g. skylights, solar tubes).

Visible light transmittance (T_{vis}) is the ratio of total transmitted light to total incident light. (I.e., the amount of visible spectrum light passing through a glazing surface divided by the amount of light striking the glazing surface. The higher T_{vis} value, the more incident light passes through the glazing.

Vision glazing is that portion of exterior windows between 0.76 metres (30 inches) and 2.3 metres (90 inches) above the floor that permits a view to the outside.

Window-to-floor ratio (WFR) is the total area of the window (measured vertically from 0.76 metres (30 inches) above the finished floor to the top of the glass, multiplied by the width of the glass) divided by the floor area.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

14. CASE STUDY

BROOKSIDE PUBLIC SCHOOL

LEED Canada-NC 1.0 Gold, 23-September 2008

Location: Toronto, Ontario
Building Type: K-9 School
Owner Type: School Board
Building Size: 6,600m^2
Owner Name: Toronto District School Board
LEED Consultant: Enermodal Engineering Ltd.
Responsible Firm (for this credit): Teeple Architects
Photo Credit: Enermodal Engineering Ltd.

Brookside Public School is the second LEED certified school for the Toronto District School Board (TDSB) and is built on the lessons learned from the Board's previous experience. Both owner and project team were committed to building a school that fully meets the need for a healthy, productive learning environment. One contributing factor to this atmosphere is the availability of natural daylight and views to the outdoors, which has been linked to increased student productivity and test scores.

The architect designed the building in a figure-8 pattern with two interior courtyards to allow daylighting in interior classrooms typically excluded from natural lighting. All of the classrooms and a couple of other rooms had daylight sensors. The sensors provided on/off control of the row of lighting next to the window (3 rows of light total). Atypically, the gymnasium also has significant functional glazing and daylighting.

To allow maximum visibility for occupants, the window sills in early years classrooms were lowered from 0.75m above the floor to be between 0.25-0.5m above the floor. Also, a semi-transparent fibreglass product was inserted into the curtain wall installation below the windows to allow more light into the classrooms. Also, each classroom has at least two operable windows, which also allows for increased ventilation and natural climate control. In total, there are over 100 different glazing units of various sizes and shapes in the building.

Lessons learned:

- Designing the building floor plates incorporating the central courtyards and putting glazed areas in non-traditional spaces (eg., gymnasium) required significant design and coordination time between each discipline and the owner.

IEQ	
NC	Credit 8.1
CS	Credit 8.1

TOHU

LEED Canada-NC 1.0 Gold, 16 December 2005

Location: Montreal, Quebec
Building Type: Assembly
Owner Type: Commercial
Building Size: 49,000 m^2
Owner Name: TOHU
LEED Consultant: ÆDIFICA
Responsible Firm (for this credit): Schème Consultants inc., Jodoin Lamarre Pratte et associés architectes, L'Architecte Jacques Plante, Ædifica Inc.
Photo Credit: Alex Legault

Operating since 2004, TOHU is a non-profit organization offering one of the largest facilities in the world for the creative development, production, and training in circus arts. With a view to making Montréal the world capital of circus arts, TOHU plans on being an active participant in the renovation of the Saint-Michel environmental complex (which currently holds one of North America's largest landfills, slated to become a large park) and the Saint-Michel district in general.

With its unique architecture, the Pavilion is not only green in design, but also in spirit! The vision of the Pavilion's architects was to provide occupants and visitors alike with a sense of constant contact with the outdoors in a building that is well integrated with its site, all while offering maximum comfort.

All living and work spaces are bathed in a generous amount of natural light. Work areas were constructed such that the installed band of windows facilitated the penetration of light into each corner.

To continue the focus on comfort, both electric and natural light can be controlled by occupants. Large bay windows fill common areas with light and provide views of the outdoors.

All rooms (other than the performance hall) have at least one window that opens to allow those inside to benefit from natural light, a view of the exterior, and fresh air.

IEQ	
NC	Credit 8.2
CS	Credit 8.2

DAYLIGHT AND VIEWS: VIEWS

	NC	CS
Credit	IEQ Credit 8.2	IEQ Credit 8.2
Points	1 point	1 point

INTENT

To provide building occupants a connection to the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

REQUIREMENTS: NC & CS

Achieve direct line of sight to the outdoor environment via vision glazing between 0.76 metres and 2.3 metres (30 inches and 90 inches) above the finished floor for building occupants in 90% of all regularly occupied areas. Determine the area with direct line of sight by totalling the regularly occupied floor area that meets the following criteria:

- In plan view, the area is within sight lines drawn from perimeter vision glazing.
- In section view, a direct sight line can be drawn from the area to perimeter vision glazing.

Line of sight may be drawn through interior glazing. For private offices, the entire floor area of the office can be counted if 75% or more of the area has direct line of sight to perimeter vision glazing. For classrooms and other multi-occupant spaces, the actual floor area with direct line of sight to perimeter vision glazing is counted.

CS ADDITIONAL REQUIREMENT:

The core and shell design must incorporate a feasible tenant layout(s) per the default occupancy counts (or some other justifiable occupancy count) that can be used in the analysis of this credit.

INTERPRETATIONS

Spaces that are hindered by the presence of views or low-level windows may be granted an exemption from the "regularly occupied" area. An example could be a gymnasium where low-level windows could be susceptible to damage and views could distract athletes.

IEQ	
NC	Credit 8.2
CS	Credit 8.2

1. BENEFITS AND ISSUES TO CONSIDER

ENVIRONMENTAL ISSUES

Providing access to views of the outdoors through the incorporation of vision glazing enables building occupants to maintain a visual connection to the surrounding environment. The additional glazed area may reduce the need for interior electric lighting, resulting in decreased energy use. This conserves natural resources and reduces air pollution impacts due to energy production and consumption.

When designing for maximum views and daylighting, designers must evaluate and balance a number of environmental factors, including heat gain and loss, glare control, visual quality, and variations in daylight availability. Appropriate interior or exterior shading devices to control glare will provide a high level of visual comfort.

ECONOMIC ISSUES

Additional glazing required to provide access to views can increase initial costs for a project and can lead to increased heat gain if not designed properly. Glazing provides less insulating effects compared to standard walls, resulting in higher energy use and requiring additional maintenance. However, offices with sufficient natural daylight and a visual connection to outdoor environments have been proven to increase occupant productivity and comfort, leading to increased worker production and increased employee retention.

2. RELATED CREDITS

Increasing the area of vision glazing is likely to provide greater access to daylight. The following credit has related requirements:

- IEQ Credit 8.1: Daylight and Views—Daylight

The increased window-to-wall ratio in a design can alter energy performance and has a direct correlation to lighting design strategies to conserve energy. The interior lighting design can be used to maximize the energy savings by providing daylighting controls. Refer to the following:

- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance
- IEQ Credit 6: Controllability of Systems

3. SUMMARY OF REFERENCED STANDARDS

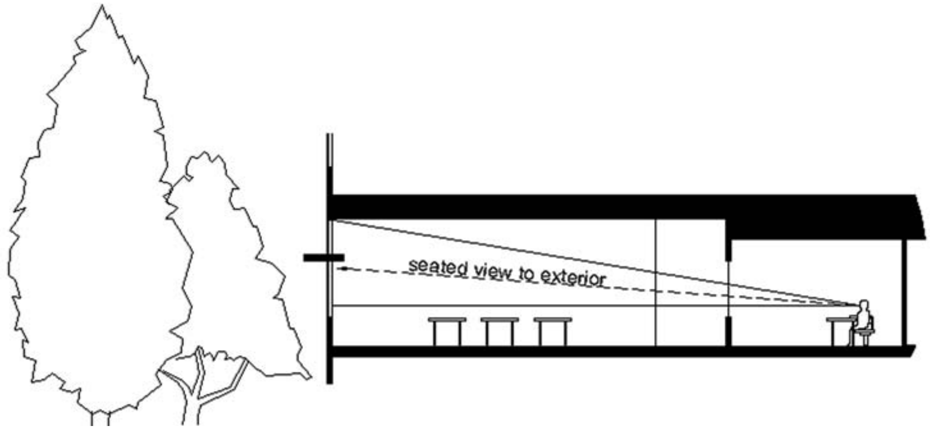
There are no standards referenced for this credit.

4. IMPLEMENTATION

One successful design strategy is for designers to locate open plan areas, including classrooms, along the exterior walls, while placing private offices and areas not regularly occupied at the core of the building. This design maintains the optimum number of available views. The line of sight used for the determination of horizontal views is assumed to be 1.07 metre (42 inches) for the average seated adult, but is lower for students. Design teams may want to use alternate view heights for areas with non-typical functions. Maintaining the views for spaces near the core is an important design objective. See Figure 1.

IEQ	
NC	Credit 8.2
CS	Credit 8.2

FIGURE 1. HORIZONTAL VIEW AT EYE HEIGHT



Regularly occupied spaces include office spaces, conference rooms, classrooms, core learning spaces, and cafeterias. Areas that do not need to be considered include support areas for copying, storage, mechanical equipment, laundry, and restrooms.

Despite the known benefits of views in buildings, 1 clear downside is the increased likelihood that birds may fly into the windows. Perhaps as many as 1 billion birds die in this way each year. Larger areas of unfragmented or untreated glazing increase the risk. To reduce these collisions, consider treating the window glazing. Use exterior shading devices, introduce etched or fritt patterns, and/or create appropriate visual markers, such as differentiated planes, materials, textures, colors, opacity, or other features that help fragment glass reflections and reduce apparent overall transparency and reflectivity. (For further guidance on bird-safe designs and resources see SS Credit 5 - Site Development.)

5. TIMELINE AND TEAM

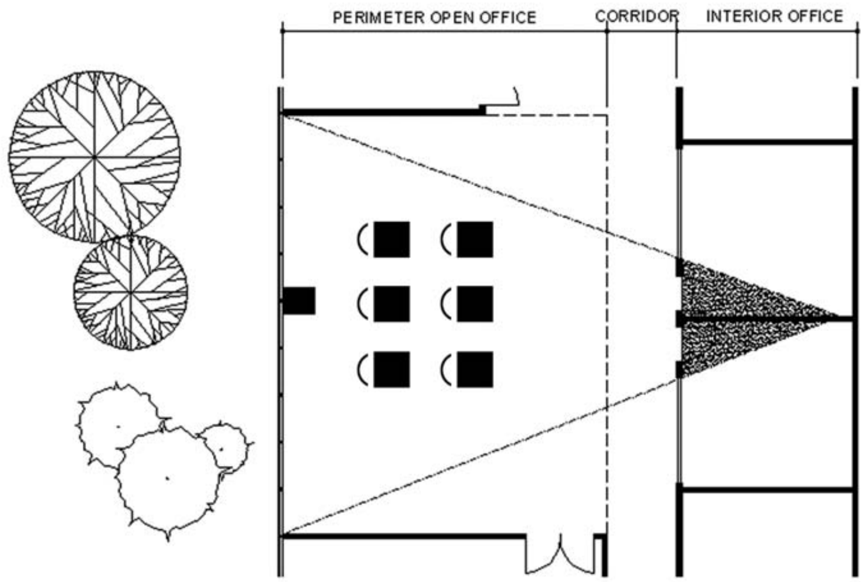
During schematic design, the architect, civil engineer, and landscape architect should orient the building on its site to incorporate desirable views. During the building programming efforts, spaces and rooms that are regularly occupied should be identified as primary candidates for access to views. Determine how best to allocate interior building spaces and consider locating regularly occupied spaces along the building perimeter, with access to views. The owner, architect, and interior designer should assess the needs for views in all regularly occupied spaces.

6. CALCULATIONS

Two calculations are required to determine compliance. One, using the direct line of sight to perimeter glazing, determines whether 90% of the regularly occupied area has the potential for views. It is based on vision glazing between 0.76 metres (30 inches) and 2.3 metres (90 inches) above the floor and the location of full-height interior partitions. Movable furniture and partitions are included in the scope of this credit calculation. See Figure 2. The other uses the horizontal view at a typical seated eye height to determine access to views.

IEQ	
NC	Credit 8.2
CS	Credit 8.2

FIGURE 2. DIRECT LINE OF SIGHT TO PERIMETER GLAZING



DETERMINING DIRECT LINE OF SIGHT TO PERIMETER GLAZING

- Create a spreadsheet and identify all regularly occupied areas. Determine the floor area (square footage) of each applicable space using construction documents.
- Using a floor plan, determine the fraction of the regularly occupied area that has direct line of sight to the outdoors for each window. The line of sight can pass through 2 interior glazing surfaces but not through doorways with solid doors. See Table 1.
- For private offices, if the percentage of floor area with direct line of sight is 75% or more (i.e., only the corners are noncompliant), enter the entire floor area of that room in the spreadsheet (Table 1) as meeting the credit requirement. If less than 75% of the room has a direct line of sight, estimate the compliant floor area and enter that value.
- For multi-occupant spaces, such as conference rooms and classrooms, estimate the actual floor area with direct line of sight to perimeter vision glazing.

DETERMINING HORIZONTAL VIEW AT APPROPRIATE EYE HEIGHT

- Using representative building sections, draw a line starting at 1.07 metres (42 inches) (typical seated eye height) across the section to a point on the perimeter vision glazing between 0.76 metres and 2.3 metres above the floor that does hit any obstruction (i.e., work stations, walls and fixed partitions). (Figure 1).
- For each space with a horizontal view (as defined above) that does not hit an obstruction, enter yes in the spreadsheet (Table 1). If a room has direct line of sight on the floor plan but has an obstructed view at eye height, the floor area does not count toward the requirement; enter no.
- Total the areas that meet all the above criteria and divide the sum by the total regularly occupied area to determine whether the building meets the 90% access to views requirement.

IEQ	
NC	Credit 8.2
CS	Credit 8.2

CS

Develop a feasible tenant layout(s) per the default occupancy counts (or some other justifiable occupancy count) that can be used in the analysis of this credit.

TABLE 1. DETERMINATION OF COMPLIANCE

ROOM	REGULARLY OCCUPIED FLOOR AREA (m^2)	PLAN AREA OF DIRECT LINE OF SIGHT TO PERIMETER VISION GLAZING (m^2)	CALCULATED AREA OF DIRECT LINE OF SIGHT TO PERIMETER VISION GLAZING (m^2)	HORIZONTAL VIEW AT 1.07 METRES (YES/NO)	COMPLIANT AREA (m^2)
101 Office	75	73	75	Yes	75
102 Office	30	26	30	Yes	30
103 Open Office	450	430	430	Yes	430
104 Office	25	18	25	No	0
105 Office	25	16	16	Yes	16
Total	605				551
Percent access to views (551/605)					91.1% credit earned

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Maintain documentation—floor plans, sections, and elevations—showing the location of regularly occupied spaces with views.
- Maintain a spreadsheet documenting the view area as outlined in the Calculations section to account for any changes in design.

8. EXAMPLES

The following example demonstrates the percentage of spaces with access to views that could be realized for a 7,432 square metre (80,000 square foot) office building. The floor plan was designed to locate private offices toward the inside the building. In the example, 96% of views are achieved, which meets the threshold for this credit.

IEQ	
NC	Credit 8.2
CS	Credit 8.2

FIGURE 3. VIEW LINES

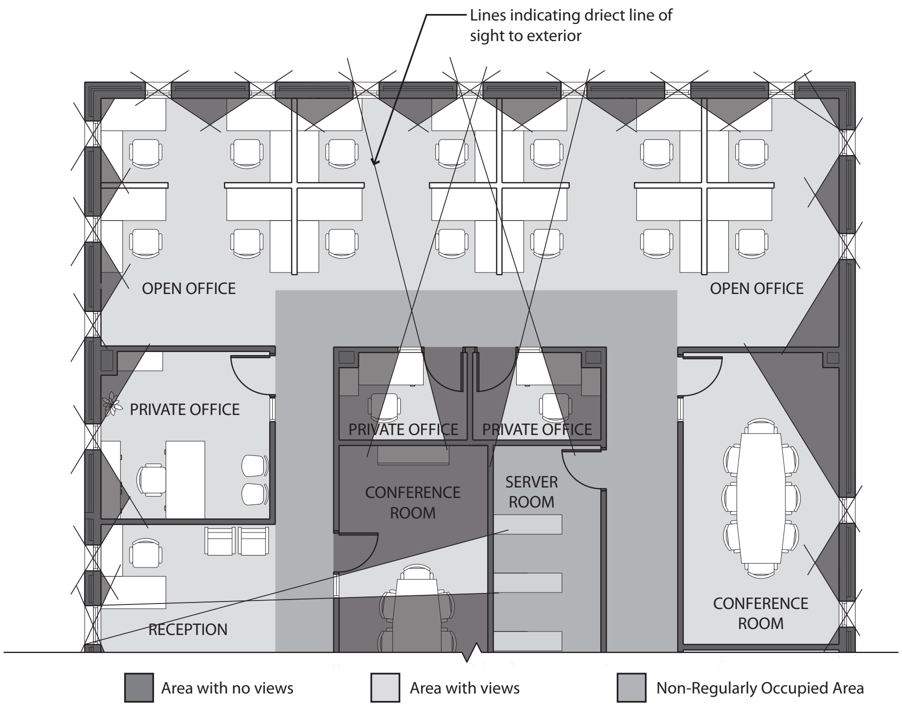
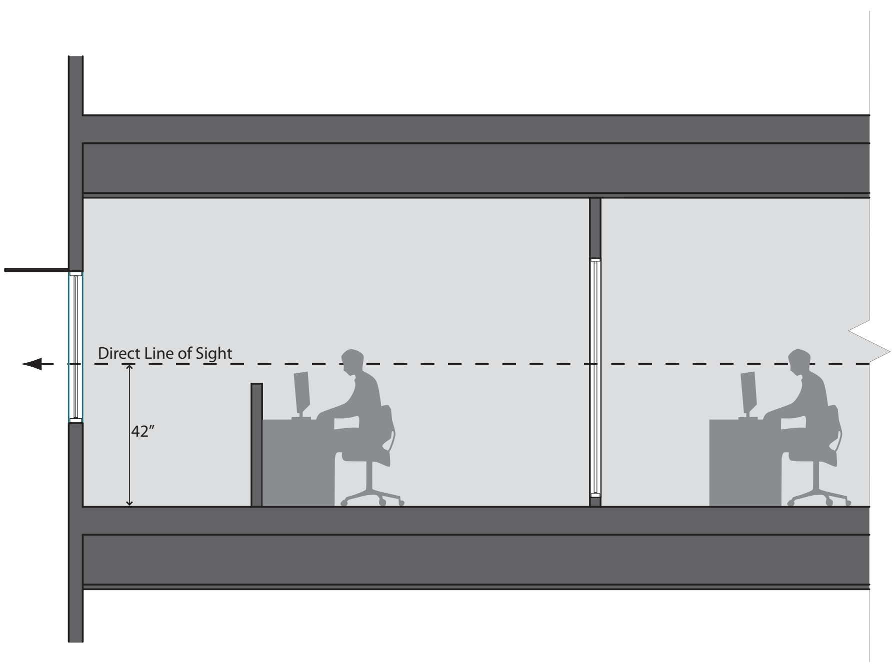


FIGURE 4. DIRECT LINE OF SIGHT THROUGH INTERIOR WINDOW OVER LOW PARTITION



IEQ	
NC	Credit 8.2
CS	Credit 8.2

TABLE 2. SAMPLE CALCULATION

ROOM	DESCRIPTION	FLOOR AREA (m^2)	HORIZONTAL VIEW AT 1.07 METRES	VIEWS (m^2)
216	Open office	409	Y	409
220	Office	12.6	Y	12.6
222	Office	10.7	Y	10.7
223	Conference	18.4	Y	18.3
224	Office	10.7	Y	10.7
225	Open office	20.8	Y	0
226	Office	11.1	Y	11.1
227	Conference	15.7	Y	15.0
232	Office	12.3	Y	12.3
Totals		521		500
Percentages of Area with Views: (500/521)				96%

9. EXEMPLARY PERFORMANCE

Exemplary performance may be demonstrated for this credit by meeting 2 of the following 4 measures:

1. 90% or more of regularly occupied spaces have multiple lines of sight to vision glazing in different directions at least 90 degrees apart.
2. 90% or more of regularly occupied spaces have views that include views of at least 2 of the following 3 options: 1) vegetation, 2) human activity, or 3) objects at least 70 feet from the exterior of the glazing.
3. 90% or more of regularly occupied spaces have access to unobstructed views located within the distance of 3 times the head height of the vision glazing.
4. 90% or more of regularly occupied spaces have access to views with a view factor of 3 or greater.

Measures determined per the Heschong Mahone Group study, Windows and Offices; A Study of Office Worker Performance and the Indoor Environment. Refer to page 47, for their Primary View (seated at workstation, facing computer screen). See: http://h-m-g.com/downloads/Daylighting/day_registration_form.htm to download the report.

10. REGIONAL VARIATIONS

Available duration and potency of solar radiation can directly affect the heat gain and loss through glazing systems. Consideration should be given when selecting glazing systems to minimize undesirable heat loss and gain through the glazing. The visual appeal of the exterior environment greatly affects the subjective quality of the views.

IEQ	
NC	Credit 8.2
CS	Credit 8.2

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Glazing and shading systems should be regularly cleaned and maintained. Windows and skylights require periodic sealant and flashing inspections to ensure water tightness. Additionally, any landscaping that may provide for high-quality views should be well maintained.

Future modifications to the building, both interior and exterior, can directly affect occupants' access to views. Care should be taken during tenant build-out to protect views.

12. RESOURCES

WEBSITES

A Literature Review of the Effects of Natural Light on Building Occupants
http://www.nrel.gov/docs/fy02osti/30769.pdf

NREL/TP-550-30769, July 2002, L. Ed-wards and P. Torcellini. A wide-ranging compilation of international research on benefits of daylighting and outdoor views, covering offices, schools, retail and health-care facilities.

American Bird Conservancy (ABC)
http://www.abcbirds.org

ABC is a national leader in reducing human effects on birds and wildlife. ABC's bird collision program supports national efforts to reduce bird mortality through education and advocacy.

Analysis of the Performance of Students in Daylit Schools
http://www.innovativedesign.net/studentperformance.htm

This website details Innovative Design researchers Michael Nicklas and Gary Bailey's 1996 study of 3 daylit schools in North Carolina.

The Art of Daylighting
http://www.edcmag.com/Articles/Feature_Article/10e5869a47697010VgnVCM100000f932a8c0

This Environmental Design + Construction article provides a solid introduction to daylighting.

City of Chicago, Department of Environment
http://www.cityofchicago.org/Environment/BirdMigration/sub/main.html

In 1 of the first cities to implement a mandatory lights-out program, Chicago's Department of Environment has many resources for bird-friendly design.

Fatal Light Awareness Program (FLAP)
http://www.flap.org

Initiated the Bird-Friendly Building Development Program for the City of Toronto, FLAP monitors and promotes bird-friendly design.

New Buildings Institute's Productivity and Building Science Program
http://www.newbuildings.org/photometrics_download.htm

This report provides case studies and information on the benefits of daylighting.

New York City Audubon
http://www.nycaudubon.org

This Audubon chapter takes a leadership role in reducing bird collisions with buildings. The chapter publishes Bird-Safe Building Guidelines, conducts monitoring, and, through its Project Safe Flight, promotes bird-friendly design.

IEQ	
NC	Credit 8.2
CS	Credit 8.2

Psychosocial Value of Space
http://www.wbdg.org/resources/psychspace_value.php

Judith Heerwagen provides an excellent summary of the scientific research on the impact of building environments on the way people work and live, particularly benefits of daylight, access to natural views and personal environmental control.

Radiance Software
http://gaia.lbl.gov/vls/

This site offers free daylighting simulation software from the Lawrence Berkeley National Laboratory.

The Sustainable Building Technical Manual
http://www.freshstart.ncat.org/articles/ptipub.htm

Green Building Design, Construction, and Operations: This manual produced jointly by the U.S. Department of Energy (DOE) and Public Technology, Inc. (PTI) is one of the most comprehensive publications now available to help architects, developers, building owners, government officials, and others implement sustainable development practices. It contains more than 300 pages of practical, step-by-step advice on sustainable buildings written by some of the foremost experts in the field.

Tips for Daylighting with Windows
http://btech.lbl.gov/pub/pub/designguide/

A comprehensive guide to daylighting from Lawrence Berkeley National Laboratory

Whole Building Design Guide, Daylighting
http://www.wbdg.org/resources/daylighting.php

Whole Building Design Guide, Electric Lighting Controls
http://www.wbdg.org/resources/electriclighting.php?r=school_library

The Daylighting and Electric Lighting Controls sections provide a wealth of resources including definitions, fundamentals, materials, and tools.

PRINT MEDIA

Sustainable Building Technical Manual, Public Technology Institute (Public Technology Institute, 1996): http://www.pti.org.

Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life, by Kellert, Heerwagen, and Mador (John Wiley & Sons, 2008).

Avian Collisions at Communication Towers, second edition, by Joelle Gehring and Paul Kerlinger (Curry & Kerlinger, 2007).

Bird Density and Mortality at Windows, by Stephen B. Hager, Heidi Trudell, Kelly J. McKay, Stephanie M. Crandall, and Lance Mayer, Wilson Journal of Ornithology 120(3) (2008): 550-564.

13. DEFINITIONS

IEQ	
NC	Credit 8.2
CS	Credit 8.2

Core learning spaces are spaces for educational activities where the primary functions are teaching and learning (ANSI S12.60–2002).

Daylighting is the controlled admission of natural light into a space to reduce or eliminate electric lighting.

Direct Line of Sight to Perimeter Vision Glazing is the approach used to determine the calculated area of regularly occupied areas with direct line of sight to perimeter vision glazing. The area determination includes full height partitions and other fixed construction prior to installation of furniture.

Glare is any excessively bright source of light within the visual field that creates discomfort or loss in visibility.

Regularly occupied spaces in commercial buildings are areas where people sit or stand as they work. In residential applications these spaces include all living and family rooms and exclude bathrooms, closets, or other storage or utility areas. In schools, they are areas where students, teachers, or administrators are seated or standing as they work or study.

Vision glazing is that portion of exterior windows between 0.76 metres (30 inches) and 2.3 metres (90 inches) above the floor that permits a view to the outside.

INDOOR ENVIRONMENTAL QUALITY ENDNOTES

[1] Health Canada. "Environmental and Workplace Health – Indoor Air Quality". Website updated on March 3, 2009. Retrieved March 2009, http://www.hc-sc.gc.ca/ewh-semt/air/in/index-eng.php.

[2] U.S. Environmental Protection Agency. Healthy Buildings, Healthy People: A Vision for the 21st Century. 2001. http://www.epa.gov/iaq/hbhp/hbhptoc.html (accessed May 2008).

[3] U.S. Environmental Protection Agency. Unfinished Business: A Comparative Assessment of Environmental Problems. Washington, DC: U.S. EPA, 1987.

[4] U.S. Environmental Protection Agency. Reducing Risk: Setting Priorities and Strategies for Environmental Protection. Washington, DC: U.S. EPA, 1990.

[5] U.S. Environmental Protection Agency. Indoor Air in Large Buildings. 2002. http://www.epa.gov/iaq/largebldgs/i-beam/text/budgets_accounts.html (accessed May 2008).

[6] American Academy of Allergy, Asthma & Immunology (AAAAI). Promoting Best Practice: Guide for Managing Asthma in Children. Pediatric Asthma, 2004.

[7] Centers for Disease Control and Prevention, National Center for Health Statistics. "Asthma Prevalence, Health Care Use and Mortality, 2002." http://www.cdc.gov/nchs/products/pubs/pubd/hestats/asthma/asthma.htm (accessed November 2008).

[8] Asthma and Allergy Foundation of America. "Asthma Facts and Figures." http://www.aafa.org/display.cfm?id=8&sub=42#_ftnref20 (accessed November 2008).

[9] Statistics Canada. "Elementary and Secondary Public School Enrolments, Graduates and Educators." Website updated on September 22, 2009. Retrieved November 2009. http://www.statcan.gc.ca/daily-quotidien/090922/dq090922c-eng.htm

[10] Ibid.

[11] Environmental Health, Safety and Quality Management Services for Business and Industry, and Federal, State and Local Government, IAQ Fact Sheet. March 9, 2006.

[12] Rocky Mountain Institute. "Greening the Building and the Bottom Line." http://www.rmi.org/images/PDFs/BuildingsLand/D94-27_GBBL.pdf (accessed November 2008).

[13] This assumes that $100,000 in indoor air quality improvements are invested. Damiano, Leonard, and David Dougan. The Big Carrots: Productivity and Health. Ebtron, Inc., 2003. http://www.automatedbuildings.com/news/apr03/articles/ebtron/ebtron.htm (accessed May 2008).

[14] U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute. "Smoking and Tobacco Control Monograph 10." Health Effects of Exposure to Environmental Tobacco Smoke. NIH, 1999. http://cancercontrol.cancer.gov/tcrb/monographs/10/m10_complete.pdf (accessed May 2008).

[15] Ibid.

[16] U.S. Department of Health and Human Services, Public Health Service, Office of the Surgeon General. Women and Smoking: A Report of the Surgeon General. 2001. http://www.cdc.gov/tobacco/sgr/sgr_forwomen/index.htm (accessed May 2008).

[17] Prill, Rich. Why Measure Carbon Dioxide in Buildings? Washington State University Extension Energy Program. 2000. http://www.energy.wsu.edu/documents/building/iaq/CO2inbuildings.pdf (accessed November 2008).

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airborne particles in the community." Archives of Environmental Health 54 (1999).

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[25] Bauman, F.S. "Giving Occupants What They Want: Guidelines for Implementing Personal Environmental Control in Your Building." Center for the Built Environment, 1999.

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INNOVATION IN DESIGN (ID)

OVERVIEW

Sustainable design strategies and measures are constantly evolving and improving. New technologies are continually introduced to the marketplace, and up-to-date scientific research influences building design strategies. The purpose of this LEED® category is to recognize projects for innovative building features and sustainable building practices and strategies.

Occasionally, a strategy results in building performance that greatly exceeds what is required in an existing LEED credit. Other strategies may not be addressed by any LEED prerequisite or credit but warrant consideration for their sustainability benefits. In addition, LEED is most effectively implemented as part of an integrated design process, and this category addresses the role of a LEED Accredited Professional in facilitating that process.

IMPLEMENTING NEW TECHNOLOGIES AND METHODS

As the building design and construction industry introduces new strategies for sustainable development, opportunities leading to additional environmental benefits will continue to emerge. Opportunities that are not currently addressed by *LEED Canada for New Construction* or *Core & Shell* may include environmental solutions specific to a particular location, condition, or region. With all sustainable strategies and measures, it is important to consider related environmental impacts. Project teams must be prepared to demonstrate the environmental benefits of innovative strategies and are encouraged to pursue opportunities that provide benefits of particular significance. Project teams can earn exemplary performance points for implementing strategies that result in performance that greatly exceeds the level or scope required by an existing LEED prerequisite or credit. Exemplary performance opportunities are noted throughout this reference guide.

CREDIT	TITLE
ID Credit 1	Innovation in Design
ID Credit 2	LEED® Accredited Professional

ID	
NC	Credit 1
CS	Credit 1

INNOVATION IN DESIGN

	NC	CS
Credit	ID Credit 1	ID Credit 1
Points	1-5 points	1-5 points

INTENT

To provide design teams and projects the opportunity to achieve exceptional performance above the requirements set by this rating system and/or innovative performance in Green Building categories not specifically addressed by this rating system.

REQUIREMENTS: NC & CS

Credit can be achieved through any combination of the paths below:

PATH 1. INNOVATION IN DESIGN (1-5 points)

Achieve significant, measureable environmental performance using a strategy not addressed in the *LEED Canada for New Construction and Major Renovations 2009* and *LEED Canada for Core and Shell Development 2009*.

One point is awarded for each innovation achieved. No more than 5 points under ID Credit1 may be earned through PATH 1—Innovation in Design.

Identify the following in writing:

- The intent of the proposed innovation credit.
- The proposed requirement for compliance.
- The proposed submittals to demonstrate compliance.
- The design approach (strategies) used to meet the requirements.

ID	
NC	Credit 1
CS	Credit 1

PATH 2. EXEMPLARY PERFORMANCE (1-3 points)

Achieve exemplary performance in an existing credit that allows exemplary performance as specified in the *LEED Canada Reference Guide for Green Building Design and Construction*. An exemplary performance point may be earned for achieving double the credit requirements and/or achieving the next incremental percentage threshold of an existing credit in LEED.

One point is awarded for each exemplary performance achieved. No more than 3 points under IDc1 may be earned through PATH 2— Exemplary Performance.

INTERPRETATIONS

There are no interpretations for this credit.

ID	
NC	Credit 1
CS	Credit 1

1. BENEFITS AND ISSUES TO CONSIDER

Sustainable design comes from innovative strategies and thinking. Institutional measures to reward such thinking—like the achievement of this credit—benefit our environment. Recognition of the exceptional will spur further innovation.

2. RELATED CREDITS

LEED Canada for New Construction (NC) and *LEED Canada for Core & Shell* (C&S) credits hold ideas for Innovation in Design (ID) points and strategies. Refer to the Exemplary Performance section of credits in this reference guide.

3. SUMMARY OF REFERENCED STANDARDS

There is no standard referenced for this credit. Please refer to the Summary of Referenced Standards section in each credit for relevant standards.

4. IMPLEMENTATION

Credits in this section may be earned by documenting increased benefits to the environment in 1 of 2 ways:

EXEMPLARY PERFORMANCE STRATEGY

Exemplary performance strategies result in performance that greatly exceeds the level or scope required by existing *LEED Canada NC* and *LEED Canada CS* credits.

As a rule of thumb, ID credits for exemplary performance are awarded for doubling the credit requirements and/or achieving the next incremental percentage threshold. For instance, to achieve an ID credit for exemplary performance in MR Credit 4, Recycled Content, the total recycled value must be 30% or greater.

Exemplary performance is not available for all credits in *LEED Canada NC* and *LEED Canada CS*. Credits that allow exemplary performance through a predetermined approach are noted throughout this reference guide and the LEED Letter Templates. A maximum of 3 ID points can be earned for exemplary performance.

INNOVATIVE STRATEGIES

Innovative strategies are those that are not addressed by existing *LEED Canada NC* or *LEED Canada CS* credits. Credits from other *LEED Canada Rating Systems* (*Commercial Interiors, Existing Buildings: Operations & Maintenance (EB:O&M)*, the upcoming *Neighbourhood Development*) or new credits added to USGBC Rating Systems unavailable in Canada (*LEED for Healthcare*, *LEED for Retail*, *LEED for Schools*) that are not in *LEED Canada NC* or *LEED Canada CS* may be examined as potential innovative strategies. Only those strategies that demonstrate a comprehensive approach and have significant, measurable environmental benefits are applicable. Meeting a prerequisite or the lowest level of a multi-level credit from another rating system would not be considered significant.

ID	
NC	Credit 1
CS	Credit 1

There are 3 basic criteria for achieving an innovation credit for a category not specifically addressed by *LEED Canada NC* or *LEED Canada CS*:

1. The project must demonstrate quantitative performance improvements for environmental benefit (establishing a baseline of standard performance for comparison with the final design).
2. The process or specification must be comprehensive. For example, a team that is considering applying for an innovation credit for a green cleaning program would need to demonstrate that the program applies to the entire project being certified under LEED and addresses at least half of the *LEED Canada EB:O&M* credits for green cleaning, one of which must include EB:O&M IEQ Credit 3.1 (Green Cleaning: High Performance Cleaning Program), as a program has more relevance to a new construction project than other elements, such as auditing. Measures that address a limited portion of a project or are not comprehensive in other ways are not eligible.
3. The concept the project team develops for the innovation credit must be applicable to other projects and must be significantly better than standard sustainable design practices.

ID credits awarded for 1 project at a specific point in time do not constitute automatic approval for similar strategies in a future project.

ID credits are not awarded for the use of a particular product or design strategy if the technology aids in the achievement of an existing LEED credit.

Approved ID credits may be pursued by any LEED project, but the project team must sufficiently document the achievement using the LEED credit equivalence process.

CS

Core & Shell projects pursuing ID credits must implement a comprehensive strategy. In many instances, this will mean that strategies must apply to the whole building and include both the core and shell scope and common areas, as well as the tenant spaces. For example, a *LEED Canada for Core & Shell* project who is pursuing an innovation credit for a green housekeeping program or integrated pest management, the base building management must either control the cleaning or pest management of both the base building and tenant spaces or enforce the requirements through a legally binding sales agreement or tenant lease for the areas not controlled by the base building management.

5. TIMELINE AND TEAM

Innovation in Design ideally begins at a project's conception, but it can enter at any step of the process and come from any member of the project team. Open-mindedness, creativity, and rigor in follow-through are the critical ingredients. Options for innovation may come from the spheres of the technological—for example, an inventive wall section for climate control—or the general, such as educational outreach measures. Thus, team members with a variety of skills and interests will be able to contribute to the achievement of this credit.

6. CALCULATIONS

For exemplary performance, please refer to the Calculations section within each applicable credit.

ID	
NC	Credit 1
CS	Credit 1

7. DOCUMENTATION GUIDANCE

The Documentation Guidance section helps project teams prepare for formal certification application and complete the LEED Letter Templates documentation requirements. Refer to the LEED Letter Templates for the complete descriptions of all required documentation.

- Document the process by which the project team has worked to develop and/or implement environmental benefits beyond the requirements set by this rating system and/or innovative performance in other areas.
- Track development and implementation of the specific exceptional and innovative strategies used.
- For Core & Shell projects, state the scope of the building that the innovation credit covers.

8. EXAMPLES

The level of effort involved in achieving an ID credit should be extraordinary. For example, installing a single green product or addressing a single aspect of a sustainability issue is not a sufficient level of effort. An environmental educational program consisting of simple signage in a building would not by itself be considered a significant benefit. Conversely, a visitor's center interactive display, coupled with an educational website and video highlighting the project's environmental strategies, would be eligible for an ID credit.

SUGGESTED TOPICS FOR INNOVATION CREDITS

The following list illustrates sample actions and concepts that may be viable candidates for an ID credit, given appropriate implementation and documentation. It is the responsibility of the project team to determine the feasibility of possible ID-related programs or initiatives, develop and execute the program in a manner that yields a meaningful environmental benefit, and provide documentation and calculations that substantiate the validity of the project team's approach and implementation. Project teams are encouraged to explore the full range of innovative opportunities within their buildings.

This list provides examples only and does not constitute formal preapproval of any ID strategy. ID strategies are only awarded through the certification review process. However project teams desiring formal direction on an ID approach can submit a CIR (Credit Interpretation Request) explaining the proposal in detail. Note that approval of the CIR does not constitute credit achievement of the strategy: credits cannot be awarded through the CIR process.

- Green Education Program - To take advantage of the educational value of the green building features of a project and to earn a LEED point, any approach should be actively instructional; i.e., informing and engaging users to take action on the basis of information presented. Two of the following four elements must be included in the educational program; at least one should be actively instructional while others may be passive:

    1. A comprehensive signage program built into the building's spaces to educate the occupants and visitors of the benefits of green buildings. This program may include windows to view energy-saving mechanical equipment or signs to call attention to water-conserving landscape features. To be acceptable as a comprehensive signage program, multiple signs must be highly visible throughout the building. Signage must also be varied (i.e., one sign repeated is not acceptable) and informative (describing process and measures that achieve one or more LEED credit intents). Examples include:

ID	
NC	Credit 1
CS	Credit 1

   a. Active — A signage program that prompts action from the user at each sign (e.g., explaining the usage of a new technology).

   b. Passive — A signage program that highlights green features in the building.

2. The development of a manual, guideline or case study to inform the design of other buildings based on the successes of this project. This manual will be made available to the CaGBC for sharing with other projects. Examples include:

   a. Active — A detailed document (e.g., ~5000 words with images / graphs) that educates or transfers knowledge to designers of future buildings. The case study must be combined with an effective outreach program that promotes and disseminates the case study to a wide audience (e.g., through website, conference presentations).

   b. Passive — Brochure made available at the building site to all occupants and guests.

3. An educational outreach program or guided tour could be developed to focus on sustainable living, using the project as an example. Examples include:

   a. Active —Tours, delivered by live tour guide or audio/video recorded messaging, that are actively promoted and delivered on a regular basis (e.g., weekly over several months).

   b. Passive — Brochure or LCD display with station points for self-guided tours.

4. Use of electronic media is acceptable as another education approach. Examples include:

   a. Active — Interactive computer kiosk or website with real-time monitoring data and/or animation.

   b. Passive — Scrolling through screens on computer kiosk or website.

Other educational elements may be accepted on their merits. It is important to note that the educational strategies should include diverse media that respond to different learning styles and audiences.

- Green Cleaning - Demonstrate that the cleaning program applies to the entire project being certified under LEED and addresses at least half of the *LEED Canada EB:O&M* credits for green cleaning, one of which must include EB:O&M IEQ Credit 3.1 (Green Cleaning: High Performance Cleaning Program), as a program has more relevance to a new construction project than other elements, such as auditing.
- Evaluate a substantial quantity of products or materials being used (or being considered for use in the building) on the basis of an ISO 14040 life-cycle assessment.
- Divert significant volumes of waste generated from sources other than the project building site and associated grounds via expanded waste management and diversion programs. For example, provide a collection and recycling program that allows building occupants or members of the community to bring in end-of-life home electronic equipment for recycling.

ID	
NC	Credit 1
CS	Credit 1

CS

Core & Shell projects also have the option of developing legally binding performance criteria, based on existing LEED credits for tenants that require buyers or tenants to design and construct in accordance with LEED credit requirements. An Innovation in Design point may be awarded for having mandatory tenant lease agreements requiring tenant fit-ups to achieve at least 6 of the following *LEED Canada NC* requirements as outlined in this reference guide: SS Credit 8, EA Credit 6, MR Credit 2 to 7, IEQ Credit 4.1 to 4.4. The owner must commit to implement and enforce these agreements.

9. REGIONAL VARIATIONS

ID credits may have regional content. For example, for sites close to wilderness areas or along bird flight paths, implementing a wildlife management program to mitigate human impact on the surrounding wilderness area or minimize bird strikes might be worthy of an ID point.

Extraordinary designs that use the vernacular architectural strategies of the region may be among the most environmentally sound. Project teams should look to the characteristic buildings of their region as a source for innovation.

ID	
NC	Credit 1
CS	Credit 1

10. CASE STUDY

CAMBRIDGE CITY HALL
LEED Canada-NC 1.0 Gold, 31 July 2008

Location: Cambridge, Ontario
Building Type: Office building
Owner Type: Government - Local
Building Size: 7600m^2
Owner Name: The Corporation of the City of Cambridge
LEED Consultant: Enermodal Engineering Ltd.
Responsible Firm (for this credit): Nedlaw Living Walls
Photo Credit: Enermodal Engineering Ltd.

Located in downtown Galt, the new Cambridge City Hall is visually linked to surrounding historic buildings by a new civic square. Inside the building, a more efficient layout provides office space for hundreds of city employees while allowing for easier customer service.

The design team and client agreed to create a functional building that could also serve to showcase a variety of green construction products and practices to the community City Hall serves. The focal point of the central atrium is a 110 m^2 living wall of tropical plants that immediately draws visitors' attention upward. Beyond being a pleasing aesthetic feature, the living wall contributes to improved air quality. Specially selected plants cleanse indoor air of VOCs, dust, and spores. The building HVAC system circulates return air through the living wall, which cleans the air and adds humidity in dry winter months. The project was installed during the winter of 2008 as construction was wrapping up. Because the HVAC systems were not fully online, there were a few periods of less

ID	
NC	Credit 1
CS	Credit 1

than ideal growing conditions and thus some of the initial plantings died out. These plants were replaced and are thriving now that HVAC systems are fully operational and properly commissioned.

Behind the living wall, water trickles down to provide moisture for the plants in a growing medium. In this high-moisture environment it was necessary to use durable, water-resistant sealants to protect other building materials from moisture damage. The project team did so while maintaining the project commitment to the use of products that meet LEED requirements for low-emitting adhesives and sealants.

Lessons learned:

- Careful consideration must be given to scheduling and coordinating the plant installation in the living wall to reduce the necessity of plant replacement. This coordination involves the contractor, commissioning agent, and living wall installer.
- The City of Cambridge noticed that after a year of operation, the water quality (level of pH/ salts) circulating in the wall, needed to be adjusted and monitored regularly. They recommend installing an automated system to monitor water conditions and that would adjust the inlet and outlet water valves to balance the water conditions.

ID	
NC	Credit 1
CS	Credit 1

EARTH RANGERS CENTRE

LEED Canada-NC 1.0 Gold, 21 April 2006

Location: Woodbridge, Ontario
Building Type: Conservation Centre
Owner Type: Nonprofit
Building Size: 5,800m^2
Owner Name: Earth Rangers
LEED Consultant: Enermodal Engineering Ltd.
Responsible Firm (for this credit): Owner
Photo Credit: Enermodal Engineering Ltd. and Earth Rangers Centre

The Earth Rangers Centre in Woodbridge, Ontario, is a 5,800 m^2 nature education centre located on a rolling 31 acre property. The Earth Rangers Centre is a world-class facility that is home to a Canadian charitable organization called Earth Rangers, which empowers kids to help improve the health of the planet.

Earth Rangers was distinctly interested in promoting environmental design and technology with its new headquarters. After completing construction on their LEED Gold building, Earth Rangers noticed a significant number of birds struck the building's windows. Therefore, Earth Rangers wanted to incorporate some sort of innovative window technology to decrease the number of bird strikes.

In addition to occupancy sensors (reducing excess illumination in the evening), blinds (reducing dangerous reflections and illusions), and low-e window coatings (making windows appear more like solid objects to birds), the Earth Rangers facility now features a patterned window film.

The tree-patterned protective window film was applied to more than 100 windows. The film is mostly installed on the second floor windows and windows adjacent to the green roof area as these are the most likely locations for bird strikes. The film is fixed to the windows producing glazing that is visible to birds from a distance. Additionally, because birds can fly between dense tree branch configurations and small voids, the film pattern is very "busy," consisting of spaces no larger than 4" by 2". Tiny perforations allow light to pass through the film while still providing a visual surface to redirect a bird's flight.

Besides decreasing the number of bird strikes, the low-e window coatings were important for achieving the daylighting credit as the coating defuses light and helps reduce glare in occupied spaces.

Performance:

- The window technology implemented by Earth Rangers has been effective in significantly reducing the number of bird strikes.

ID	
NC	Credit 2
CS	Credit 2

LEED® ACCREDITED PROFESSIONAL

	NC	CS
Credit	ID Credit 2	ID Credit 2
Points	1 point	1 point

INTENT

To support and encourage the design integration required by LEED to streamline the application and certification process.

REQUIREMENTS: NC & CS

At least 1 principal participant of the project team must be a LEED Accredited Professional (AP).

INTERPRETATIONS

There are no interpretations for this credit.

ID	
NC	Credit 2
CS	Credit 2

1. BENEFITS AND ISSUES TO CONSIDER

LEED APs have the expertise required to design a building to LEED standards and to coordinate the documentation process that is necessary for LEED certification. The LEED AP understands the importance of integrated design and the need to consider interactions between the prerequisites and credits and their respective criteria. Architects, engineers, consultants, owners, and others who have a strong interest in sustainable building design are all appropriate candidates for accreditation. The LEED AP should champion the project's LEED application and be an integral member of the project team. The LEED AP can also educate other team members about LEED and green buildings.

2. RELATED CREDITS

There are no related credits for the achievement of this credit.

3. SUMMARY OF REFERENCED STANDARDS

LEED Accredited Professional
Green Building Certification Institute

Individuals who successfully complete the LEED professional accreditation exam are LEED APs. Accreditation certifies that the individual has the knowledge and skills necessary to participate in the LEED application and certification process, holds a firm understanding of green building practices and principles, and is familiar with LEED requirements, resources, and processes. The Green Building Certification Institute (GBCI), established with the support of the U.S. Green Building Council (USGBC), handles exam development and delivery to ensure objective and balanced management of the credentialing program. All Canadians who received LEED AP accreditation through the CaGBC have their accreditation migrated into the GBCI's database.

4. IMPLEMENTATION

A LEED AP is a valuable resource in the LEED design and construction process. Although not required, the presence of a LEED AP aids the project team in understanding the elements of the rating system, the importance of considering interactions among the prerequisites and credits, and the LEED application process.

Including a LEED AP on the project team meets the credit requirements and can be accomplished in either of 2 ways:

- Engaging an individual within the organization who is already a LEED AP to participate in the certification application process.
- Hiring a LEED AP to support the project. Consider selecting a LEED AP experienced with *LEED Canada for New Construction* or *Core & Shell* and industry best green practices in design and construction.

5. TIMELINE AND TEAM

There is no guidance for this credit.

ID	
NC	Credit 2
CS	Credit 2

6. CALCULATIONS

There are no calculations associated with this credit.

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measure. Refer to LEED Letter Templates for the complete descriptions of all required documentation.

- Obtain confirmation certificate from team members who are LEED APs.

8. RESOURCES

WEBSITES

Green Building Certification Institute
www.gbci.org

The GBCI administers the LEED Professional Accreditation program to ensure objective management of the credential. The GBCI manages exam development, registration, and delivery. It was established as a separately incorporated entity with the support of the USGBC. See the GBCI website for more information on workshops, testing locations, fees, and topics covered on the accreditation exam.

9. DEFINITIONS

LEED **Accredited Professionals (APs)** are individuals who have successfully completed the LEED professional accreditation exam.

REGIONAL PRIORITY (RP)

OVERVIEW

The Regional Priority Category provides for additional recognition to issues that are important regionally in Canada, whether as a whole under RP Credit 1 (Durable Building) or to specific regions under RP Credit 2 (Regional Priority).

DURABLE BUILDING

Durability is the ability of a building or any of its components to perform its required functions in its service environment over a period of time without unforeseen cost for maintenance or repair. When the predicted service life meets or exceeds the design service life, the resulting minimization of replacement and maintenance needs of the building and its components reduces material waste, resource extraction, and pollution. In general, as durability increases, so do the environmental merits of the project as a whole. However, short-term economic savings gained from compromising on a detail with cheaper and less durable materials and assemblies can result in costly future complications and associated costs. The "Leaky Condo" crisis in BC is an unfortunate example of widespread economic and social costs associated with short-sighted design and construction.

Previously under LEED® Canada-NC 1.0 durability was recognized as a credit under Materials and Resources. In order to align internationally with LEED 2009, the credit was moved to the Regional Priority category, recognizing the importance of this credit to Canada as an entire region.

OTHER REGIONAL ISSUES

The remainder of regional priority focuses on giving extra weighting to existing credits that are important to a particular region. Due to the presence of regionally-unique environmental issues and to encourage design teams to focus on issues that are particularly important near a project site, these regional priority points provide an opportunity to teams to achieve additional recognition for addressing issues pertinent to their locale.

These regional priority points can only be earned when the points gained from core LEED Canada credits are sufficient to attain basic certification.

CREDIT	TITLE	NC	CS
RP Credit 1	Durable Building	1 point	1 point
RP Credit 2	Regional Priority	1-3 points	1-3 points

RP	
NC	Credit 1
CS	Credit 1

DURABLE BUILDING

	NC	CS
Credit	RP Credit 1	RP Credit 1
Points	1 point	1 point

INTENT

To minimize materials use and construction waste over a building's life resulting from inappropriate material selection or premature failure of the building and its constituent components and assemblies.

REQUIREMENTS: NC & CS

Develop and implement a Building Durability Plan, in accordance with the principles in CSA S478-95 (R2007) – Guideline on Durability in Buildings, for the components within the scope of the Guideline, for the construction and preoccupancy phases of the building as follows:

- Design and construct the building with the intent that the predicted service life equals or exceeds the design service life (DSL) established in Table 2 in CSA S478-95 (R2007) – Guideline on Durability in Buildings.
- Provide the owner's expectation of design service life.
- Where component and assembly design service lives are shorter than the design service life, of the building, design and construct those components and assemblies so that they can be readily replaced, and use a design service life in accordance with Table 3 in CSA S478-95 (R2007) – Guideline on Durability in Buildings, as follows:
    - For components and assemblies whose Categories of Failure are 6, 7 or 8 in Table 3, use a design service life equal to the design service life of the building.
    - For components and assemblies whose Categories of Failure are 4 or 5 in Table 3, use a design service life equal to at least half of the design service life of the building.
- Demonstrate the predicted service life of chosen components or assemblies by documenting demonstrated effectiveness, modeling of the deterioration process or by testing in accordance with Clauses 7.3, 7.4 or 7.5.
- Complete Tables A1, A2 and A3 from CSA S478-95 (R2007) – Guideline on Durability in Buildings or the *LEED Canada Durable Building Tables*, which correspond to CSA S478 Tables A1, A2 and A3.

RP	
NC	Credit 1
CS	Credit 1

- Develop and document the quality management program in accordance with CSA S478-95 (R2007) – Guideline on Durability in Buildings.
- Document the elements of quality assurance activities (including design and field reviews) carried out in the format contained in Table 1, Quality Assurance and the Building Process, of CSA S478-95 (R2007) – Guideline on Durability in Buildings.
- Utilize a qualified building science professional to develop and deliver the Building Durability Plan who:
  - Is employed by a firm with an Engineering Certificate of Authorization or an Architectural Certificate of Practice.
  - Has experience in performing building science reviews focused on the envelope durability for at least two prior buildings.
  - One of the following:
    - Has successfully completed at least 35 hours of instruction in building science courses that address envelope durability within the last 10 years.

    OR

    - Has a certificate demonstrating building envelope expertise from a building warranty program (e.g., TARION).

    OR

    - Is independent of the architectural firm of record.

INTERPRETATIONS

The components considered relevant within the scope of this credit are: all major structural elements (including foundations), building cladding assemblies, glazing assemblies, roofing assemblies, and those elements representing significant impact on building's operation or performance (excluding mechanical and electrical equipment).

For buildings that exceed 60 years, it is unlikely that all components within the assembly can meet the ½ building design life (e.g., windows and roofing membranes), due to material limitations. Such materials are therefore required to meet at least a 30 year design service life.

RP	
NC	Credit 1
CS	Credit 1

1. BENEFITS AND ISSUES TO CONSIDER

Durability is the ability of a building or any of its components to perform its required functions in its service environment over a period of time without unforeseen cost for maintenance or repair. When the predicted service life meets or exceeds the design service life, the resulting minimization of replacement and maintenance needs of the building and its components reduces material waste, resource extraction, and pollution. In general, as durability increases, so do the environmental merits of the project as a whole. However, many other factors influence the actual service life of building components and materials and components are often removed prematurely as a result of changing preference. The art of building design in large part lies in providing for the design to accommodate changing needs, with a classic aesthetic that improves with time and use.

It is often difficult to justify the value of including materials and components as performance durability criteria to a building owner since the current marketplace does not often encourage investment in the future. However, short-term economic savings gained from compromising on a detail with cheaper and less durable materials and assemblies can result in costly future complications and associated costs. The "Leaky Condo" crisis in BC is an unfortunate example of widespread economic and social costs associated with short-sighted design and construction.

All materials and components are expected to withstand some stress and weathering during their life-span. However, exposure to stresses that have either been ignored or not anticipated in design may lead to premature failure of one building element, with the subsequent deterioration of others influenced by it. Most damage of this type occurs to components of the building envelope, especially exterior walls, roof or floor finishes and claddings directly exposed to wind, rain or extreme temperature fluctuations or the migration of moisture or air through the building envelope. There is increasing awareness and concern for envelope design, for example:

- Rain-screen cladding systems in BC designed and constructed with best building practices are less likely to be problematic than other systems.
- In Ontario, the Architects Insurance Plan will only cover drained cladding systems or solid masonry or concrete systems that are moisture tolerant.

ENVIRONMENTAL ISSUES

Durable materials and components following carefully considered design details can potentially remain useful in the materials cycle for longer periods of time, reducing the need for new materials and the environmental costs of resource extraction, production processes and waste disposal.

Designing for maintenance, deconstruction and adaptability can extend the life of building components and buildings as a whole. The use of easily demountable components and connections and the use of fasteners that ease deconstruction eases maintenance, and increases the potential future re-use of building materials and components. In addition, the incorporation of flexible and easily accessible systems greatly reduces the need for extensive renovations or even replacement in the future.

ECONOMIC ISSUES

While durable materials and higher quality, regionally-appropriate construction practices may incur higher initial costs, they typically require less in the way of maintenance and replacement and typically prove to be more cost effective in the long run.

Selection of exterior materials and finishes plays an important role in affecting occupants' and the publics' response to a building. Durable materials that weather well in their appropriate climate

RP	
NC	Credit 1
CS	Credit 1

and physical context present a longer lasting positive public face to a building. This can further the acceptance of sustainable building practices in the market.

Assessing life-cycle costs based on design service life of the structure and the building envelope can be helpful in assessing alternative systems for the building. Use of life-cycle cost analysis for key assemblies and components can help owners and design teams make informed decisions about construction investments with long-term benefits to subsequent occupants.

Premature failure of building envelopes, especially due to moisture, imposes remediation costs on building owners that may not be covered by warranties. In British Columbia, remediation costs per dwelling unit for leaky condominiums often exceeded their initial sale price; these costs were borne by owners, developers and the provincial government. The costs of premature deterioration are social as well as economic. Buildings that age well and require less frequent renovation or replacement create a more cohesive urban fabric and encourage pride in place. Durable buildings also spare communities the disruption of constant construction and building abandonment.

The use of regionally appropriate components and construction methods can help improve the durability of a building, and connect occupants to the unique climate and qualities of their environments. For example, adobe construction is extremely successful in hot and dry climates, but fails in cold and wet regions. Communities therefore benefit economically through the use of local materials and knowledgeable trades people.

2. RELATED CREDITS

In addition to the benefits afforded by the prevention of premature deterioration of the building envelope, durable assemblies can also dramatically reduce energy consumption. Appropriately designed and constructed building assemblies can improve effective insulation values, allow thermal storage, reduce heat gain and minimize heat loss. Overall building health (IEQ) can also be improved by the use of durable materials with zero or low emissions that prevent moisture accumulation and mould or mildew growth. Refer to the credit requirements in the following:

- EA Prerequisite 2: Minimum Energy Performance
- EA Credit 1: Optimize Energy Performance

The use of local materials and trades can reduce transportation impacts, while increasing regional employment and expertise. Local materials and assemblies also increase potential durability with historically-proven, materials, assemblies and installations well-adapted to local climatic conditions. Refer to the credit requirements in the following:

- MR Credit 5: Regional Materials

A durable building, however, does not ensure a long life. If the building is not designed to accommodate program and occupant changes, it may become prematurely obsolete even though all of its components are still functioning and in good condition. Considering future adaptations and expansions with deconstructable assemblies can prolong a building's life long after the original designers and builders have moved on.

Innovative green wall and roof assemblies, such as vegetated walls/roofs, building integrated photovoltaic panels, solar walls, etc., are a few examples of the future of green envelopes. Special attention should be paid to durability and maintenance issues whenever an innovative approach is used, since contractors, operators and occupants are likely to be unfamiliar with their application and use. Refer to the credit requirements in the following:

- SS Credit 7.2: Heat Island Effect – Roof
- EA Credit 2: On-Site Renewable Energy

RP	
NC	Credit 1
CS	Credit 1

Although this durable building credit is limited to the building envelope, the design team may want to consider the benefits of extending the durability principles to building energy systems, and interior components and finishes. Refer to the credit requirements in the following:

- IEQ Credit 4: Low-Emitting Materials

Durability applied to these areas can result in a building with reduced damage or faster rehabilitation after problematic events (e.g., flooding):

EA Prerequisite 1, Fundamental Commissioning of Building Energy Systems, sets a minimum threshold for commissioning activities of primarily the mechanical / electrical systems in the building. Additional rigour and verification are awarded under EA Credit 3 Enhanced Commissioning and an exemplary performance of EA Credit 3 can be achieved for commissioning of building envelope that looks at improved energy performance.

- EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems
- EA Credit 3: Enhanced Commissioning

3. SUMMARY OF REFERENCED STANDARDS

Canadian Standards Association: S478-95 (R2007)

This Guideline provides a set of recommendations to assist designers in creating durable buildings. The Guideline provides a framework within which durability targets may be set and suggests criteria for specifying durability performance of buildings in terms that are commonly used, but that were previously undefined. The Guideline contains generic advice on the environmental and other design factors that have an impact on the durability of building components and materials, and identifies the need to consider initial and long-term costs, maintenance, and replaceability in the selection of materials and components.

The Guideline makes it clear that service life requirements and design choices which may affect durability should be thoroughly discussed and agreed upon by all relevant parties, in particular the owner, designer, and constructor. Model documents for recording these decisions are provided in the Guidelines' *Appendix A*. Later Appendices discuss and expand upon issues related to identification and (relative) quantification of environmental loading, deterioration mechanisms, and damage avoidance strategies, including the need for appropriate maintenance over the life of the building.

4. IMPLEMENTATION

Issues that directly and indirectly influence durability should be incorporated into a design from the outset. The environmental loads and harmful agents to which the building components will be subjected during service life should influence design decisions and materials selection.

- Design strategies should be selected that are appropriate to the region to minimize premature deterioration of the walls, roofs and floors.

- Careful detailing of assemblies (e.g. rain-screens, appropriately placed air and vapour barriers, overhangs, redundancy in moisture protection, etc.) will minimize premature deterioration of the building. Special attention should be given to vulnerable components and penetrations of the building envelope. Design service life can be further extended by incorporating input from contractors, fabricators, and material suppliers, knowledgeable in the use and installation of specified materials and systems as well as input from the

RP	
NC	Credit 1
CS	Credit 1

operations and maintenance staff.

- Durability of specific materials can only be effective if assembled properly. Specifying a realistic and achievable level of workmanship, which typically involve practical construction methods and readily available technologies, will often lead to fewer construction problems. The use of new materials, or traditional materials in unconventional applications, should be based on sufficient modeling, testing and design guidance to achieve a high level of success in the application. Recognizing the allowable and expected construction tolerances of components in design, and the appropriate sequencing of the trades involved will tend to maximize efficiency and minimize unforeseen problems. Flexible, adaptable designs will accommodate alterations in design, construction, scheduling, conditions, or material availability that may arise during construction and future adaptations.
- The appropriate design service life of each component should be determined by considering exposure conditions, difficulty, frequency and expense of maintenance, consequences of failure, disruption in operation, future availability of materials; the design service life of the building; and aesthetic or functional obsolescence. In multi-component assemblies, confirm that each component has similar predicted service lives, and ease of maintenance or removal and replacement of materials with the lowest service life can be achieved without damage to neighbouring assemblies or components.
- Designs should provide ease of access for repairs, replacements, and alterations throughout the service life of the building. A maintenance plan should be developed in the design stage to address future repairs and materials replacements, and help in defining the objectives and expectations of owners, occupants, operators and designers.
- Defining and following a detailed quality assurance is essential at every stage in the life of the building. Envelope designs should be based on the 4-D's principle developed by Canada Mortgage and Housing Corporation (CMHC): Deflection, Drainage, Drying, and Durable materials. A fifth "D" can be added: Details; assemblies often fail prematurely due to poorly considered or non-existent design detailing.

Due to the concerns with ensuring a Durable building for their clients, responsible design professionals and building science professionals are encouraged to check with their specific insurance provider regarding their LEED Letter Template declarations.

5. TIMELINE AND TEAM

The project team should engage the building science professional early in the design phase to gain insights for design decisions and an indication of how to achieve prescribed levels of building durability.

6. CALCULATIONS

The LEED Canada Durable Building Tables provide a simplified Excel form for applicants applying the CSA S478-95 (R2007) standard to their project. Applicants are still required to obtain a copy of the standard for their reference, but these tables allow for a simplified submission process on this credit. These tables are available on CaGBC's website, www.cagbc.org, alongside the LEED Letter Templates.

RP	
NC	Credit 1
CS	Credit 1

7. DOCUMENTATION GUIDANCE

As a first step in preparing to complete the LEED documentation requirements, work through the following measures. Refer to the LEED letter templates for the complete descriptions of all required documentation.

- Create a Building Durability Plan and update it at milestones throughout the project. This should happen, at a minimum, during the design development phase, the construction documents phase, and just prior to the kick-off meeting with the general contractor.
- Obtain confirmation that Building Durability Plan has been both developed and signed by the building science professional and endorsed, implemented and signed by the building owner.
- Obtain confirmation that the building envelope construction is in general conformance with the design details, co-signed by the building science professional and the general contractor.
- Obtain confirmation of the qualifications of the building science professional as per the requirements.
- Retain copies of the following:
  - Building Envelope Design Review Report,
  - Building envelope field review report by the building science professional, demonstrating review of details at approximately 75% to 100% completion of the building envelope,
  - Building Durability Plan that includes the completed LEED Canada Durable Building Tables or CSA S478-95 (R2007) Tables A1, A2 and A3.

8. EXAMPLES

There are no examples for this credit.

9. EXEMPLARY PERFORMANCE

This credit is not eligible for exemplary performance under the Innovation in Design section. However building envelope commissioning linked to energy is available for an ID Credit 1 point under EA Credit 3.

10. REGIONAL VARIATIONS

There are no regional variations associated with this credit.

11. OPERATIONS AND MAINTENANCE CONSIDERATIONS

There are no specific operations and maintenance considerations for this credit. A maintenance plan would be useful and be a good addition to the tables.

RP	
NC	Credit 1
CS	Credit 1

12. RESOURCES

WEBSITES

The ATHENA Institute: EcoCalculator
http://www.athenasmi.org/index.html

This non-profit organization has developed an "EcoCalculator" to perform Life Cycle Assessment of building materials.

Building for Environmental and Economic Sustainability (BEES)
http://www.bfrl.nist.gov/oae/software/bees.html

BEES 4.0 software provides a powerful technique for selecting cost-effective, environmentally-preferable building products. Version 4.0 will include expanded environmental and economic data.

Building Life-Cycle Cost (BLCC)
http://www.wbdg.org/tools/blcc.php?c=3

BLCC5.3-06 from the National Institute of Building Sciences contains energy and water conservation analysis including life-cycle cost of alternative designs to determine the more economical in the long run.

Cost-Effective Software Tool (CET)
http://www.bfrl.nist.gov/oae/oae.html

The CET software tool helps users make straightforward comparisons of risk mitigation strategies based on established economic evaluation practices.

Deconstruction Institute
http://www.deconstructioninstitute.com/

Provides educational materials, tools and techniques, networking, case studies, articles, facts about the environmental impacts of deconstructing, and many other downloadable and interactive modules.

Institute for Research in Construction
http://irc.nrc-cnrc.gc.ca/codes/

IRC's Canadian Codes Centre plays a vital role in this process by providing technical and administrative support to the Canadian Commission on Building and Fire Codes (CCBFC) and its related committees, which are responsible for the development of the national model construction codes of Canada.

ISO 15686-5 - Buildings and constructed assets -- Service life planning – Part 5: Whole life costing
http://www.iso.org

Life cycle costing enables comparative cost assessments to be made over a specific time, taking into account initial capital costs and future operational costs.

Life Cycle Costing (CaGBC Training Workshops)
http://www.lifecyclecosting.org

Introduction to ASTM and ISO Building Economics Standards using comprehensive financial tables.

RP	
NC	Credit 1
CS	Credit 1

National Building Envelope Council
http://www.nbec.net/

The objective of the National Building Envelope Council is to do anything that is necessary to encourage the pursuit of excellence in the design, construction, and performance of the building envelope.

PRINT MEDIA

Best Practice Guide: Building Technology Wood-Frame Envelopes in the Coastal Climate of British Columbia. Canada Mortgage and Housing Corporation (CMHC). 1998

The Envelope Drying Rates Analysis Study. Canada Mortgage and Housing Corporation (CMHC). Technical Series 01-139.Guide refers to the 4 D's which include Deflection, Drainage, Drying and Durable materials.

High-Rise Residential Construction Guide. Ontario New Home Warranty Program. See National Building Code of Canada 2005, volume 2, section A-5.8.1.1.(1).

Facilities Maintenance & Repair 2009 Book. RS Means – Reid Construction Data. http://rsmeans.reedconstructiondata.com/60309.aspx.

13. DEFINITIONS

There are no definitions associated with this credit.

RP	
NC	Credit 1
CS	Credit 1

14. CASE STUDY

RIDEAU VALLEY CONSERVATION CENTRE
LEED Canada-NC 1.0 Gold, 8 September 2008

Location: Manotick, Ontario
Building Type: Office / Conservation Centre
Owner Type: Government - Local
Building Size: 2,000 m^2
Owner Name: Rideau Valley Conservation Authority
LEED Consultant: Morrison Hershfield Limited
Responsible Firm (for this credit): Morrison Hershfield Limited
Photo Credit: Peter Fritz

The Rideau Valley Conservation Centre is the headquarters building for the Rideau Valley Conservation Authority (RVCA), a local environmental agency established to provide environmental protection and water resource management on a watershed basis to municipalities in the Rideau River watershed.

Given the building's program as a conservation authority headquarters, the client wanted energy efficiency and durability to be incorporated into the design. Both of these mandates factored into the building envelope strategy. As well as designing the envelope to be highly insulative, large expanses of glazing were integrated to facilitate daylighting and passive solar gains.

The building envelope used several different assemblies, including insulated concrete forms, aluminum curtain wall and three types of cladding: red cedar siding, Hardie Board (a fibre-cement panel), and stone veneer. Red cedar is a dimensionally stable and highly weather-resistant species of wood; properly detailed to allow ventilation behind it, red cedar can last 25 years as a siding material. Hardie Board is also very durable, impervious to moisture and completely resistant to bugs, and may well outperform the 20 years it is predicted to last at the RVCC. Because the cedar siding and Hardie Board are predicted to last half the life of the building, connections were designed to allow the straightforward replacement of panels: both are attached with screwed connections. The stone veneer is historically proven to last at least the predicted service life of the building.

The roofing membrane is a white modified-bitumen product called Soprema Soprastar. Because of the slope of the roofs, this product was able to also earn Credit SS Credit 7.2: Heat Island Effect - Roof.

RP	
NC	Credit 2
CS	Credit 2

REGIONAL PRIORITY CREDIT

	NC	CS
Credit	RP Credit 2	RP Credit 2
Points	1-3 points	1-3 points

INTENT

To provide incentive for the achievement of credits that address geographically-specific environmental priorities.

REQUIREMENT: NC & CS

Up to 3 points for Regional Priority Credit 2 may be proposed for *LEED Canada for New Construction and Major Renovations 2009* and *Core and Shell Development 2009*. The Regional Priority credit is intended to allow adding point emphasis to recognize one or more issues that have additional regional environmental importance.

To achieve a Regional Priority credit, the applicant must identify LEED credits which have additional regional environmental importance. A project must achieve the base credit and then propose that credit as a Regional Priority credit.

INTERPRETATIONS

There are no interpretations for this credit.

RP	
NC	Credit 2
CS	Credit 2

1. BENEFITS AND ISSUES TO CONSIDER

Refer to the Benefits and Issues section under the credit being proposed as a Regional Priority credit.

2. RELATED CREDITS

For a list of applicable credits, refer to the CaGBC website at www.cagbc.org, in the section on LEED tools for the *LEED Canada for New Construction 2009* and *LEED Canada for Core & Shell 2009*.

3. SUMMARY OF REFERENCED STANDARDS

Refer to the standards under the credit being proposed as a Regional Priority credit.

4. IMPLEMENTATION

Refer to the Implementation section under the credit being proposed as a Regional Priority credit. Note that Regional Priority points can only be earned when the points gained from core LEED Canada credits are sufficient to attain basic certification.

5. TIMELINE AND TEAM

Identify Regional Priority credits early in the project timeline.

6. CALCULATIONS

Refer to the Calculations section under the credit being proposed as a Regional Priority credit.

7. DOCUMENTATION GUIDANCE

Documentation for this credit is in addition to those required by the credit selected for highlighting regionally. Project teams should prepare a narrative that summarizes why the environmental impacts underlying the proposed credit are a higher priority for the region in which the project is located than for adjacent regions or most others in Canada. Provide supporting documentation to justify this claim (e.g., maps, research and technical data).

8. EXAMPLES

Refer to the Examples section under the credit being proposed as a Regional Priority credit. The guidance provided on the website also provides additional direction on presenting a regional priority.

9. REGIONAL VARIATIONS

Refer to the Regional Variations section under the credit being proposed as a Regional Priority credit.

RP	
NC	Credit 2
CS	Credit 2

10. OPERATIONS AND MAINTENANCE CONSIDERATIONS

Refer to the Operations and Maintenance section under the credit being proposed as a Regional Priority credit.

11. RESOURCES

Refer to the Resources section of the credit being proposed as a Regional Priority credit and the guidance provided on the website for direction on regional priority.

12. DEFINITIONS

Refer to the Definitions section under the credit being proposed as a Regional Priority credit.

LEASED TENANT SPACE APPENDIX 1

DEFAULT OCCUPANCY COUNTS

Because of the speculative nature of core and shell construction or any project with leased tenant space, a project team may not know the final occupant count during the LEED certification process. Determining and demonstrating compliance with some LEED credits can prove challenging and complex. For projects that do not know the final occupant count, a default table has been developed.

Core and Shell projects that do not have final occupancy counts must utilize the default occupancy counts provided in this appendix unless otherwise noted in this reference guide. New Construction projects with leased tenant space must also use these default occupancy counts, unless known. Projects that know the tenant occupancy must use the actual numbers, as long as the gross floor area per employee is not greater than that in the default occupancy count table. If code required gross floor area per occupant is less than those in the table, this is also acceptable. Default occupancy counts are provided for typical project types with leased tenant space. If the buildings and circumstances are not covered in this appendix, provide documentation for comparable buildings demonstrating average gross floor area per occupant when estimating the building occupancy.

TABLE 1. DEFAULT OCCUPANCY NUMBERS

DEFAULT OCCUPANCY NUMBERS	GROSS FLOOR AREA m^2 (ft^2) PER OCCUPANT	
	EMPLOYEES	TRANSIENTS
General office	23 (250)	0
Retail, general	51 (550)	12 (130)
Retail or service (e.g, financial, auto)	56 (600)	12 (130)
Restaurant	40 (435)	9 (95)
Grocery store	51 (550)	11 (115)
Medical Office	21 (225)	31 (330)
R&D or laboratory	37 (400)	0
Warehouse, distribution	232 (2,500)	0
Warehouse, storage	1858 (20,000)	0
Hotel	139 (1,500)	65 (700)
Educational, daycare	59 (630)	10 (105)
Educational, K-12	121 (1,300)	13 (140)
Educational, postsecondary	195 (2,100)	14 (150)

Sources:
ANSI/ASHRAE/IESNA Standard 90.1–2004 (Atlanta, GA, 2004).
2001 Uniform Plumbing Code (Los Angeles, CA)
California Public Utilities Commission, 2004–2005 Database for Energy Efficiency Resources (DEER) Update Study (2008).
California State University, Capital Planning, Design and Construction Section VI, Standards for Campus Development Programs (Long Beach, CA, 2002).
City of Boulder Planning Department, Projecting Future Employment—How Much Space per Person (Boulder, 2002).

Metro, 1999 Employment Density study (Portland, OR 1999).
American Hotel and Lodging Association, Lodging Industry Profile (Washington, DC, 2008).
LEED for Core & Shell Core Committee, personal communication (2003 - 2006).
LEED for Retail Core Committee, personal communication (2007)
OWP/P, Medical Office Building Project Averages (Chicago, 2008).
OWP/P, University Master Plan Projects (Chicago, 2008).
U.S. General Services Administration, Childcare Center Design Guide (Washington, DC, 2003).

The defaults provided above are based on gross floor area (or building floor area) per occupant and not net or leasable square foot per occupant. Gross floor area is defined in the Glossary section of this reference guide. Underground and/or structured parking is excluded from the gross floor area.

DETERMINING FTE OCCUPANTS

If the occupancy count for full-time equivalents (FTEs) is not known, calculate the default occupancy using Equation 1. If the tenant occupancy is known, calculate the FTE for both full- and part-time employees, assuming that an 8-hour occupant has a FTE value of 1.0; part-time occupants have a FTE value based on their hours per day divided by the standard occupancy period (typically 8 hours; other durations may be used if appropriate). Use Equation 2.

Equation 1

$$\text{FTE Occupants} = \frac{\text{Building Gross floor area (m}^2\text{)}}{\text{Gross floor area per FTE}}$$

Equation 2

$$\text{FTE Occupants} = \frac{\text{Occupants Hours}}{8}$$

EXAMPLE

A mixed-used retail and commercial office building of 60,000 m^2 gross floor area has a single-shift occupancy. The transient occupant numbers used below are taken from the default data in Table 1.

STEP 1

Determine the area for each occupancy type in the building, and then the gross square feet per FTE and transient occupants.

TABLE 2. SAMPLE CALCULATIONS FOR AREA PER OCCUPANCY TYPE

OCCUPANCY TYPE	AREA (m^2)		
	TOTAL	PER FTE	PER TRANSIENT OCCUPANT
General office	55,000	23	0
Retail space	4,000	51	12
Restaurant	1,000	40	9
Total Building	60,000		

STEP 2

Calculate the FTE occupancy and transient occupancy for each occupancy type.

FTE Occupants

General Office: $\frac{55,000}{23} = 2,391.3$ or $2,391$

Retail space: $\frac{4,000}{51} = 78.4,$ or 78

Restaurant: $\frac{1,000}{40} = 25$

Transient Occupants

Retail space: $\frac{4,000}{12} = 333.3,$ or 333

Restaurant: $\frac{1,000}{9} = 111.1$ or 111

STEP 3

Add the FTE and transient occupants for each space to determine whole building occupancy.

General Office:	2,391	+	0		
Retail space:	78	+	333		
Restaurant:	25	+	111		
Total:	2,494	+	444	=	2,938

LEASED TENANT SPACE APPENDIX 2

LEASED TENANT SPACE ENERGY MODELLING GUIDELINES

These guidelines are intended to ensure that projects in different markets approach the energy modelling requirements in a similar manner, and to establish a minimum benchmark for energy optimization. The energy modelling is based on the MNECB or ANSI/ASHRAE/IESNA 90.1–2007 Building Performance Rating Method. This can be used for developing a whole building model when some or all tenant space development is unknown.

Leased Tenant Spaces are the areas intended for lease and fit-up by organizations that are at arm's length (i.e., not controlled by the same organization) from the building owner. This includes retail/office areas that are sold or leased to suite/unit owners and are not fit-up as part of the base building contract. In some cases the tenant may choose to have the building owner fit-up the tenant space to the tenant requirements. These spaces would be considered leased tenant space since the building owner is not responsible for the design. Normally residential spaces are fit-up as part of the base building and are considered building owner fit-up tenant space. However in some cases (e.g., high-end custom condos) the residential units are fit-up after purchase by the suite/unit owner. This space would be considered leased tenant space because the building owner does not have control over the fit-up.

The base building is defined as the entire building less any parts of the building that are leased tenant space and not fit-up as part of the certification (either CS or NC). The base building includes owner fit-up space (i.e., area that the building owner or related companies will occupy or fit-up as part of the base building contract) and for NC certification all tenant space included to achieve the 50% fit-up threshold. Any constraints or guidance issued to the tenant, such as a maximum level of lighting density or restrictions on occupancy type, must be outlined in the tenant lease or sales agreement (see Appendix 4).

STEP 1. MODEL THE PROPOSED BUILDING.

Base Building

- Model the heating, ventilation, and air-conditioning (HVAC) system as described in the design documents. If the HVAC system is not yet designed, use the same HVAC system as the baseline model.
- Model the building envelope as shown in the architectural drawings.
- Model the lighting power as shown in the design documents for all base building spaces.

Leased Tenant Spaces

- If the team is pursuing any additional energy-saving opportunities not associated with the base building areas, outline the opportunities or requirements in the tenant lease or sales agreement (see Appendix 4). If unknown, tenant space occupancy numbers must be determined by using the default space occupancies outlined in Appendix 1.
- Leased tenant space lighting and associated controls must either be installed, supplied, shown on fit-up drawings or have a mandatory lease agreement defining maximum

lighting power density to get credit for lighting energy savings. If no lighting is supplied or specified in the mandatory lease agreement, then the proposed tenant lighting is equal to the reference or baseline tenant lighting as per Model National Energy Code for Buildings (MNECB) or ASHRAE 90.1:2007. For leased spaces that are not fully fit-up and only minimal lighting is provided (under the Illuminating Engineering Society of North America (IESNA) recommended lighting levels), the proposed lighting power density must be increased to provide light levels meeting the IESNA recommendations. This will be calculated by increasing the current lighting power by the ratio of the IESNA lighting level to the installed lighting level. For indirect lighting systems designed to be used with task lighting, either include an allowance for task lighting (20 watts per person) or use the additional lighting installed or shown on fit-up drawings.

- Model electric meters for lighting power in tenant spaces. Choose a space type classification for the building spaces in Appendix 1. Use lighting levels shown in MNECB, Table 4.3.3.4 for the space type classification, or Table 4.3.2.1 for overall building type or ANSI/ASHRAE/IESNA 90.1–2007, Table 9.6.1 for the space type classification, or Table 9.5.1 for overall building type. If the tenant lighting is designed and installed as part of the base building work (or any work included in the submission for certification), the project team may model the designed lighting systems.
- Model separate meters for tenant plug loads and process loads. Use the values in Table 1 to model tenant plug loads, or provide documentation for the modelled loads (see the process energy section of EA Credit 1). These default plug loads do not necessarily reflect all process loads.

TABLE 1. DEFAULT TENANT RECEPTACLE LOADS, BY OCCUPANCY TYPE

OCCUPANCY TYPE	RECEPTACLE LOAD (W/m²)	RECEPTACLE LOAD (W/ft²)
General office	16.2	1.5
Retail, general	14.5	1.35
Retail, service	14.5	1.35
Restaurant	8.6	0.8
Grocery store	26.9	2.5
Medical office building	16.2	1.5
R&D or laboratory building	15.1	1.4
Warehouse, distribution	7.0	0.65

Source: Derived from energy modelling exercises undertaken by OWP/P.

STEP 2. MODEL THE BASELINE BUILDING.

Base Building

- Model the baseline building HVAC system per *LEED Canada Energy Modelling Rules*.
- For the building envelope, comply with the prescriptive requirements of MNECB (if following Path 1) or ANSI/ASHRAE/IESNA 90.1–2007 (if following Path 2).
- Model the lighting power by the space type classification of MNECB, Table 4.3.3.4 for the space type classification, or ANSI/ASHRAE/IESNA 90.1– 2007, Table 9.6.1.

Leased Tenant Spaces

- Model separate electric meters for the lighting in the tenant spaces. Use the same lighting power as modelled in the proposed building, unless efficiencies can be supported by a tenant sales or lease agreement.
- Model separate meters for receptacle loads and process loads in the tenant scope. Use the same values for receptacle loads as used in the proposed building.

STEP 3. PERFORM ENERGY SIMULATIONS OF THE PROPOSED BUILDING AND THE BASELINE BUILDING.

STEP 4. COMPARE THE RESULTING ANNUAL ENERGY COSTS.

From the simulation, determine the annual energy costs of the budget building and the design building, then calculate the percentage savings for annual energy costs.

Renewable energy should be included in the energy model or accounted for using the exceptional calculation method.

LEASED TENANT SPACE APPENDIX 3

LEASED TENANT SPACE PROJECT SCOPE

The checklist below helps project teams identify and document the scope of Core and Shell projects, and if necessary, the scope of New Construction projects with leased tenant space. It is available within the LEED Letter Templates. The checklist is a summary description of the building occupancy and its full-time equivalent (FTE) employees and transient occupants.

The checklist also identifies who has control of each building system—that is, the party that has design control and oversight of the construction activities for a given system. The base building developer may have sole control over a system, or the tenant may have independent control over a system; alternatively, the tenant may have control over a system but the developer may enforce system requirements through a sales agreement or tenant lease, thereby influencing its design and/ or construction. Refer to Appendix 4, Tenant Lease and Sales Agreement, for further information on this option.

Portions of systems may be controlled by both the developer and the tenant, or the systems listed may not be a part of the project at all. Complete the checklist to reflect varied conditions; a team may check zero, one, or multiple boxes for each system listed below.

BUILDING USE AND OCCUPANCY

PROJECT NAME						
SIZE (GROSS FLOOR AREA m²)						
OCCUPANCY TYPE	PERCENTAGE OF TOTAL BUILDING	OCCUPANCY TYPE AREA (GROSS FLOOR AREA, m²)	AREA PER FTE (GROSS FLOOR AREA, m²)	FTEs	AREA PER TRANSIENT (GROSS FLOOR AREA, m²)	TRANSIENTS
General office						
Retail, general						
Retail, service						
Restaurant						
Grocery store						
Medical office building						
R&D or laboratory building						
Warehouse, distribution						
Warehouse, storage						
Hotel						
Educational, daycare						
Educational, K–12						
Educational, postsecondary						
Other (specify):						
Total building occupancy						
Total FTEs						
Total transients						

CONTROL OF BUILDING SYSTEMS

This optional table helps Core and Shell projects determine the scope of the project and demonstrate it in certification reviews. Although not part of the LEED Letter Templates, applicants are welcome to create a table similar to below or demonstrate the scope of work in some alternative manner (e.g., detailed narrative description). To use the table below, applicants fill in the table based on the division of work throughout the project. In some cases, multiple or no boxes may be checked. The table may also assist New Construction projects with leased tenant spaces to determine their project scope.

	MAIN LOBBY			MAIN CORRIDOR			SECONDARY LOBBY, CORRIDORS			BUILDOUTS			HVAC			ELECTRICAL			PLUMBING		
Floor finishes																					
Wall finishes																					
Ceiling finishes																					
Air terminal equipment																					
Air inlets and outlets																					
Light fixtures																					
Lighting controls																					
AHUs/RTUs/ Air supply equipment																					
Chillers																					
Cooling tower																					
Boilers																					
Primary ductwork																					
Electrical panels																					
Switchgear																					
Bus duct																					
Water closets																					
Urinals																					
Showers																					
Public lavatory faucets, aerators																					
Public metering lavatory faucets, aerators																					
Kitchen sinks																					
Janitor sinks																					
Metering faucets																					
	Owner/Developer	Tenant	Lease agreement	Owner/Developer	Tenant	Lease agreement	Owner/Developer	Tenant	Lease agreement	Owner/Developer	Tenant	Lease agreement	Owner/Developer	Tenant	Lease agreement	Owner/Developer	Tenant	Lease agreement	Owner/Developer	Tenant	Lease agreement

LEASED TENANT SPACE APPENDIX 4

TENANT LEASE OR SALES AGREEMENT

OVERVIEW

In a *LEED Canada for Core and Shell* building, tenants can choose whether to pursue *LEED Canada for Commercial Interiors* without affecting the building's *LEED Canada for Core and Shell* certification. However, if a developer makes technical requirements from the *LEED Canada for Core and Shell Rating System* part of a binding lease or sales agreement, the project may be able to earn additional points for credits where the technical requirements are not fully addressed in the Core and Shell project design and construction scope. By encouraging green building practices in the tenant's scope of work, Core and Shell projects with a limited scope can achieve credits for activities that would otherwise be beyond their design and construction control.

Similarly, projects certifying under *LEED Canada for New Construction* may also have leased tenant space which must have binding requirements on the fit-up in order for the project to meet a specific prerequisite or credit, as outlined in the Introduction and throughout this reference guide.

Compliance through a binding tenant lease or sales agreement can be pursued as an alternative to or in conjunction with the standard approach to credit documentation. Clearly identify which components of the credit will be implemented as part of the developer's scope of work, and which portions will be part of the tenants' scope of work and enforced through binding tenant lease or sales agreements.

REQUIREMENTS

The technical prerequisite or credit requirements must be incorporated into a legally binding document to be signed by both the developer (or owner) and the tenant. The document must explicitly state performance requirements for the tenant work, such as lighting power density (watts per floor area), plumbing fixture flow rates, or bike racks and showers. Refer to the requirements and the LEED Letter Templates submittal documentation.

Guidelines, such as the tenant design and construction guidelines required for SS Credit 9, and other nonbinding documents do not meet the requirements for this compliance method. Although all projects are encouraged to develop design and construction guidelines that help tenants adopt green practices, only legally binding documents satisfy the requirements of the Tenant Lease or Sales Agreement (e.g., mandatory lease agreement) compliance method.

DOCUMENTATION GUIDANCE

Submit Tenant Lease or Sales Agreements (e.g., mandatory lease agreements) when applying for certification that cover any prerequisite/credit for which the tenant scope is included in the overall application for the prerequisite/credit. For specific documentation requirements, refer to the LEED Letter Templates.

Tenant Lease agreements must provide clear direction to applicants on what is required but need not provide direction to design elements, products, resources, etc. The direction on mandatory requirements could be in the form of an attached schedule to the lease agreement or directly in the lease agreement. If the owner wishes to provide tenant guidelines in addition to the lease agreement, this is covered under SS Credit 9 (Tenant Design and Construction Guidelines) for Core and Shell projects. Note that there must also be a letter of commitment to use these tenant lease agreements from the owner.

Two examples of lease agreement language are also provided below:

WE Prerequisite 1 (Water Use Reduction)

- Unacceptable: "Meet *LEED Canada for Core & Shell 2009* WEp1 requirements."
- Acceptable (at a minimum): "All tenant installed fixtures for water use must use the following flow rates or lower. Tenant specific plumbing fixtures not listed here (e.g., kitchenettes) are excluded from the minimum requirements.
  - Toilets dual flush at 6/3 Litres per flush (LPF)
  - Urinals 1.0 LPF (or use waterless)
  - Showerheads 5.7 Litres per minute
  - Lavatory (restroom) faucets
    - 1.9 LPM at 414 kPa
    - 0.95 Litres per cycle for metering faucet".
- In this case, the lease agreement directs tenants to meet the necessary levels to ensure the project achieves its targeted reduction. The example project has applied using the future tenant fit-up as part of the performance level reduction. If the project had not wished to give this direction to their tenants, the design case fixture water use rates (for the tenanted space) would be assumed equal to the maximum values allowed by the local building code or if not specified, the default baseline values defined in the credit.

MR Credit 3 (Materials Reuse)

- Unacceptable: "Meet *LEED Canada for New Construction 2009* MRc3 requirements."
- Acceptable (at a minimum): "All tenant spaces are required to use salvaged, refurbished or reused materials, the sum of which constitutes at least 10%, based on cost, of the total value of materials on the project. Mechanical, electrical and plumbing components and specialty items such as equipment cannot be included in this calculation. Include only materials permanently installed in the project. Furniture may not be included."
- Note the latter requirement to exclude furniture is based on the approach the remainder of the project used. In this case the example is given to exclude furniture as the areas that were fit-up for certification for the applicable credits did not include furniture.

Further direction on lease agreement requirements is noted in the prerequisites and credits, particularly in the Interpretation sections.

Applicable Credits for Core and Shell Projects

Below is a list of prerequisites and credits that are impacted by tenant space in Core and Shell Projects, and therefore submittal documentation must include data from the entire project building. New Construction projects must refer to the Requirements and Interpretations in this reference guide for directions on the incorporation of tenant space.

The two cases in the table differ on the treatment of tenant space work:

CASE 1:

These credits must be met on the whole building level with the entire building meeting the credit requirements. Usually the requirements for these credits are met by base building elements. However if they cannot be met by the base building (e.g., showers under SS Credit 4.2), then they must be met through tenant sales agreement in order to achieve the credit.

CASE 2:

These credits must include data for the entire building. Base building must comply with credit requirements and anticipated tenant work can either be treated as neutral, or if claiming performance improvements based on anticipated tenant work, must be supported by tenant sales agreements.

PREREQUISITE OR CREDIT	CASE 1	CASE 2
SS Credit 4.2	X	
WE Prerequisite 1		X
WE Credit 2		X
WE Credit 3		X
EA Prerequisite 3	X	
EA Prerequisite 2 / EA Credit 1(Performance Path)		X
EA Prerequisite 2 / EA Credit 1 (Prescriptive Path)	X	
EA Credit 2		X
EA Credit 4	X	
IEQ Prerequisite 1	X	
IEQ Prerequisite 2	X	
IEQ Credit 1	X	
IEQ Credit 2	X	
IEQ Credit 5	X	
IEQ Credit 6	X	

EXEMPLARY PERFORMANCE

Developers for Core and Shell Projects can achieve an Innovation in Design point for exemplary performance by requiring their tenants to meet certain credits. See ID Credit 1 for more details. This is not applicable to New Construction projects

GLOSSARY

LEED **Accredited Professionals (APs)** are individuals who have successfully completed the LEED professional accreditation exam.

Active ventilation is synonymous with mechanical ventilation.

Adapted (or introduced) plants reliably grow well in a given habitat with no winter protection, pest control, fertilization, or irrigation once their root systems are established. Adapted plants are considered low maintenance and not invasive.

Adaptive reuse is the renovation of a space for a purpose different from the original.

An **adhesive** is any substance that is used to bond 1 surface to another by attachment. Adhesives include bonding primers, adhesive primers, and adhesive primers for plastics. (SCAQMD Rule 1168)

Aerosol adhesive is an aerosol product in which the spray mechanism is permanently housed in a nonrefillable can. Designed for hand-held application, these products do not need ancillary hoses or spray equipment. Aerosol adhesives include special-purpose spray adhesives, mist spray adhesives, and web spray adhesives. (SCAQMD Rule 1168)

Agrifibre board is a composite panel product derived from recovered agricultural waste fibre from sources cereal straw, sugarcane bagasse, sunflower husk, walnut shells, coconut husks, and agricultural prunings. The raw fibres are processed and mixed with resins to produce panel products with characteristics similar to those derived from wood fibre. The following conditions describe which products must comply with the requirements:

1. The product is inside the building's waterproofing system.
2. Composite components used in assemblies are to be included (e.g., door cores, panel substrates).
3. The product is part of the base building systems.

Air-conditioning is the process of treating air to meet the requirements of a conditioned space by controlling its temperature, humidity, cleanliness, and distribution. (ASHRAE 62.1–2007)

Air-handling units are mechanically indirect heating, ventilating, or air conditioning systems in which air is treated or handled by equipment located outside the space served, and conveyed to and from the space by means of a fan and duct system. (NEEB 1997 edition)

Albedo is synonymous with **solar reflectance**.

Alternative daily cover is material (other than earthen material) that is placed on the surface of the active face of a municipal solid waste landfill at the end of each operating day to control vectors, fires, odours, blowing litter, and scavenging.

Alternative fuel refuelling station is a refuelling station which serves fully functioning alternative fuel vehicles (as might be used by commuters to travel to and from the project site).

Alternative fuel vehicles are substantially non-petroleum and yield energy security and environmental benefits. These are: Methanol and denatured ethanol as alcohol fuels (alcohol mixtures that contain no less than 70% of the alcohol fuel), Bio-diesel, Natural gas (compressed or liquefied), Liquefied petroleum gas, Hydrogen, Fuels derived from biological materials, and electricity (including solar energy), Efficient gas-electric hybrid vehicles that can drive using only electric power are included in this designation

Anticorrosive paints are coatings formulated and recommended for use in preventing the corrosion of ferrous metal substrates.

Aquatic systems are ecologically designed treatment systems in which a diverse community of biological organisms (e.g., bacteria, plants, fish) treat wastewater.

An **aquifer** is an underground water-bearing rock formation or group of formations that supply groundwater, wells, or springs.

Architectural nonporous sealant primer is a substance used as a sealant primer on nonporous materials.

Architectural porous sealant primer is a substance used as a sealant on porous materials.

An **area-weighted SRI** is a weighted average calculation that may be performed for buildings with multiple roof surfaces to demonstrate that the total roof area has an average solar reflectance index equal to or greater than that of a theoretical roof 75% of whose surfaces have an SRI of 78 and 25% have an SRI of 30.

An **assembly** can be either a product formulated from multiple materials (e.g., concrete) or a product made up of subcomponents (e.g., a workstation).

Assembly recycled content is the percentage of material in a product that is either post-consumer or pre-consumer recycled content. It is determined by dividing the weight of the recycled content by the overall weight of the assembly.

Audiovisual (A/V) media are slides, film, video, sound recordings, and other such devices used to present information.

Automatic fixture sensors are motion detectors that automatically turn on and turn off lavatories, sinks, water closets, and urinals. Sensors can be hard wired or battery operated.

The **base building** is defined as the entire building less any parts of the building that are leased tenant space and not fit-up as part of the certification (either CS or NC). The base building includes owner fit-up space (i.e., area that the building owner or related companies will occupy or fit-up as part of the base building contract) and for NC certification all tenant space included to achieve the 50% fit-up threshold. Any constraints or guidance issued to the tenant, such as a maximum level of lighting density or restrictions on occupancy type, must be outlined in the tenant lease or sales agreement (see Appendix 4).

Baseline building performance is the annual energy cost for a building design intended for use as a baseline for rating above standard design, as defined in ASHRAE 90.1-2007, Appendix G.

Baseline irrigation water use is the amount of water used by conventional irrigation in the region.

Basis of design includes design information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations, and guidelines.

A **bay** is a component of a standard, rectilinear building design. It is the open area defined by a building element such as columns or a window. Typically, there are multiple identical bays in succession.

Bicycle racks, in LEED, include outdoor bicycle racks, bicycle lockers, and indoor bicycle storage rooms.

Biochemical oxygen demand is a measure of how fast biological organisms use up oxygen in a body of water. It is used in water quality management and assessment, ecology, and environmental science.

Biodiversity is the variety of life in all forms, levels, and combinations, including ecosystem diversity, species diversity, and genetic diversity.

Biofuel-based systems are power systems that run on renewable fuels derived from organic materials, such as wood by-products and agricultural waste. Examples of biofuels include untreated wood waste, agricultural crops and residues, animal waste, other organic waste, and landfill gas.

Biomass is plant material from trees, grasses, or crops that can be converted to heat energy to produce electricity.

Biomass power is electrical or thermal energy that is generated through the combustion of biomass (e.g., plant material such as trees, grasses, and crops).

Blackwater definitions vary, but wastewater from toilets and urinals is always considered blackwater. Wastewater from kitchen sinks (perhaps differentiated by the use of a garbage disposal), showers, or bathtubs is considered blackwater under some provincial or local codes.

The **breathing zone** is the region within an occupied space between 3 and 6 feet above the floor. Note that this definition varies from that of ASHRAE 62.1-2007, which states that the breathing zone is between 3 inches and 6 feet from the floor, and 2 feet from the walls as well as fixed air conditioning equipment.

A **Brownfield site** or **contaminated site** is a site where below-grade "substances occur in concentrations that:

1. are above background levels and pose, or are likely to pose, an immediate or long-term hazard to human health or the environment; or
2. exceed the levels specified in policies and regulations."[1]

Building density is the floor area of the building divided by the total area of the site.

The **building envelope**, or shell, is the exterior surface of a building's construction—the walls, windows, roof, and floor.

Building floor area is the sum of the floor areas of the spaces within the building including basements, mezzanine and intermediate-floored tiers, and penthouses with headroom height of 7.5 ft (2.2 metres) or greater. It is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features. (ASHRAE 90.1 – 2007)

Building flush-out is a process that involves running a building's ventilation systems prior to or during building occupancy to facilitate the removal of contaminants and other harmful airborne particles.

Building footprint is the area on a project site used by the building structure, defined by the perimeter of the building plan. Parking lots, landscapes, and other non-building facilities are not included in the building footprint.

A **campus** is a group of buildings that share a common site and are under single ownership or property management and control. The campus area must be contiguous, with exception granted for sites separated by transportation corridors.

A **campus or private bus** is a bus or shuttle service that is privately operated and not available to the general public. In LEED, a campus or private bus line that falls within 1/4 mile of the project site and provides transportation service to the public can contribute to earning credits.

Campus Full Time Equivalency (FTE) occupancy is the number of full-time and part-time occupants in all of the Campus buildings, based on the full-time equivalent calculation. Since in many Campuses occupants will move from building to building throughout the day, the Campus FTE can be less than the sum of the occupancy of all the individual buildings.

A **carpool** is an arrangement by which 2 or more people share a vehicle for transportation.

Chain-of-custody (COC) is a tracking procedure for a product from the point of harvest or extraction to its end use, including all successive stages of processing, transformation, manufacturing, and distribution.

Chain-of-custody certification is awarded to companies that produce, sell, promote, or trade forest products after audits verify proper accounting of material flows and proper use of the Forest Stewardship Council name and logo. The COC certificate number is listed on invoices for non-labelled products to document that an entity has followed FSC guidelines for product accounting.

Chlorofluorocarbons (CFCs) are hydrocarbons that are used as refrigerants and cause depletion of the stratospheric ozone layer.

CO_2 is carbon dioxide.

A **coating** is applied to beautify, protect, or provide a barrier to a surface. (SCAQMD Rule 1113)

Combined heat and power (CHP), or **cogeneration**, generates both electrical power and thermal energy from a single fuel source.

Comfort criteria are the specific original design conditions that at minimum include temperature, humidity, and air speed as well as outdoor temperature design conditions, outdoor humidity design conditions, clothing, and expected activity. (ASHRAE 55–2004)

Commissioning (Cx) is the process of verifying and documenting that a building and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements.

The **commissioning authority (CxA)** is the individual designated to organize, lead, and review the completion of commissioning process activities. The CxA facilitates communication among the owner, designer, and contractor to ensure that complex systems are installed and function in accordance with the owner's project requirements.

The **commissioning plan** is a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

The **commissioning process** is a systematic quality-focused effort to ensure that building systems are designed, specified, procured, installed, and functioning in accordance with the owner's intent. The process uses planning, documentation, and verification of testing to review and oversee the activities of both designer and constructor.

The **commissioning report** documents the commissioning process, including a commissioning program overview, identification of the commissioning team, and description of the commissioning process activities.

Commissioning specification is the contract language used in the construction documents to detail the objective, scope, and implementation of the construction and acceptance phases of the commissioning process as developed in the design phase of the commissioning plan. This allows the construction contractor to ensure that these activities are considered in proposals for the construction work.

The **commissioning team** includes those people responsible for working together to carry out the commissioning process.

Composite wood consists of wood or plant particles or fibres bonded together by a synthetic resin or binder. Examples include plywood, particle-board, oriented-strand board (OSB), medium-density fiberboard (MDF), and composite door cores. The following conditions describe which products must comply with the credit requirements:

1. The product is inside the building's waterproofing system.
2. Composite components used in assemblies are to be included (e.g., door cores, panel substrates).
3. The product is part of the base building systems.

Composting toilet system. See non-water toilet system.

Conditioned space is the part of a building that is heated or cooled, or both, for the comfort of occupants. (ASHRAE 62.1–2007)

Construction and demolition debris includes waste and recyclables generated from construction and from the renovation, demolition, or deconstruction of pre-existing structures. It does not include land-clearing debris, such as soil, vegetation, and rocks.

A **construction IAQ management plan** outlines measures to minimize contamination in a specific project building during construction and/or describes procedures to flush the building of contaminants prior to occupancy.

Construction waste calculation is used to determine the percentage of waste diverted from landfill and incineration facilities.

Construction waste management plan is a document specific to a building project that outlines measures and procedures that divert construction waste materials from landfill and incineration facilities.

Contaminants are unwanted airborne elements that may reduce air quality. (ASHRAE 62.1–2007)

Controls are operating mechanisms that enable a person to turn on or off devices (e.g., lights, heaters) or adjust systems within a range (e.g., lighting, temperature).

Conventional irrigation refers to the most common irrigation system used in the region where the building is located. A conventional irrigation system commonly uses pressure to deliver water and distributes it through sprinkler heads above the ground.

The building's **Core and Shell floor area** is the area of all common spaces and common systems.

Core learning spaces are spaces for educational activities where the primary functions are teaching and learning (ANSI S12.60–2002).

Covered bicycle storage is secure bicycle racks, which are protected from the elements. Examples include enclosed lockers, storage provided within the building, or racks provided under shelter.

Curfew hours are locally determined times when lighting restrictions are imposed. When no local or regional restrictions are in place, 10:00 p.m. is regarded as a default curfew time.

Daylight illuminance levels are the lighting levels achieve through the use of daylight alone.

Daylight-responsive lighting controls are photosensors used in conjunction with other switching and dimming devices to control the amount of artificial lighting in relationship to the amount and quality of natural daylight.

Daylighting is the controlled admission of natural light into a space, used to reduce or eliminate electric lighting.

Daylighting zone is the total floor area that meets the performance requirements for daylighting.

Demand control ventilation is the automatic reduction of outside air to a level below design rates when occupancy is less than design determined by occupancy indicators; such as, time-of-day schedules, a direct count of occupants, or an estimate of occupancy or ventilation rate per person using occupancy sensors.

Densely occupied space is an area with a design occupant density of 25 people or more per 93 square metres (1,000 square feet) or 3.7 square metres or less per person (40 square feet or less per person).

Density factor (k_d) is a coefficient used in calculating the landscape coefficient. It modifies the evapotranspiration rate to reflect the water use of a plant or group of plants, particularly with reference to the density of the plant material.

Design light output is the light output of lamps at 40% of their useful life.

A **detention basin** is a small storage lagoon for slowing stormwater runoff. Water is only retained in it for a short period of time after a heavy rainfall.[2]

A **detention facility** is "a surface water runoff storage facility that is normally dry but is designed to hold (detain) surface water temporarily during and immediately after a runoff event. Examples of detentional facilities are: natural swales provided with crosswise earthen berms to serve as control structures, constructed or natural surface depressions, subsurface tanks or reservoirs, rooftop storage, and infiltration or filtration basins."[3]

The **development footprint** is the area affected by development or by project site activity. Hardscape, access roads, parking lots, nonbuilding facilities, and the building itself are all included in the development footprint.

Direct line of sight to perimeter vision glazing is the approach used to determine the calculated area of regularly occupied areas with direct line of sight to perimeter vision glazing. The area determination includes full height partitions and other fixed construction prior to installation of furniture.

A **district energy system (DES)** is a central plant and distribution system that provides energy (heat, cooling and/or electricity) to a group of buildings in a small district. Examples include central plants on university campuses or those that serve the downtown cores of cities. Large-scale utilities that supply energy to large regions, provinces or municipalities, are not considered DESs. Refer to the *LEED Canada Interpretation Guide for District Energy Systems* for further information.

Downstream equipment consists of all heating or cooling systems, equipment, and controls located within the project building and site associated with transporting thermal energy into heated or cooled spaces. This includes the thermal connection or interface with the district energy system, secondary distribution systems in the building, and terminal units.

Drip irrigation delivers water at low pressure through buried mains and submains. From the submains, water is distributed to the soil from a network of perforated tubes or emitters. Drip irrigation is a high-efficiency type of microirrigation.

Ecologically sensitive land is land that includes rare or fragile ecosystems, places of significant and recognized biodiversity of habitat for rare or endangered species.

An **economizer** is a device used to make building systems more energy efficient. Examples include HVAC enthalpy controls, which are based on humidity and temperature.

An **ecosystem** is a basic unit of nature that includes a community of organisms and their nonliving environment linked by biological, chemical, and physical processes.

Embodied energy is the energy used during the entire life cycle of a product, including its manufacture, transportation, and disposal, as well as the inherent energy captured within the product itself.

Emissivity is the ratio of the radiation emitted by a surface to the radiation emitted by a black body at the same temperature.

An **endangered species** is threatened with extinction because of harmful human activities or environmental factors.

Energy conservation measures are installations or modifications of equipment or systems intended to reduce energy use and costs.

An **energy simulation model**, or **energy model**, is a computer-generated representation of the anticipated energy consumption of a building. It permits a comparison of energy performance, given proposed energy efficiency measures, with the baseline.

An **ENERGY STAR** rating is a measure of a building's energy performance compared with that of similar buildings, as determined by the ENERGY STAR Portfolio Manager. A score of 50 represents average building performance.

Enhanced commissioning is a set of best practices that go beyond fundamental commissioning to ensure that building systems perform as intended by the owner. These practices include designating a commissioning authority prior to the construction documents phase, conducting commissioning design reviews, reviewing contractor submittals, developing a systems manual, verifying operator training, and performing a post-occupancy operations review.

Entryway systems can be open floor grates or grilles with a recessed area designed to capture dirt and other debris from people entering the building.

Environmental tobacco smoke (ETS), or secondhand smoke, consists of airborne particles emitted from the burning end of cigarettes, pipes, and cigars, and is exhaled by smokers. These particles contain about 4,000 different compounds, up to 50 of which are known to cause cancer.

Erosion is a combination of processes or events by which materials of the earth's surface are loosened, dissolved, or worn away and transported by natural agents (e.g., water, wind, or gravity).

Eutrophication is the slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. During the later stages of eutrophication the water body is choked by abundant plant life due to higher levels of nutritive compounds such as nitrogen and phosphorus. Human activities can accelerate the process.[4]

Evapotranspiration (ET) rate is the amount of water lost from a vegetated surface in units of water depth. It is expressed in millimetres per unit of time.

Exfiltration is air leakage through cracks and interstices and through the ceilings, floors, and walls.

Exhaust air is removed from a space and discharged outside the building by means of mechanical or natural ventilation systems.

Existing area is the total area of the building structure, core, and envelope that existed when the project area was selected. Exterior windows and doors are not included.

Extraction is the removal of natural materials from the Earth for the purposes of human use. Examples include mining and forestry practices.

Farm building is a building or part thereof which does not contain a residential occupancy and which is associated with, and located on, land devoted to the practice of farming and used essentially for the housing of equipment or livestock, or the production, storage or processing of agricultural and horticultural produce or feeds.

Fly ash is the solid residue derived from incineration processes. Fly ash can be used as a substitute for Portland cement in concrete.

A **footcandle (fc)** is a measure of light falling on a given surface. One footcandle is defined as the quantity of light falling on a 1-square-foot area from a 1 candela light source at a distance of 1 foot (which equals 1 lumen per square foot). Footcandles can be measured both horizontally and vertically by a footcandle meter or light meter.

Formaldehyde is a naturally occurring VOC found in small amounts in animals and plants, but is carcinogenic and an irritant to most people when present in high concentrations, causing headaches, dizziness, mental impairment, and other symptoms. When present in the air at levels above 0.1 ppm parts of air, it can cause watery eyes, burning sensations in the eyes, nose and throat; nausea, coughing, chest tightness, wheezing, skin rashes, and asthmatic and allergic reactions.

Frequent service is access to public transit with intervals of no more than 30 minutes during peak times for each line in each direction and available during hours of building operation.

OR

is at least 50 transit rides per day total, at all stops (half-hourly service 24 hours per day or more frequent service for less than 24 hours per day) and available during hours of building operation. For example, 1 bus line with 30 transit rides per day in one direction and a second line with 20 transit rides per day would meet the definition of frequent service. You may only count transit rides for one direction of a transit line.

Fuel-efficient vehicles are vehicles having a Combined Fuel Consumption Rating (CFCR) of 6.5L/100km or less, as defined by Natural Resources Canada's Office of Energy Efficiency.

A **full-cutoff luminaire** has zero candela intensity at an angle of 90 degrees above the vertical axis (nadir or straight down) and at all angles greater than 90 degrees from straight down. Additionally, the candela per 1,000 lamp lumens does not numerically exceed 100 (10%) at an angle of 80 degrees above nadir. This applies to all lateral angles around the luminaire.

Full time equivalent (FTE) occupants are building users, such as staff, that occupy the building for extended periods of time. The total FTE occupancy of a building for LEED calculations is taken for the 8 hour (consecutive) period during which the highest occupancy occurs. Part-time users are prorated to an equivalent 8 hour period

Fundamental commissioning is a set of essential best practices used to ensure that building performance requirements have been identified early in the project's development and to verify that the designed systems have been installed in compliance with those requirements. These practices include designating a commissioning authority, documenting the owner's project requirements and basis of design, incorporating commissioning requirements into the construction documents, establishing a commissioning plan, verifying installation and performance of specified building systems, and completing a summary commissioning report.

Geothermal energy is electricity generated by converting hot water or steam from within the earth into electrical power.

Geothermal heating systems use pipes to transfer heat from underground steam or hot water for heating, cooling, and hot water. The system retrieves heat during cool months and returns heat in summer months.

Geothermal power is heat or electricity generated from steam or high temperature hot water released from the Earth. Ground-source heat pumps, which typically operate at moderate temperatures, are considered an energy efficiency technology similar to efficient air-source heat pumps, and are recognized under EA Credit 1, rather than a renewable energy source recognized by EA Credit 2.

Glare is any excessively bright source of light within the visual field that creates discomfort or loss in visibility.

Graded site is any land or property that has been modified for human use as farmland or open space.

Green cleaning is the use of cleaning products and practices that have lower environmental impacts and more positive indoor air quality impacts than conventional products and practices.

Green power is synonymous with renewable energy.

Green power contract certifies that a unit of electricity was generated from a renewable source. This contract may be separate from the sale of the electricity itself, allowing the purchase of green power by any electricity customer.

Green-e is a program established by the Center for Resource Solutions to both promote green electricity products and provide consumers with a rigorous and nationally recognized method to identify those products.

Greenfield / Previously undeveloped land is property that has not been modified for human use through construction or manipulation of the land, or has returned to a natural state after an extended period during which no human influence was present.

Greenhouse gases (GHGs) absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by Earth's surface, clouds, and the atmosphere itself. Increased concentrations of greenhouse gases are a root cause of global climate change.

Greywater is defined by the American Uniform Plumbing Code (UPC) in its Appendix G, Gray Water Systems for Single-Family Dwellings, as "untreated household waste water which has not come into contact with toilet waste. Greywater includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washer and laundry tubs. It must not include waste water from kitchen sinks or dishwashers." The International Plumbing Code (IPC) defines greywater in its Appendix C, Gray Water Recycling Systems, as "waste water discharged from lavatories, bathtubs, showers, clothes washers and laundry sinks." Some provincial and local authorities allow kitchen sink wastewater to be included in greywater. Other differences with the UPC and IPC definitions can likely be found in provincial and local codes. Project teams should comply with greywater definitions as established by the authority having jurisdiction in the project areas.

Group multi-occupant spaces include conference rooms, classrooms, and other indoor spaces used as places of congregation.

Halons are substances, used in fire-suppression systems and fire extinguishers, that deplete the stratospheric ozone layer.

Hard surface flooring includes vinyl, linoleum, laminate flooring, wood flooring, rubber flooring, wall base, and associated sundries.

Hardscape consists of the inanimate elements of the building landscaping. Examples include pavement, roadways, stone walls, concrete paths and sidewalks, and concrete, brick, and tile patios.

Harvested is a material that is all or part of a plant or that has been collected and removed from the location of its growth.

Heat island effect refers to the absorption of heat by hardscapes, such as dark, nonreflective pavement and buildings, and its radiation to surrounding areas. Particularly in urban areas, other sources may include vehicle exhaust, air-conditioners, and street equipment; reduced airflow from tall buildings and narrow streets exacerbates the effect.

Heat islands are defined as thermal gradient differences between developed and undeveloped areas.

Horizontal footcandles occur on a horizontal surface. They can be added together arithmetically when more than 1 source provides light to the same surface.

The **hospitality industry** consists of companies within the food services, accommodations, recreation, and entertainment sectors.

HVAC systems are equipment, distribution systems, and terminals that provide the processes of heating, ventilating, or air-conditioning. (ASHRAE 90.1-2007)

Hybrid vehicles use a gasoline engine to drive an electric generator and use the electric generator and/or storage batteries to power electric motors that drive the vehicle's wheels.

Hydrochlorofluorocarbons (HCFCs) are refrigerants that cause significantly less depletion of the stratospheric ozone layer than chlorofluorocarbons.

Hydrofluorocarbons (HFCs) are refrigerants that do not deplete the stratospheric ozone layer but may have high global warming potential. HFCs are not considered environmentally benign.

Hydrology is the study of water occurrence, distribution, movement, and balances in an ecosystem.

Hydropower is electricity produced from the downhill flow of water from rivers or lakes.

Impervious surfaces have a perviousness of less than 50% and promote runoff of water instead of infiltration into the subsurface. Examples include parking lots, roads, sidewalks, and plazas.

In situ remediation involves treating contaminants in place using injection wells, reactive trenches, or other technologies that take advantage of the natural hydraulic gradient of groundwater; they usually minimize disturbance of the site.

Incineration Facilities are waste management operations that use combustion as a means of reducing the volume of waste materials and/or producing heat or energy.

In **individual occupant spaces**, workers use standard workstations to conduct individual tasks. Examples are private offices and open office areas with multiple workers.

Indoor adhesive, sealant, or sealant primer product is defined as an adhesive or sealant product applied on-site, inside the building's weatherproofing system.

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Indoor carpet systems are carpet, carpet adhesive, or carpet cushion products installed inside the building's weatherproofing system.

Indoor composite wood or agrifibre is a product installed inside the building's weatherproofing system.

Indoor paints or **coating products** are applied inside a building's weatherproofing system.

Infiltration is air leakage into conditioned spaces through cracks and interstices in ceilings, floors, and walls. (ASHRAE 62.1–2007).

Infrared (or thermal) emittance is a parameter between 0 and 1 (or 0% and 100%) that indicates the ability of a material to shed infrared radiation (heat). The wavelength range for this radiant energy is roughly 5 to 40 micrometers. Most building materials (including glass) are opaque in this part of the spectrum and have an emittance of roughly 0.9. Materials such as clean, bare metals are the most important exceptions to the 0.9 rule. Thus clean, untarnished galvanized steel has low emittance, and aluminum roof coatings have intermediate emittance levels.

An **installation inspection** examines components of the building systems to determine whether they are installed properly and ready for systems performance testing.

Integrated pest management (IPM) is the coordinated use of knowledge about pests, the environment, and pest prevention and control methods to minimize pest infestation and damage by the most economical means while minimizing hazards to people, property, and the environment.

Interior lighting power allowance is the maximum lighting power (in watts) allowed for the interior of a building.

Interior non-structural components reuse is determined by dividing the area of retained components by the area of the completed design.

Interior of the building is all space and materials located within the building's weatherproofing system.

Invasive plants are non-native to the ecosystem and likely to cause harm once introduced. These species are characteristically adaptable and aggressive, have a high reproductive capacity, and tend to overrun the ecosystems they enter. Collectively, they are among the greatest threats to biodiversity and ecosystem stability.

Laminate adhesive is used in wood or agrifibre products (veneered panels, composite wood products contained in engineered lumber, door assemblies, etc.).

Landfills are waste disposal sites for solid waste from human activities.

Landscape area of the site is the total site area less the building footprint, paved surfaces, water bodies, and patios.

The **landscape coefficient (K_L)** is a constant used to calculate the evapotranspiration rate. It takes into account the species factor, density factor, and microclimate factor of the area.

The **leakage rate** is the speed at which an appliance loses refrigerant, measured between refrigerant charges or over 12 months, whichever is shorter. The leakage rate is expressed in terms of the percentage of the appliance's full charge that would be lost over a 12-month period if the rate stabilized. (EPA Clean Air Act, Title VI, Rule 608)

Leased Tenant Spaces are the areas intended for lease and fit-up by organizations that are at arm's length (i.e., not controlled by the same organization) from the building owner. This includes retail/office areas that are sold or leased to suite/unit owners and are not fit-up as part of the base building contract. In some cases the tenant may choose to have the building owner fit-up the tenant space to the tenant requirements. These spaces would be considered leased tenant space since the building owner is not responsible for the design. Normally residential spaces are fit-up as part of the base building and are considered building owner fit-up tenant space. However in some cases (e.g., high-end custom condos) the residential units are fit-up after purchase by the suite/unit owner. This space would be considered leased tenant space because the building owner does not have control over the fit-up.

Life cycle assessment is an analysis of the environmental aspects and potential impacts associated with a product, process, or service.

Life cycle cost analysis calculates expected future operating, maintenance, and replacement costs of designs and features used to assist owners in developing a realistic design and budget estimate.

Light pollution is waste light from building sites that produces glare, is directed upward to the sky, or is directed off the site. Waste light does not increase nighttime safety, utility, or security and needlessly consumes energy.

Light trespass is obtrusive light that is unwanted because of quantitative, directional, or spectral attributes. Light trespass can cause annoyance, discomfort, distraction, or loss of visibility.

Lighting power density is the installed lighting power, per unit area.

Local zoning requirements are local government regulations imposed to promote orderly development of private lands and prevent land-use conflicts.

Lodging are facilities that provide overnight accommodations to customers or guests, including hotels, motels, inns and resorts.

Low-emitting and **fuel-efficient vehicles**, for the purpose of this credit, are defined as vehicles having a Combined Fuel Consumption Rating (CFCR) of 6.5L/100km or less, as defined by Natural Resources Canada's Office of Energy Efficiency.

Low-impact hydro power is electricity produced from the downhill flow of water and operates such that reduced water flows are not detrimental to indigenous inhabiting species, in-stream flows downstream are adequate to support indigenous inhabiting species, and water quality is comparable to unaltered bodies within the local watershed, as well as ensuring water temperature changes are not detrimental to indigenous inhabiting species. Also provide measures to minimize fish mortality that would result from impingement and entrainment and ensure fish passage exists where man-made structures are replaced where no natural barriers exist.

A **lumen** is a unit of luminous flux equal to the light emitted in a unit solid angle by a uniform point source of 1 candle intensity.

Luminaire is a lighting fixture assembly, including lamp, housing, reflector, and ballast (if applicable).

Manufacturing Process covers the activities associated with the production of materials, goods or products.

Manufacturing refers to the final assembly of components into the building product that is furnished and installed by the trade workers.

Manufacturing site is the location of the final manufacturing process; a finished product ships from this location.

Market value, presumed to be less than replacement value, is the amount that either was paid or would have been paid for a used product.

Mass transit is designed to transport large groups of persons in a single vehicle, such as a bus or train.

Material safety data sheets (MSDS) are detailed, written instructions documenting a method to achieve uniformity of performance.

Measurement and Verification (M&V) Plan is a document specific to a building project that outlines measures and procedures to record and analyze building performance through metering.

Mechanical ventilation is ventilation provided by mechanically powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows. (ASHRAE 62.1–2007)

Metering controls limit the flow time of water. They are generally manual-on and automatic-off devices, most commonly installed on lavatory faucets and showers.

Microclimate factor (k_{mc}) is a constant used in calculating the landscape coefficient. It adjusts the evapotranspiration rate to reflect the climate of the immediate area.

Microirrigation involves irrigation systems with small sprinklers and microjets or drippers designed to apply small volumes of water. The sprinklers and microjets are installed within a few centimetres of the ground; drippers are laid on or below grade.

Minimum efficiency reporting value (MERV) is a filter rating established by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE 52.2–1999, Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size). MERV categories range from 1 (very low efficiency) to 16 (very high).

Mixed-mode ventilation combines mechanical and natural ventilation methods.

A **mixed-use project** has at least 10% of the floor area for tenants whose space function is different from the majority of the building (e.g., MURB plus either retail or office or combo of both).

Model National Energy Code for Buildings (MNECB) 1997 contains cost-effective minimum requirements for energy efficiency in new buildings. The MNECB applies to all buildings, other than houses of three storeys or less, and to additions of more than 10 m2 to such buildings The MNECB is prepared under the auspices of the Canadian Commission on Building and Fire Codes (CCBFC) and was first published in 1997 by the National Research Council Canada (NRC).

The **National Pollutant Discharge Elimination System (NPDES)** is a permit program that controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

Native (or indigenous) plants are adapted to a given area during a defined time period and are not invasive. In North America, the term often refers to plants growing in a region prior to the time of settlement by people of European descent.

Natural ventilation is provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building. (ASHRAE 62.1–2007)

Neighbourhood is synonymous with residential area.

Net metering is a metering and billing arrangement that allows on-site generators to send excess electricity flows to the regional power grid; these flows offset a portion of the energy drawn from the grid.

Non-occupied spaces include all rooms used by maintenance personnel that are not open for use by occupants. Examples are closets and janitorial, storage, and equipment rooms.

Nonporous sealant is a substance used as a sealant on nonporous materials. Nonporous materials, such as plastic and metal, do not have openings in which fluids may be absorbed or discharged.

Non-potable water is water that is not potable, typically rain or greywater.

Non-water (or composting) toilet systems are dry plumbing fixtures and fittings that contain and treat human waste via microbiological processes.

A **non-water (or dry or waterless) urinal**, replaces a water flush with a trap containing a layer of buoyant liquid that floats above the urine, blocking sewer gas and odours.

Occupants in a commercial building are workers who either have a permanent office or workstation in the building or typically spend a minimum of 10 hours per week in the building. In a residential building, occupants also include all persons who live in the building. In schools, occupants also include students, faculty, support staff, administration, and maintenance employees.

Off-gassing is the emission of volatile organic compounds (VOCs) from synthetic and natural products.

Off-site salvaged materials are recovered from a source different from the project site.

On-site renewable energy is energy derived from renewable sources located within the project site perimeter.

On-site salvaged materials are recovered from and reused at the same building site.

On-site wastewater treatment is the transport, storage, treatment, and disposal of wastewater generated on the project site.

Open-grid pavement is less than 50% impervious and accommodates vegetation in the open cells.

Open space area is usually defined by local zoning requirements, but for the purposes of LEED calculations, it is defined as the property area minus the development footprint; it must be vegetated and pervious, with exceptions only as noted in the credit requirements section. Only ground areas are calculated as open space. For projects located in urban areas that earn 5 points under SS Credit 2, Development Density and Community Connectivity, open space also includes non-vehicular, pedestrian-oriented hardscape spaces.

Outdoor air is the ambient air that enters a building through a ventilation system, either through intentional openings for natural ventilation or by infiltration. (ASHRAE 62.1–2007)

The **owner** is the person directly employed by the organization holding title to the project building and recognized by law as having rights, responsibilities, and ultimate control over the building.

Owner's project requirements is a written document that details the ideas, concepts, and criteria that are determined by the owner to be important to the success of the project.

Ozone (O_3) is a gas composed of 3 oxygen atoms. It is not usually emitted directly into the air, but at ground-level is created by a chemical reaction between oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. Ozone has the same chemical structure whether it occurs miles above the earth or at ground-level and can have positive or negative effects, depending on its location in the atmosphere. (U.S. Environmental Protection Agency)

Paint is a liquid, liquefiable, or mastic composition that is converted to a solid protective, decorative, or functional adherent film after application as a thin layer. These coatings are intended for application to interior or exterior surfaces of residential, commercial, institutional, or industrial buildings.

Parking footprint refers to the area of the project site occupied by the parking areas and structures.

Passive ventilation uses the building layout, fabric, and form to provide natural ventilation to a conditioned space using nonmechanical forms of heat transfer and air movement.

Peak discharge rate is the maximum volume flow rate exiting a site during a storm event. Peak discharge has units of volume/time (e.g. m^3/sec).

Pedestrian access allows people to walk to services without being blocked by walls, freeways, or other barriers.

Percentage improvement measures the energy cost savings for the proposed building performance compared with the baseline building performance.

Perviousness is the percentage of the surface area of a paving system that is open and allows moisture to soak into the ground below.

Pheno-formaldehyde, which off-gasses only at high temperature, is used for exterior products, although many of those products are suitable for interior applications.

Photovoltaic (PV) energy is electricity from photovoltaic cells that convert the energy in sunlight into electricity.

Plug load is synonymous with **receptacle load**.

Porous materials have tiny openings, often microscopic, which can absorb or discharge fluids. Examples include wood, fabric, paper, corrugated paperboard, and plastic foam. (SCAQMD Rule 1168)

Porous pavement and **permeable surfaces** allow runoff to infiltrate into the ground.

Portable Furniture is all furniture not affixed to the building.

Post-consumer recycled content is the percentage of material in a product that was consumer waste. The recycled material was generated by household, commercial, industrial, or institutional end-users and can no longer be used for its intended purpose. It includes returns of materials from the distribution chain (ISO 14021). Examples include construction and demolition debris, materials collected through recycling programs, discarded products (e.g., furniture, cabinetry, decking), and landscaping waste (e.g., leaves, grass clippings, tree trimmings).

Potable water meets or exceeds federal and provincial drinking water quality standards and is approved for human consumption by the provincial or local authorities having jurisdiction; it may be supplied from wells or municipal water systems.

ppm is parts per million.

Pre-consumer recycled content, formerly known as post-industrial content, is the percentage of material in a product that is recycled from manufacturing waste. Examples include planer shavings, sawdust, bagasse, walnut shells, culls, trimmed materials, overissue publications, and obsolete inventories. Excluded are rework, regrind, or scrap materials capable of being reclaimed within the same process that generated them. (ISO 14021)

Predevelopment refers to before the LEED project was initiated, but not necessarily before any development or disturbance took place. Predevelopment conditions describe conditions on the date the developer acquired rights to a majority of the buildable land on the project site through purchase or option to purchase.

Predicted mean vote is an empirical equation for predicting the mean vote on a rating scale of thermal comfort of a large population of people exposed to a certain environment.

Preferred Parking are the parking spaces that are closest to a main entrance of the project (exclusive of spaces designated for handicapped persons), the most desirable or parking passes provided at a discounted price.

Preventive maintenance is routinely scheduled equipment inspection, cleaning, and repair conducted to detect and prevent equipment failure and keep materials and systems in working order.

Previously developed is any land or property that contains (or recently contained) infrastructure or buildings.

Previously undeveloped land / Greenfield is property that has not been modified for human use through construction or manipulation of the land, or has returned to a natural state after an extended period during which no human influence was present.

Prime farmland is land that is being used for viable agriculture. This land would include Class 1, 2 and 3 as defined by the Canada Land Inventory for rural Canada and any other land which prior to acquisition for development was actively farmed. Previously developed land is not considered prime farmland.

A **primer** is a material applied to a substrate to improve adhesion of subsequently applied coats.

Prior condition is the state of the project space at the time it was selected.

Prior condition area is the total area of finished ceilings, floors, and full-height walls that existed when the project area was selected. It does not include exterior windows and doors.

Private or private use applies to plumbing fixtures in residences, apartments, and dormitories, to private (non-public) bathrooms in transient lodging facilities (hotels and motels), and to private bathrooms in hospitals and nursing facilities.

Process water is used for industrial processes and building systems such as cooling towers, boilers, and chillers. The term can also refer to water used in operational processes, such as dishwashing, clothes washing, and ice making.

Property area is the total area within the legal property boundaries of a site; it encompasses all areas of the site, including constructed and nonconstructed areas.

Proposed building performance is the annual energy cost calculated for a proposed design, as defined in MNECB and ASHRAE 90.1-2007, Appendix G.

Public or public use applies to all buildings, structures, or uses that are not defined as private or private use.

Public transportation consists of bus, rail, or other transit services for the general public that operate on a regular, continual basis.

A **rain garden** is a strategically located depressed garden designed to receive stormwater runoff.

Rapidly renewable materials are agricultural products, both fibre and animal, that take 10 years or less to grow or raise and can be harvested in a sustainable fashion.

Raw Materials are materials in its unprocessed, natural state considered usable for manufacture.

Receptacle (or plug) load is the current drawn by all equipment that is plugged into the electrical system.

Recirculated air is removed from a space and reused as supply air, delivered by mechanical or natural ventilation.

Recycled content is the proportion, by mass, of pre-consumer or post-consumer recycled material in a product (ISO 14021).

Recycling is the collection, reprocessing, marketing, and use of materials that were diverted or recovered from the solid waste stream.

A **recycling collection area** is located in regularly occupied space in the building for the collection of occupants' recyclables. A building may have numerous collection areas from which recyclable materials are typically removed to a central collection and storage area.

Refrigerants are the working fluids of refrigeration cycles that absorb heat from a reservoir at low temperatures and reject heat at higher temperatures.

Refurbished materials are products that could have been disposed of as solid waste. These products have completed their life cycle as consumer items and are then refurbished for reuse without substantial alteration of their form. Refurbishing includes renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product.

Regionally extracted materials are raw materials taken from within an 800 km (500 miles) (2,400 km if shipped by rail or water) radius of the manufacturing location.

Regionally manufactured materials are assembled as finished products within an 800 km (500 mile) (2,400 km if shipped by rail or water) radius of the project site. Assembly does not include on-site assembly, erection, or installation of finished components.

Regularly occupied spaces in commercial buildings are areas where people sit or stand as they work. In residential applications these spaces include all living and family rooms and exclude bathrooms, closets, or other storage or utility areas. In schools, they are areas where students, teachers, or administrators are seated or standing as they work or study.

Relative humidity is the ratio of partial density of airborne water vapour to the saturation density of water vapour at the same temperature and total pressure.

Remanufactured materials are items that are made into other products. One example is concrete that is crushed and used as subbase.

Remediation is the process of cleaning up a contaminated site by physical, chemical, or biological means. Remediation processes are typically applied to contaminated soil and groundwater.

Renewable energy comes from sources that are not depleted by use (renewable sources). Examples include energy from the sun, wind, and small (low-impact) hydropower, plus geothermal energy and wave and tidal systems. Ways to capture energy from the sun include photovoltaic, solar thermal, and bioenergy systems based on wood waste, agricultural crops or residue, animal and other organic waste, or landfill gas.

Renewable energy certificates (RECs) are tradable commodities representing proof that a unit of electricity was generated from a renewable energy resource. RECs are sold separately from electricity itself and thus allow the purchase of green power by a user of conventionally generated electricity.

Renewable sources are energy sources as defined and/or excluded in EA Credit 2 Section 4 Implementation.

A **residential area** is land zoned primarily for housing at a density of 25 units per hectare (10 units per acre) or greater. These areas may have single-family and multifamily housing and include building types such as townhomes, apartments, duplexes, condominiums, or mobile homes.

Retained components are portions of the finished ceilings, finished floors, full-height walls and demountable partitions, interior doors, and built-in case goods that existed in the prior condition area and remain in the completed design.

Retention is "that part of the precipitation falling on a drainage area that does not escape as a surface streamflow, during a given period."[5]

A **retention basin** is "a permanent lake or pond used to slow stormwater runoff."[6]

A **retention facility** is "a stormwater storage facility that normally holds water at a controlled level to serve functions such as recreation, aesthetic, and water supply. Stormwater runoff is temporarily stored above the controlled stage. Examples of types of retention storage reservoirs are permanent ponds in residential and commercial areas and in open spaces."[7]

A **retrofit** is any change to an existing facility, such as the addition or removal of equipment or an adjustment, connection, or disconnection of equipment.

Return air is removed from a space and then recirculated or exhausted. (ASHRAE 62.1–2007)

Reuse returns materials to active use in the same or a related capacity as their original use, thus extending the lifetime of materials that would otherwise be discarded.

Reused area is the total area of the building structure, core, and envelope that existed in the prior condition and remains in the completed design.

Safety and comfort light levels meet local code requirements and must be adequate to provide a safe path for egress without overlighting the area.

Salvaged materials or **reused materials** are construction materials recovered from existing buildings or construction sites and reused. Common salvaged materials include structural beams and posts, flooring, doors, cabinetry, brick, and decorative items.

A **sealant** has adhesive properties and is formulated primarily to fill, seal, or waterproof gaps or joints between 2 surfaces. Sealants include sealant primers and caulks. (SCAQMD Rule 1168)

A **sealant primer** is applied to a substrate, prior to the application of a sealant, to enhance the bonding surface. (SCAQMD Rule 1168)

Sealers are coatings applied to either block materials from penetrating into or leaching out of a substrate, to prevent subsequent coatings from being absorbed by the substrate, or to prevent harm to subsequent coatings by materials in the substrate.

Secure bicycle storage is an internal or external space that keeps bicycles safe from theft. It may include lockers and storage rooms.

Sedimentation is the addition of soil particles to water bodies by natural and human-related activities. Sedimentation often decreases water quality and can accelerate the aging process of lakes, rivers, and streams.

Sensors are devices that undergo a measurable change in response to environmental changes and communicate this to the appropriate equipment or control system.

Setpoints are normal operating ranges for building systems and indoor environmental quality. When the building systems are outside of their normal operating range, action is taken by the building operator or automation system.

Shielding is a nontechnical term that describes devices or techniques that are used as part of a luminaire or lamp to limit glare, light trespass, or sky glow.

Side-lighting is illumination from light entering the building through the sides (e.g. windows).

Site area is synonymous with property area.

A **site assessment** is an evaluation of a site's aboveground and subsurface characteristics, including its structures, geology, and hydrology. Site assessments are typically used to determine whether contamination has occurred, as well as the extent and concentration of any release of pollutants. Information generated during a site assessment is used to make remedial action decisions.

Site energy is the amount of heat and electricity consumed by a building, as reflected in utility bills.

Sky glow is caused by stray light from unshielded light sources and light reflecting off surfaces that then enter the atmosphere and illuminate and reflect off dust, debris, and water vapour . Sky glow can substantially limit observation of the night sky, compromise astronomical research, and adversely affect nocturnal environments.

Soft costs are expense items that are not considered direct construction costs. Examples include architectural, engineering, financing, and legal fees.

Solar reflectance, or **albedo**, is a measure of the ability of a surface material to reflect sunlight—visible, infrared, and ultraviolet wavelengths—on a scale of 0 to 1. Solar reflectance is also called albedo. Black paint has a solar reflectance of 0; white paint (titanium dioxide) has a solar reflectance of 1.

The **solar reflectance index (SRI)** is a measure of a material's ability to reject solar heat, as shown by a small temperature rise. Standard black (reflectance 0.05, emittance 0.90) is 0 and standard white (reflectance 0.80, emittance 0.90) is 100. For example, a standard black surface has a temperature rise of 90˚F (50˚C) in full sun, and a standard white surface has a temperature rise of 14.6˚F (8.1˚C). Once the maximum temperature rise of a given material has been computed, the SRI can be calculated by interpolating between the values for white and black. Materials with the highest SRI values are the coolest choices for paving. Because of the way SRI is defined, particularly hot materials can even take slightly negative values, and particularly cool materials can even exceed 100. (Lawrence Berkeley National Laboratory Cool Roofing Materials Database) SRI is calculated according to ASTM E 1980. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C 1371.

Solar thermal systems collect or absorb sunlight via solar collectors to heat water that is then circulated to the building's hot water tank. Solar thermal systems can be used to warm swimming pools or heat water for residential and commercial use.

Source energy is the total amount of raw fuel required to operate a building; it incorporates all transmission, delivery, and production losses for a complete assessment of a building's energy use.

Source reduction reduces the amount of unnecessary material brought into a building. Examples include purchasing products with less packaging.

Species factor (k_s) is a constant used to adjust the evapotranspiration rate to reflect the biological features of a specific plant species.

Stormwater consists of water created during precipitation events that flow over surfaces into sewer systems or receiving waters. All precipitation waters that leave project site boundaries on the surface are considered to be stormwater.

Stormwater Management Plan is a plan developed for an area with the objectives of maintaining ground water quantity, protecting water quality, protecting aquatic species and habitat, reducing erosion, and preventing any increase in flood risk. As part of the plan, Best Management Practices (BMPs) are employed to capture or treat stormwater runoff.

A **stormwater pollution prevention plan** describes all measures to prevent stormwater contamination, control sedimentation and erosion during construction, and comply with the requirements of the Clean Water Act.

Stormwater runoff consists of water from precipitation that flows over surfaces into sewer systems or receiving water bodies. All precipitation that leaves project site boundaries on the surface is considered stormwater runoff.

Subcomponent is a part of a product or material assembly that is composed of a single self-contained material or mixture.

Submetering is used to determine the proportion of energy use within a building attributable to specific end uses or subsystems (e.g., the heating subsystem of an HVAC system).

Supply air is air delivered by mechanical or natural ventilation to a space, composed of any combination of outdoor air, recirculated air, or transfer air. (ASHRAE 62.1–2007)

Sustainable forestry is the practice of managing forest resources to meet the long-term forest product needs of humans while maintaining the biodiversity of forested landscapes. The primary goal is to restore, enhance, and sustain a full range of forest values, including economic, social, and ecological considerations.

A **sustainable purchasing plan** is the development, adoption, and implementation of a procurement strategy that supports an organization's sustainable purchasing policy.

A **sustainable purchasing policy** gives preference to products that have little to no negative impact on the environment and society throughout their life cycle, and to the companies that supply them.

Systems performance testing is the process of determining the ability of commissioned systems to perform in accordance with the owner's project requirements, the basis of design, and construction documents.

A **tenant** is a person or entity that pays to occupy land or space that is owned by someone else.

Tertiary treatment is the highest form of wastewater treatment and includes removal of organics, solids, and nutrients as well as biological or chemical polishing, generally to effluent limits of 10 mg/L biological oxygen demand (BOD) 5 and 10 mg/L total suspended solids (TSS).

Thermal comfort exists when occupants express satisfaction with the thermal environment.

Tipping fees are charged by a landfill for disposal of waste, typically quoted per tonne.

Top-lighting is illumination from light entering the building through the roof (e.g. skylights, solar tubes).

Total suspended solids (TSS) are those solids found in wastewater or in a stream which can be removed by filtration through a 0.45 micron filter. "The origin of suspended matter may be manmade wastes or natural sources such as silt."[8]

Transient users are occupants who do not use a facility on a consistent, regular, daily basis. Examples include students in higher education settings, customers in retail settings, and visitors in institutional settings.

Undercover parking is underground or under a deck, roof, or building; its hardscape surfaces are shaded.

Upstream equipment consists of all heating or cooling systems, equipment, and controls that are associated with a district energy system but are not part of the project building's thermal connection or do not interface with the district energy system. It includes the central energy plant and all transmission and distribution equipment associated with transporting the thermal energy to the project building and site.

Urea-formaldehyde is a combination of urea and formaldehyde that is used in some glues and may emit formaldehyde at room temperature.

Vehicle Sharing Program is a membership based service that operates with a distributed fleet of motor vehicles parked at varying reserved locations that are made available to members primarily for hourly or other short term use through a self-service, fully automated system not requiring a separate contract for each use. (Washington Metro Transit Authority)

A **vendor** of certified wood is the company that supplies wood products to contractors or subcontractors for on-site installation. A vendor needs a chain-of-custody number if it is selling FSC-certified products that are not individually labelled; this includes most lumber.

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space. (ASHRAE 62.1-2007)

Verification is the range of checks and tests carried out to determine whether components, subsystems, systems, and interfaces between systems operate in accordance with the contract documents.

Vertical footcandles occur on a vertical surface. They can be added together arithmetically when more than 1 source provides light to the same surface.

Virgin Materials / Resources have not been previously used or consumed.

Visible light transmittance (T_{vis}) is the ratio of total transmitted light to total incident light. (I.e., the amount of visible spectrum light passing through a glazing surface divided by the amount of light striking the glazing surface. The higher T_{vis} value, the more incident light passes through the glazing.

Vision glazing is that portion of exterior windows between 0.76 metres (30 inches) and 2.3 metres (90 inches) above the floor that permits a view to the outside.

Volatile organic compounds (VOCs) are carbon compounds that participate in atmospheric photochemical reactions (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonates, and ammonium carbonate). The compounds vaporize at normal room temperatures.

Walking distance is the length of the walkable pathway between the building and public transportation.

Walk-off mats or roll-out mats are placed inside building entrances to capture dirt, water, and other materials tracked inside by people and equipment.

Waste comprises all materials that flow from the building to final disposal. Examples include paper, grass trimmings, food scraps, and plastics. In LEED, waste refers to all materials that are capable of being diverted from the building's waste stream through waste reduction.

Waste disposal eliminates waste by means of burial in a landfill, combustion in an incinerator, dumping at sea, or any other way that is not recycling or reuse.

Waste diversion is a management activity that disposes of waste other than through incineration or the use of landfills. Examples include reuse and recycling.

Waste reduction includes both source reduction and waste diversion through reuse or recycling.

The **waste stream** is the overall flow of waste from the building to a landfill, incinerator, or other disposal site.

Wastewater is the spent or used water from a home, community, farm, or industry that contains dissolved or suspended matter. (Federal Remediation Technologies Roundtable)

A **water meter** measures the volume of water usage. Most commercial building water meters are designed to measure cold potable water.

Waterless urinals see non-water (or dry) urinal.

Wave and tidal power systems capture energy from waves and the diurnal flux of tidal power, respectively. The captured energy is commonly used for desalination, water pumping, and electricity generation.

A **Weatherproofing System** protects the building from the exterior environment (wind and water) and is defined as the air barrier within the wall and roof assemblies.

Wetland is an area that is inundated or saturated by surface or ground water at a frequency and duration that under normal circumstances support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. A river or creek is not considered a wetland. Manmade wetlands are excluded from the requirements of SS credit 1 only if constructed as part of an overall storm system management approach.

Wind energy is electrical production generated from a wind turbine that converts the kinetic energy of the wind into electricity.

Window-to-floor ratio (WFR) is the total area of the window (measured vertically from 0.76 metres (30 inches) above the finished floor to the top of the glass, multiplied by the width of the glass) divided by the floor area.

Xeriscaping is a landscaping method that makes routine irrigation unnecessary. It uses drought-adaptable and low-water plants as well as soil amendments such as compost and mulches to reduce evaporation.

ENDNOTES

[1] Treasury Board of Canada Secretariat, Directive on Contingencies, http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=15786&section=text#Contaminated_site (accessed February 2010).

[2] Horton, Gary A. "Water Words Dictionary: A Compilation of Technical Water, Water Quality, Environmental and Water-Related Terms." Nevada Division of Water Resources. Department of Conservation and Natural Resources http://water.nv.gov/WaterPlanning/dict-1/ww-index.cfm (accessed December 2009).

[3] Ibid.

[4] U.S. Environmental Protection Agency "Terms of Environment: Glossary, Abbreviations and Acronyms." http://www.epa.gov/OCEPAterms/ [accessed March 2010].

[5] Horton, Gary A. "Water Words Dictionary: A Compilation of Technical Water, Water Quality, Environmental and Water-Related Terms." Nevada Division of Water Resources. Department of Conservation and Natural Resources http://water.nv.gov/WaterPlanning/dict-1/ww-index.cfm (accessed December 2009).

[6] Ibid.

[7] Ibid.

[8] Ibid.