The Leap to Zero Carbon: The 2030 Challenge

Defining the STEPS to Carbon Neutral Design

ARCH 126: ENVIRONMENTAL BUILDING DESIGN

Overview:

Designing to Zero Carbon standards as defined by the Architecture2030 Challenge, requires a modified approach to current sustainable and high performance design methods. This session will answer the question “What is Zero Carbon?” and through a series of key case studies differentiate the means by which sustainable/high performance and low carbon buildings are designed. Case studies will be used to demonstrate how new low-carbon strategies and systems are incorporated to reduce GHG emissions.

Learning Objectives

- **Differentiate between sustainable design and carbon neutral** (zero carbon) design.
- **Incorporate comprehensive sustainable strategies** into their projects based upon bioclimatic considerations that respond to passive environmental design basics.
- **Prioritize the critical design issues** and questions to meet advanced sustainable design targets, leading to the **potential to incorporate zero energy/zero emissions** and carbon neutral.
- **Identify key strategies** that must be included in architectural design in order to design buildings to carbon neutral, zero energy standards.
- **Assess the architectural implications and potential** of including Zero Carbon/Zero Energy strategies, materials and methods in a project.

Global Warming and Sustainable Design:

- A priority has been placed, above and beyond current trends in Sustainable Design, on the reduction of GHG emissions
- Buildings account for more than 40% of the GHG
- Green, Sustainable and High Performance Buildings are not going far enough, quickly enough in reducing their negative impact on the environment, and certainly not far enough to offset the balance of building that marches on in ignorance
- Carbon Neutrality focuses on the relationship between all aspects of “building/s” and CO_2 emissions
- Carbon Neutral Design strives to reverse trends in Global Warming

Differentiating *Sustainable* vs. *Zero Carbon/Carbon Neutral:*

Sustainable design is a *holistic* way of designing buildings to minimize their environmental impact through:

- **Reduced dependency on non-renewable resources**
- **A more bio-regional response to climate and site**
- **Increased efficiency in the design of the building envelope and energy systems**
- **A environmentally sensitive use of materials**
- **Focus on healthy interior environments**
- **Characterized by buildings that aim to *"live lightly on the earth"* and**
- ***"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."***

United Nations World Commission on Environment and Development

From ZED to Carbon Neutral

A **Near Zero Energy** building produces at least 75% of its required energy through the use of on-site renewable energy. Off-grid buildings that use some non-renewable energy generation for backup are considered near zero energy buildings because they typically cannot export excess renewable generation to account for fossil fuel energy use.

A **Carbon Neutral Building** derives 100% of its energy from non fossil fuel based renewables.

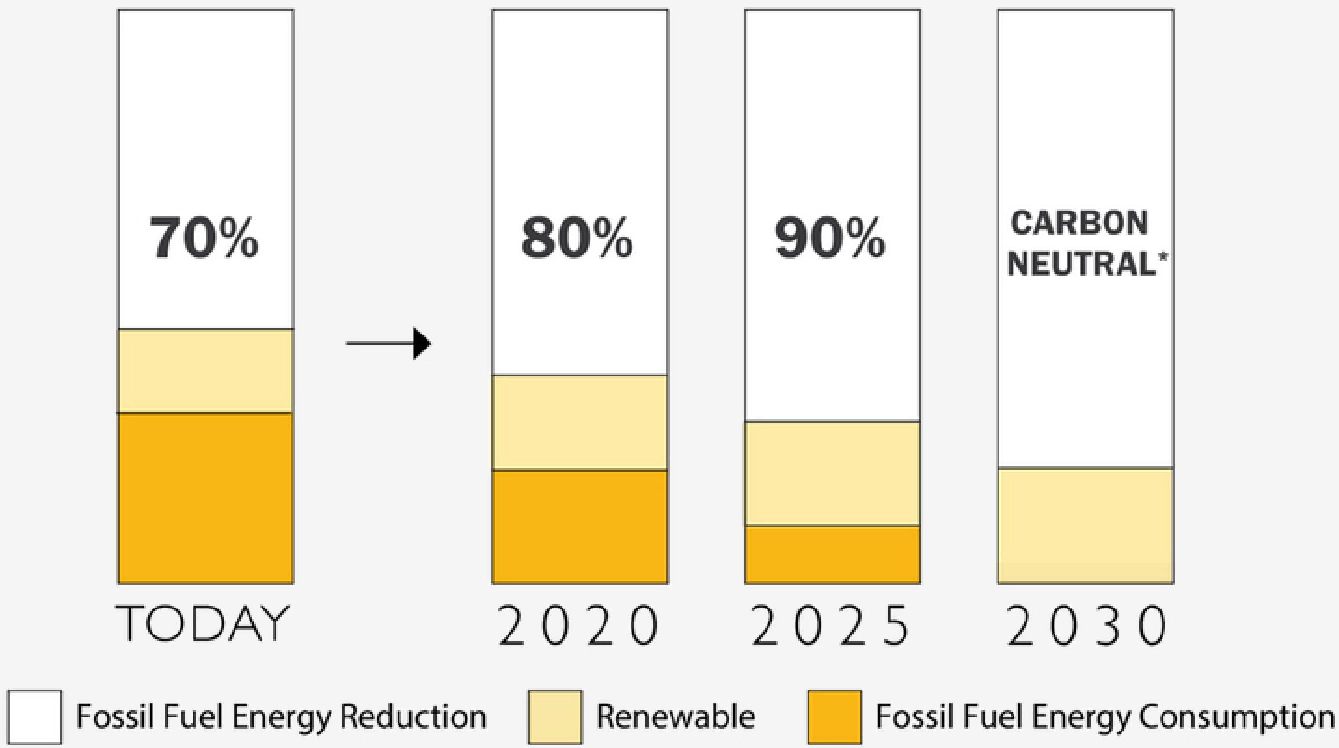
Why Assess Carbon Neutrality?

- Sustainable design does not go far enough
- Assessing carbon is complex, but necessary
- The next important goal to reverse the effects of global warming and reduce CO^2 emissions it to make our buildings **“carbon neutral”**
- **“architecture2030”** is focused on raising the stakes in sustainable design to challenge designers to radically reduce their carbon emissions by the year 2030

www.architecture2030.org

THE 2030 CHALLENGE

All new buildings, developments, and major renovations shall be carbon-neutral by 2030



The 2030 Challenge

**Using no fossil fuel GHG-emitting energy to operate.*

DESIGN STRATEGIES

The largest energy reductions can be achieved through design.

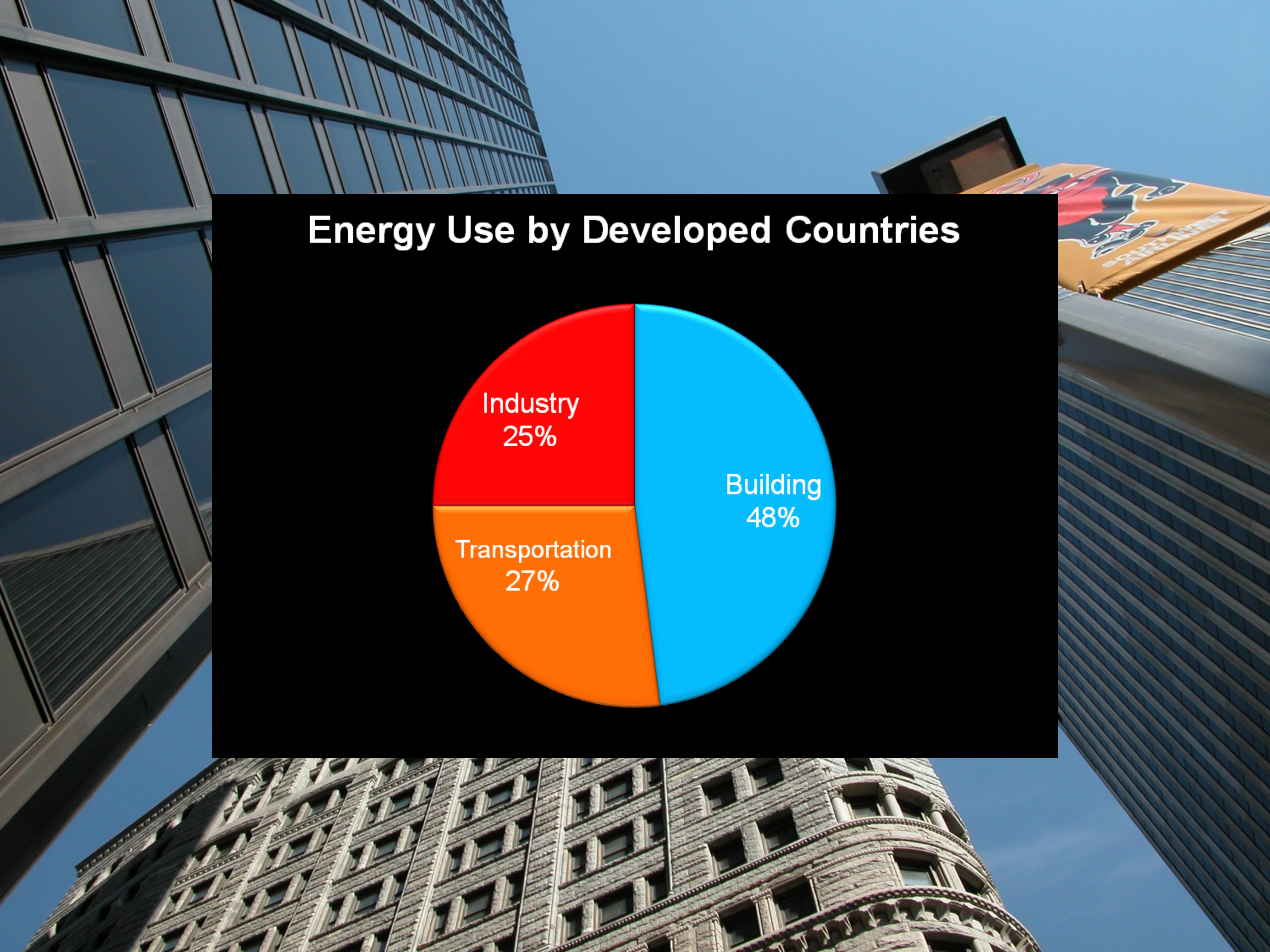
TECHNOLOGIES AND SYSTEMS

Including on-site renewable energy systems.

OFF-SITE RENEWABLE ENERGY

20% maximum.

Meeting the 2030 Challenge


Energy Use by Developed Countries
Industry
25%
Building
48%
Transportation
27%

The Global Warming Pie....

These values look at Secondary **Energy Use** by Sector in Canada (2006)

(*energy used by the final consumer i.e. operating energy*)

The LEAP to Zero Carbon and beyond…

- Energy Efficient (mid 1970s "Oil Crisis" reaction) – add insulation
- High Performance (accountable) – C2000, Hot2000
- **Green (environmentally responsive) –** Kyoto Protocol
- Sustainable (holistic and accountable) – LEED ™
- Carbon Neutral (Zero Fossil Fuel Energy) – Architecture2030
- Restorative
- Regenerative – Living Building Challenge

…a steady increase in the nature and expectations of performance criteria

Fossil Fuel Reduction Standard:

The fossil fuel **reduction standard** for all **new buildings** shall be increased to:

60% in 2010
70% in 2015
80% in 2020
90% in 2025
Carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to **operate**).

Source: www.architecture2030.org

2030 Targets - Commercial

2030 CHALLENGE Targets: National Averages

U.S. Average Site Energy Use and 2030 Challenge Energy Reduction Targets by Space/Building Type (CBECS 2003)[1]

From the Environmental Protection Agency (EPA): Use this chart to find the site fossil-fuel energy targets.

Primary Space/Building Type [2]	Available in Target Finder [3]	Average Source EUI [4] (kBtu/Sq.Ft./Yr)	Average Percent Electric	Average Site EUI [4] (kBtu/Sq.Ft./Yr)	2030 Challenge Site EUI Targets (kBtu/Sq.Ft./Yr)				
					50% Target	60% Target	70% Target	80% Target	90% Target
Administrative/Professional & Government Office	✓								
Bank	✓								
Clinic/other outpatient health		219	76%	84.2	**42.1**	33.7	25.3	16.8	8.4
College/university (campus-level)		280	63%	120	**60**	48	36	24	12
Convenience store (with or without gas station)		753	90%	241.4	**120.7**	96.6	72.4	48.3	24.1
Distribution/shipping center		90	61%	44.2	**22.1**	17.7	13.3	8.8	4.4
Fast food		1306	64%	534.3	**267.2**	213.7	160.3	106.9	53.4
Fire station/police station		157	56%	77.9	**39.0**	31.2	23.4	15.6	7.8
Hospital/inpatient health	✓								
Hotel, Motel or inn	✓								
K-12 School	✓								
Medical Office	✓								

Target Finder is an online tool:
http://www.energystar.gov/index.cfm?c=new_bldg_design.bus_target_finder

2030 Targets – Residential:

2030 CHALLENGE Targets: Residential Regional Averages

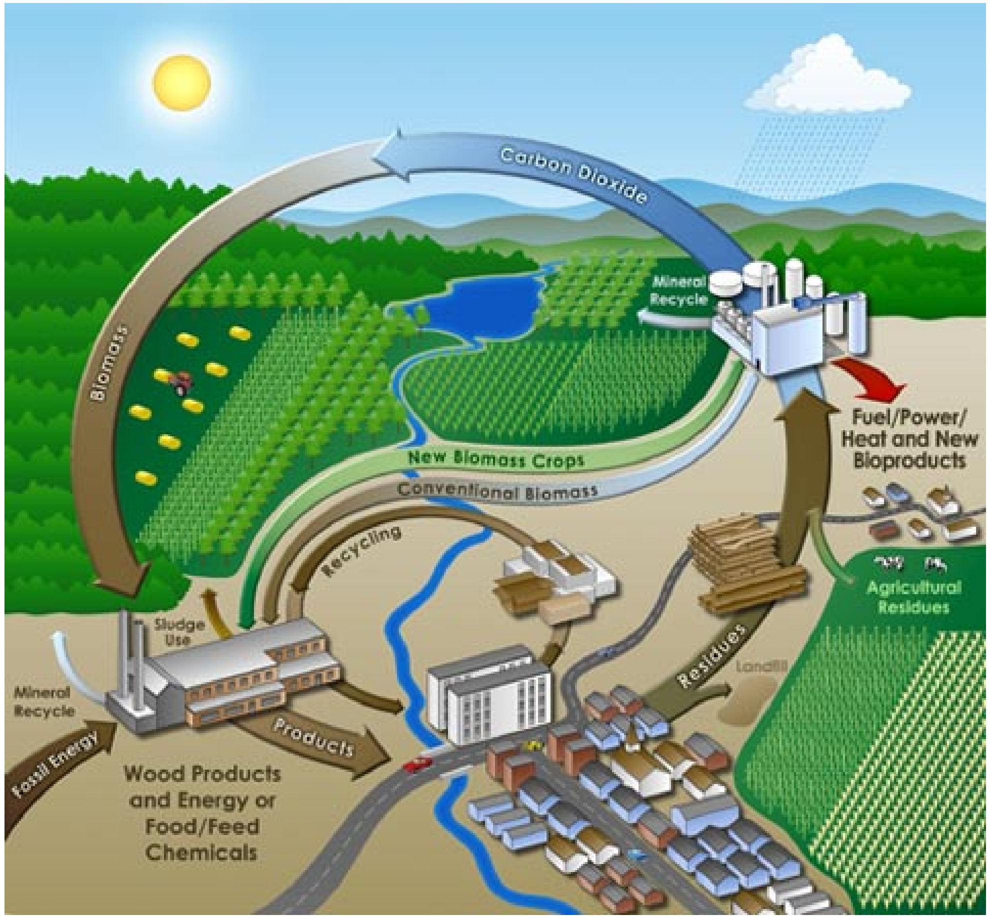
U.S. Regional Averages for Site Energy Use and 2030 Challenge Energy Reduction Targets by Residentail Space/Building Type (RECS 2001)[1]
From the Environmental Protection Agency (EPA): Use this chart to find the site fossil-fuel energy targets.

Residential Space/Building Type[2]	Average Source EUI[3, 4] (kBtu/Sq.Ft./Yr)	Average Site EUI[3, 5] (kBtu/Sq.Ft./Yr)	2030 Challenge Site EUI Targets (kBtu/Sq.Ft./Yr)				
			50% Target	60% Target	70% Target	80% Target	90% Target
Northeast							
Single-Family Detached	67.5	45.7	**22.9**	18.3	13.7	9.1	4.6
Single-Family Attached	68.6	50.3	**25.1**	20.1	15.1	10.1	5.0
Multi-Family, 2 to 4 units	78.8	57.8	**28.9**	23.1	17.3	11.6	5.8
Multi-Family, 5 or more units	98.2	60.7	**30.4**	24.3	18.2	12.1	6.1
Mobile Homes	145.5	89.3	**44.6**	35.7	26.8	17.9	8.9
Midwest							
Single-Family Detached	76.2	49.5	**24.7**	19.8	14.8	9.9	4.9

…etc.

http://www.architecture2030.org/downloads/2030_Challenge_Targets_Res_Regional.pdf

Buildings / Processes and the Carbon Cycle:



http://www.repp.org/bioenergy/bioenergy-cycle-med2.jpg

As the way that buildings interact with carbon is highly complex, the first aim is to reduce operating energy as it is the most significant and easiest to control.

Operating Energy of Building

architecture 2030

80% of the problem!

Landscape + Site

Disturbance vs. sequestration

Embodied Carbon in Building Materials

People, “Use” + Transportation

Renewables + Site Generation

Counting Carbon costs….

+ purchased offsets

Energy vs Greenhouse Gas Emissions

In BUILDINGS, for the sake of argument

ENERGY CONSUMPTION = GHG EMISSIONS

BUILDING ENERGY IS COMPRISED OF

EMBODIED ENERGY

+

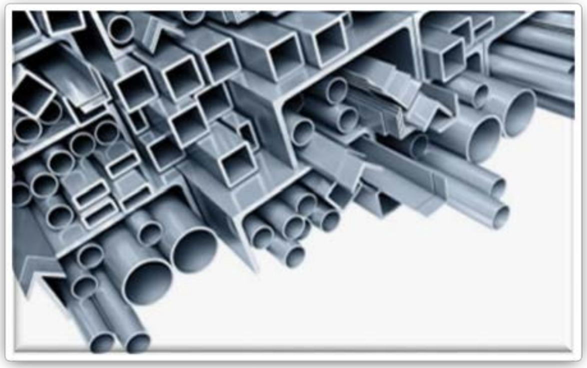
OPERATING ENERGY

Energy Use in Buildings

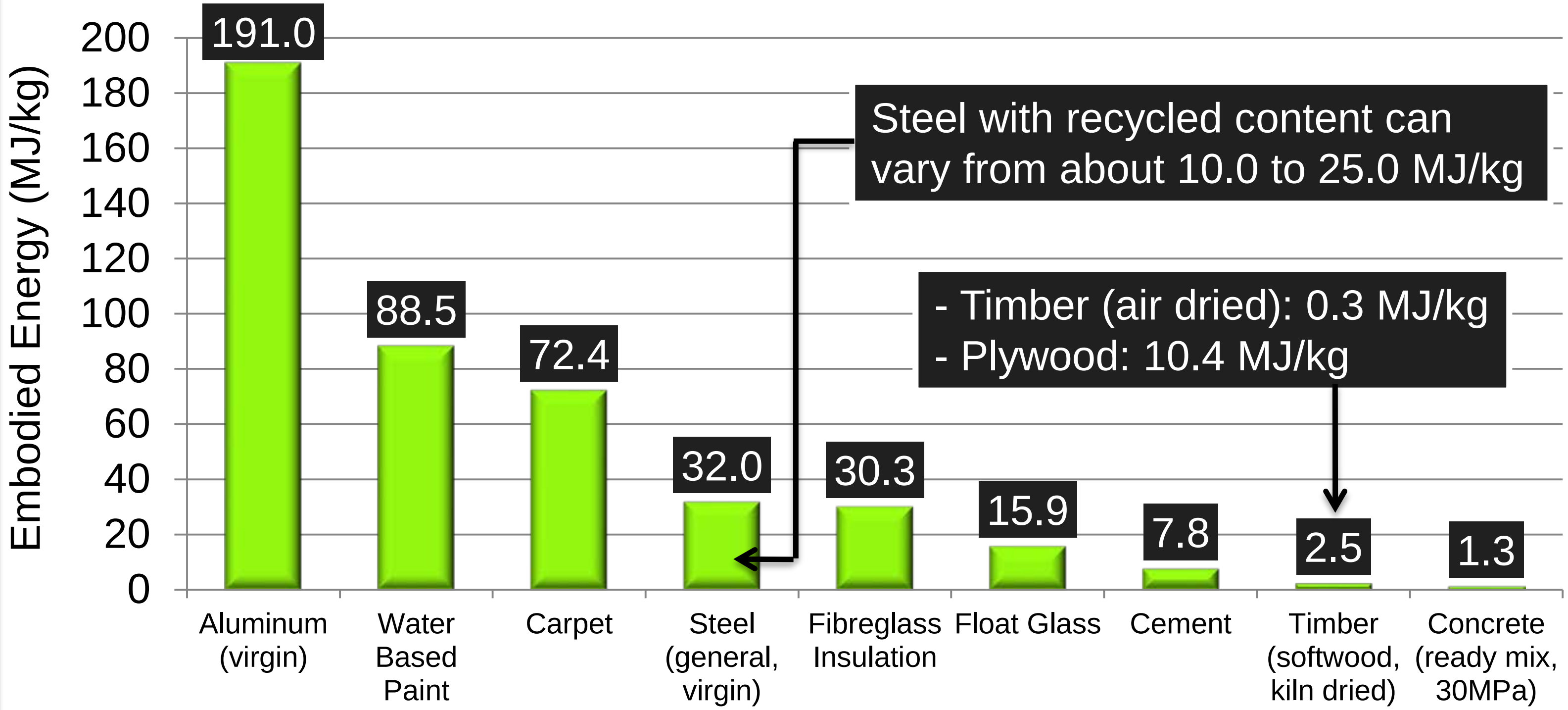
Embodied Energy

– **<u>Initial Embodied Energy</u>:** Non-renewable energy consumed in the acquisition of raw materials, their processing, manufacturing, transportation to site, and construction

– **<u>Recurring Embodied Energy</u>:** Non-renewable energy consumed to maintain, repair, restore, refurbish or replace materials, components, or systems during life of building

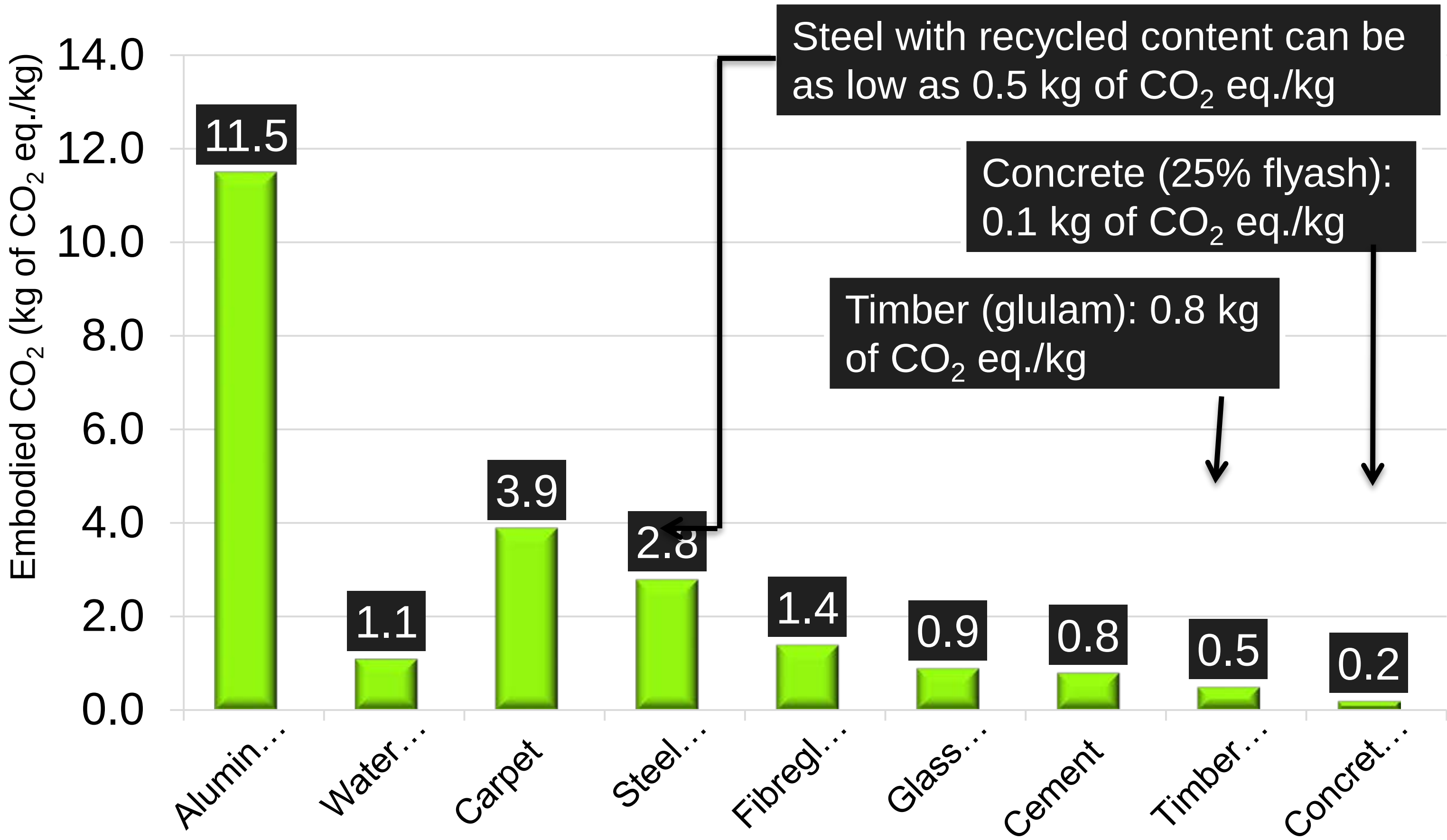


Initial Embodied Energy of Building Materials Per Unit Mass



Source: University of Wellington, NZ, Center for Building Performance Research (2004)

Embodied Carbon Dioxide of Building Materials Per Unit Mass



Source: University of Bath, UK, Inventory of Carbon and Energy (2008)

The Life Cycle of a Material

Life-Cycle Assessment (LCA)

– The main goal of a LCA is to quantify energy and material use as well as other environmental parameters at various stages of a product’s life-cycle including: resource extraction, manufacturing, construction, operation, and post-use disposal

Life-Cycle Inventory (LCI) Database

– A database that provides a cradle-to-grave accounting of the energy and material flows into and out of the environment that are associated with producing a material. This database is a critical component of a Life-Cycle Assessment

Life Cycle Assessment Methodology

Embodied Energy

– **ATHENA® Impact Estimator for Buildings**

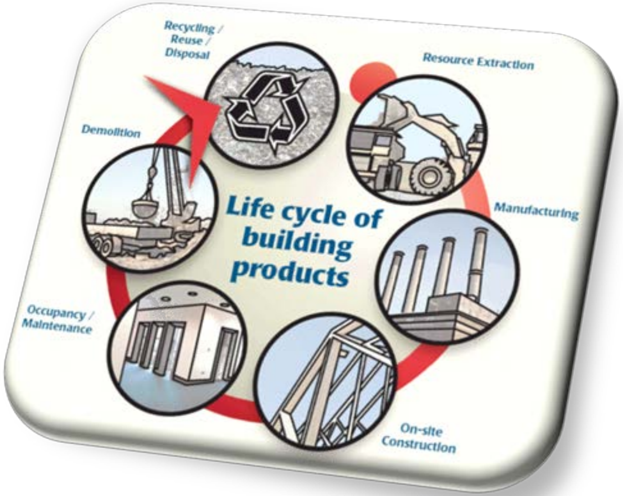
– **The only North American specific software tool that evaluates whole buildings and assemblies based on internationally recognized LCA methodology**

– **Non-profit organization that has been around for more than 10 years**

– **One of the most comprehensive LCI databases in the world with over $2 million spent on database development**

– **Considers the life-cycle impacts of:**

- ✓ Material manufacturing including resource extraction and recycled content
- ✓ Related transportation
- ✓ On-site construction
- ✓ Regional variation in energy use, transportation, and other factors
- ✓ Building type and assumed lifespan
- ✓ Maintenance, repair, and replacement effects
- ✓ Demolition and disposal
- ✓ Operating energy emissions and pre-combustion effects

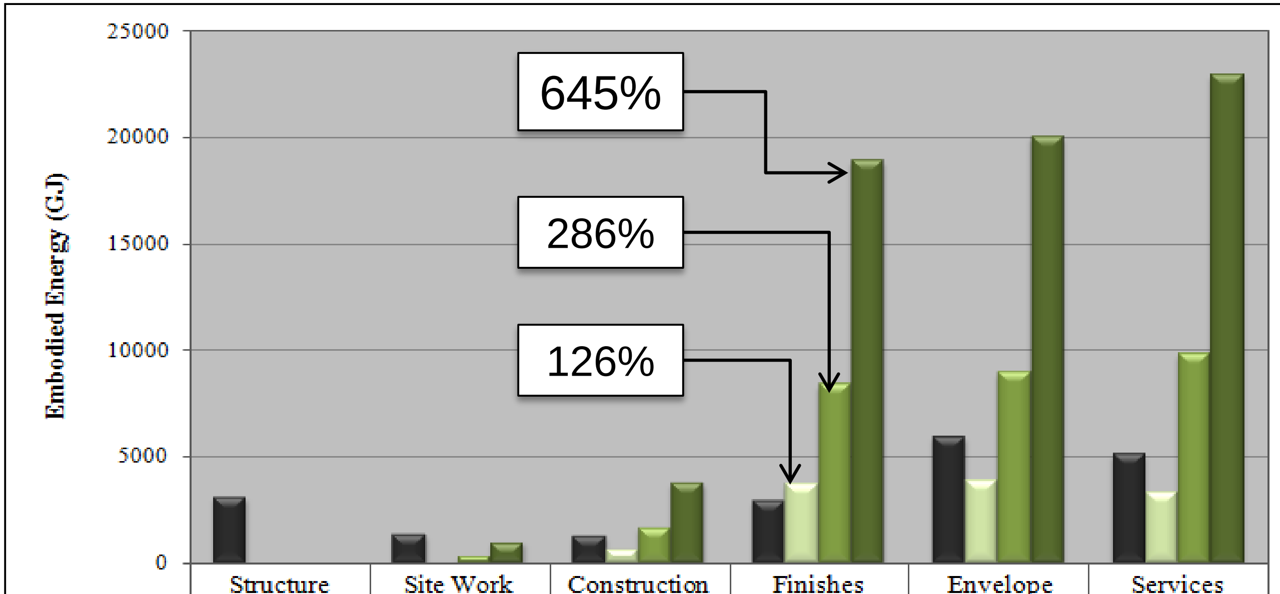


Source: The ATHENA Institute http://www.athenasmi.org/tools/impactEstimator/index.html

Energy in Common Building Components

Initial Embodied Energy vs. Recurring Embodied Energy of a Typical Canadian Office Building Constructed from Wood

Finishes, **Envelope**, & **Services** dominate the embodied energy over the building's lifespan



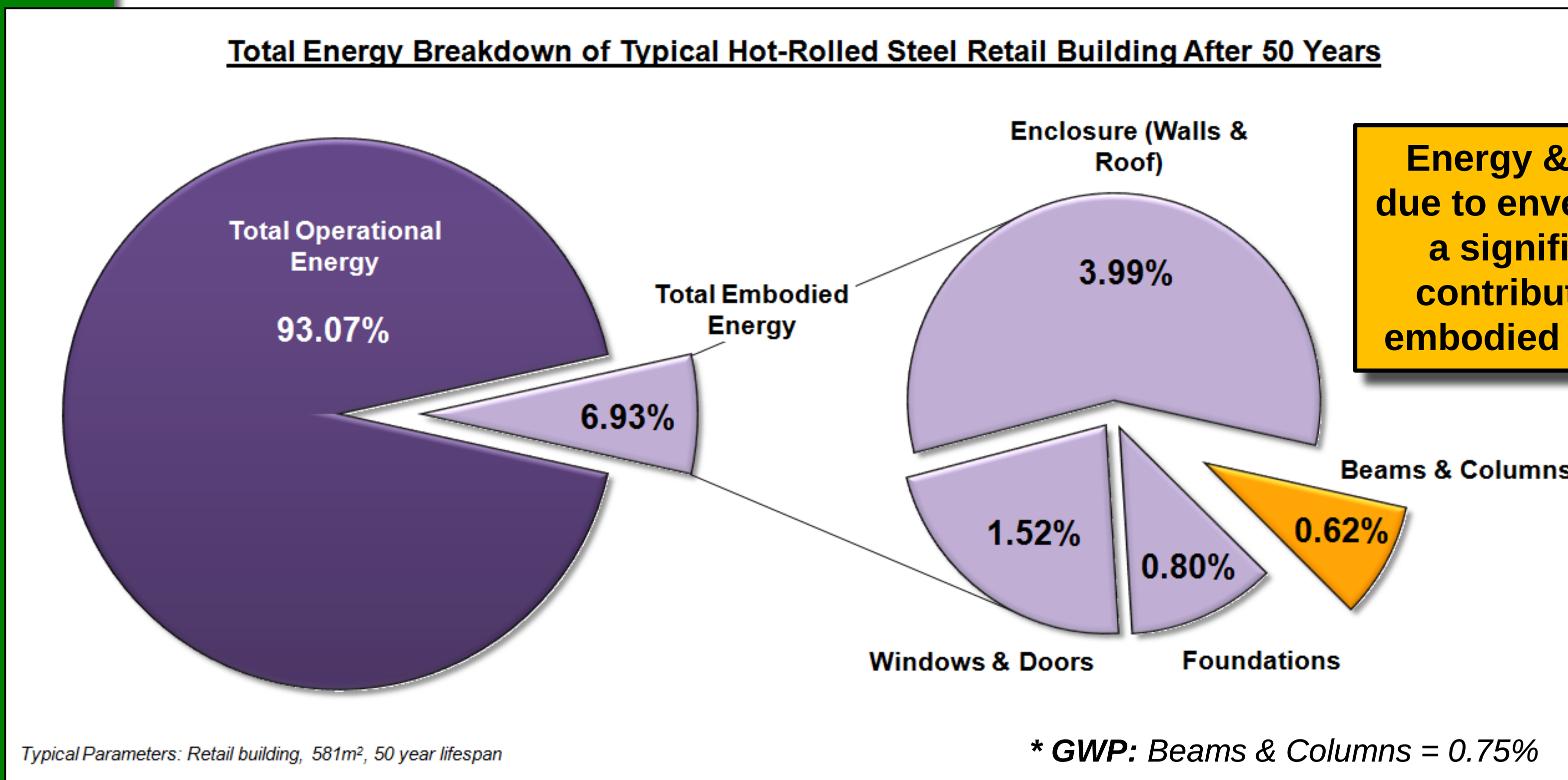
	Structure	Site Work	Construction	Finishes	Envelope	Services
Initial	3088	1344	1289	2935	5935	5110
25 Years	0	65	658	3696	3873	3338
50 Years	0	358	1653	8397	8943	9859
100 Years	0	1001	3777	18936	20060	22955

Source: Cole , R. & Kernan, P. (1996). Life-Cycle Energy Use in Office Buildings. Building and Environment, 31 (4), 307-317

Orders of Environmental Impact

Total Energy Breakdown of Typical Hot-Rolled Steel Retail Building After 50 Years

(*other building types are similar)*

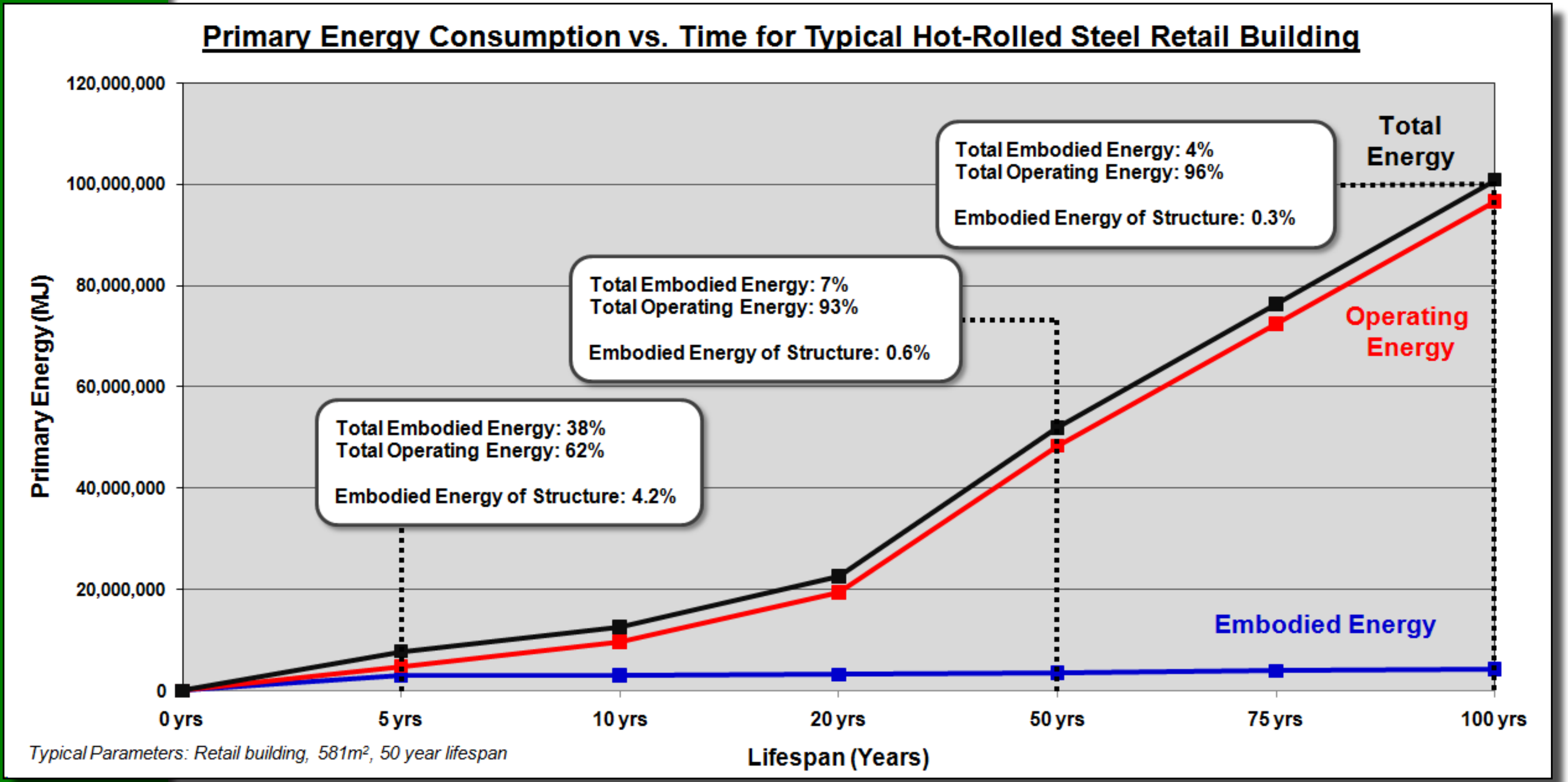


Energy & GWP due to envelope is a significant contributor to embodied energy

www.cn-sbs.cssbi.ca

Orders of Environmental Impact

Primary Energy Consumption vs. Time for Hot-Rolled Steel Retail Building (*other building types are similar)*



Source: Kevin Van Ootegham

www.cn-sbs.cssbi.ca

Embodied Energy Findings

In conventional buildings, the building envelope (walls and roof), building services, and building finishes contribute the most towards the total embodied life-cycle energy (and total embodied GWP) when looking at the Embodied Energy of the Entire Building, including Structure.

To lower GHG, choice of materials needs to reflect:

-issues of **DURABILITY**

- ability of material to assist **PASSIVE DESIGN**

- local sourcing to reduce **TRANSPORTATION**

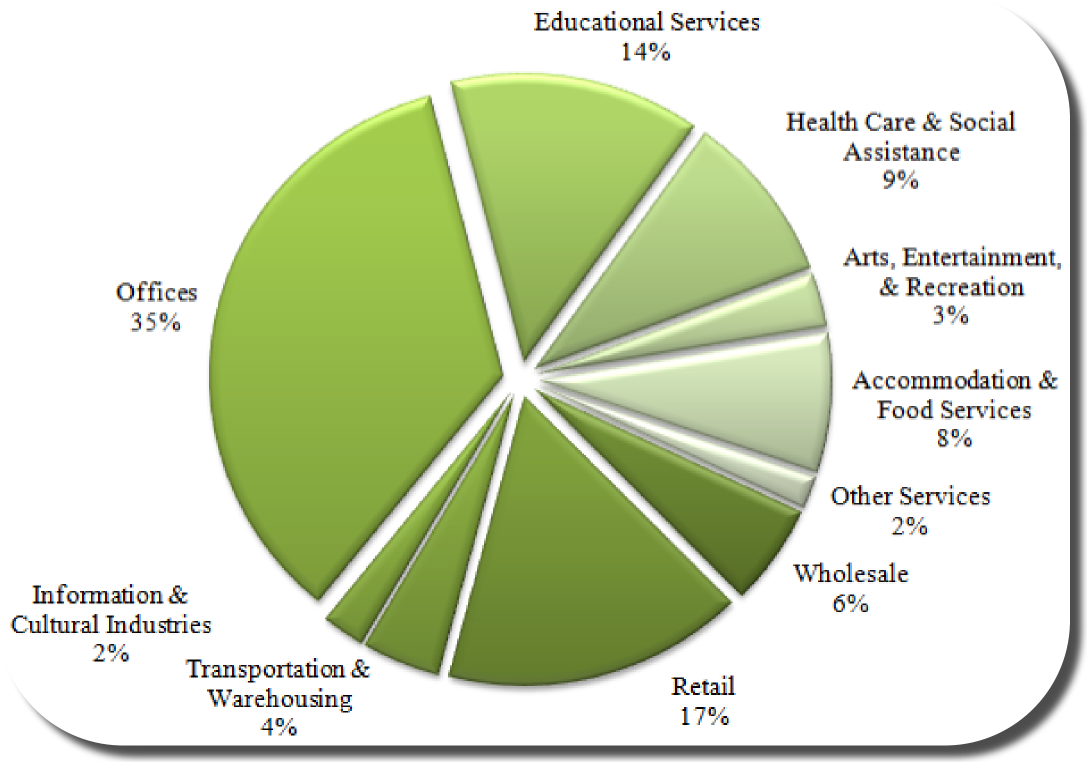
- **Cradle to Cradle concepts**

- ability of material to be 1st **REUSED** and 2nd RECYCLED

Energy Use in Buildings: Operating Energy

Amount of energy that is consumed by a building to satisfy the demand for heating, cooling, lighting, ventilation, equipment, etc.

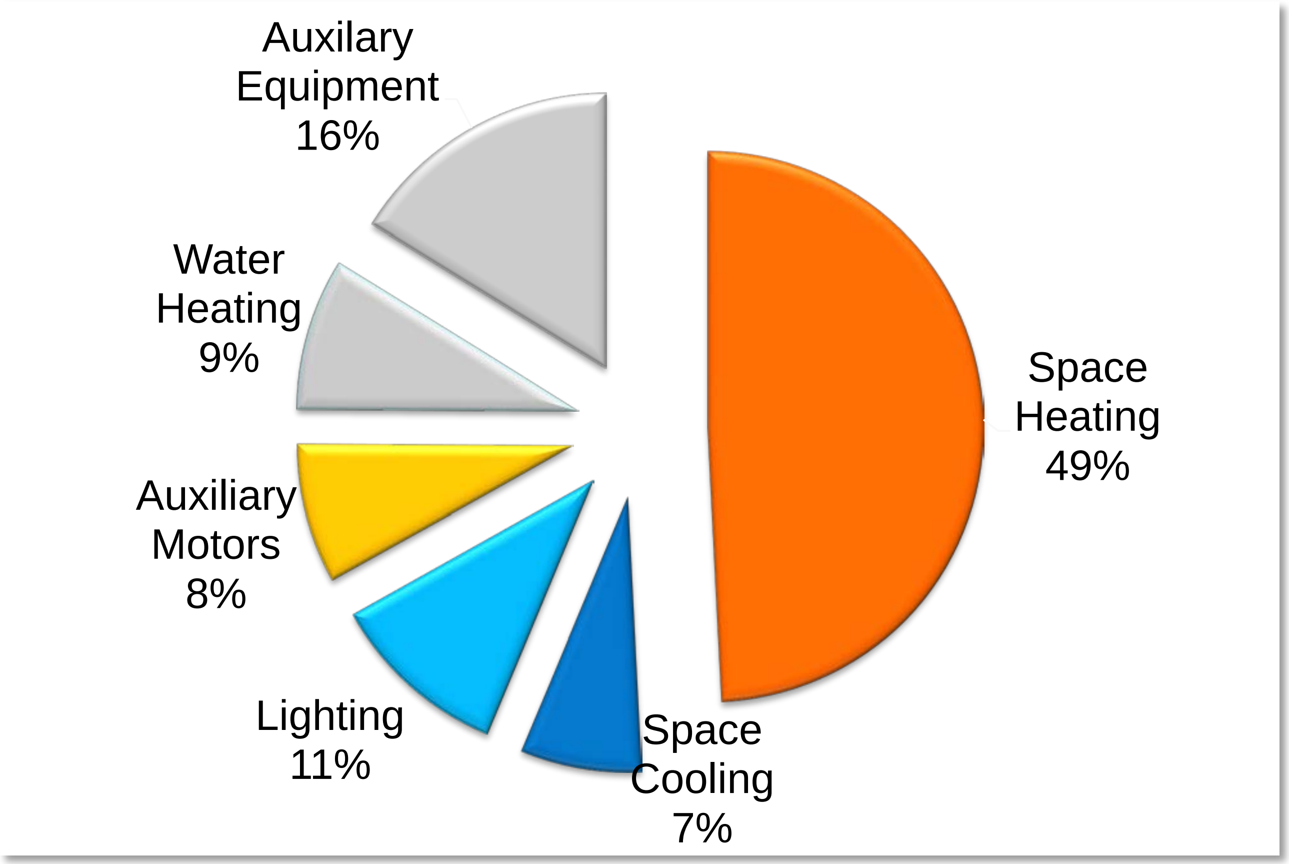
Total Commercial/Institutional Secondary Energy Use by Activity Type in Canada (2006)



Source: Natural Resources Canada, 2006

Energy Use in Buildings: Operating Energy

Total Commercial/Institutional Secondary Energy Use by End Use in Canada (2006)



Source: Natural Resources Canada, 2006

REDUCING OPERATING ENERGY

Three Key Steps – IN ORDER:

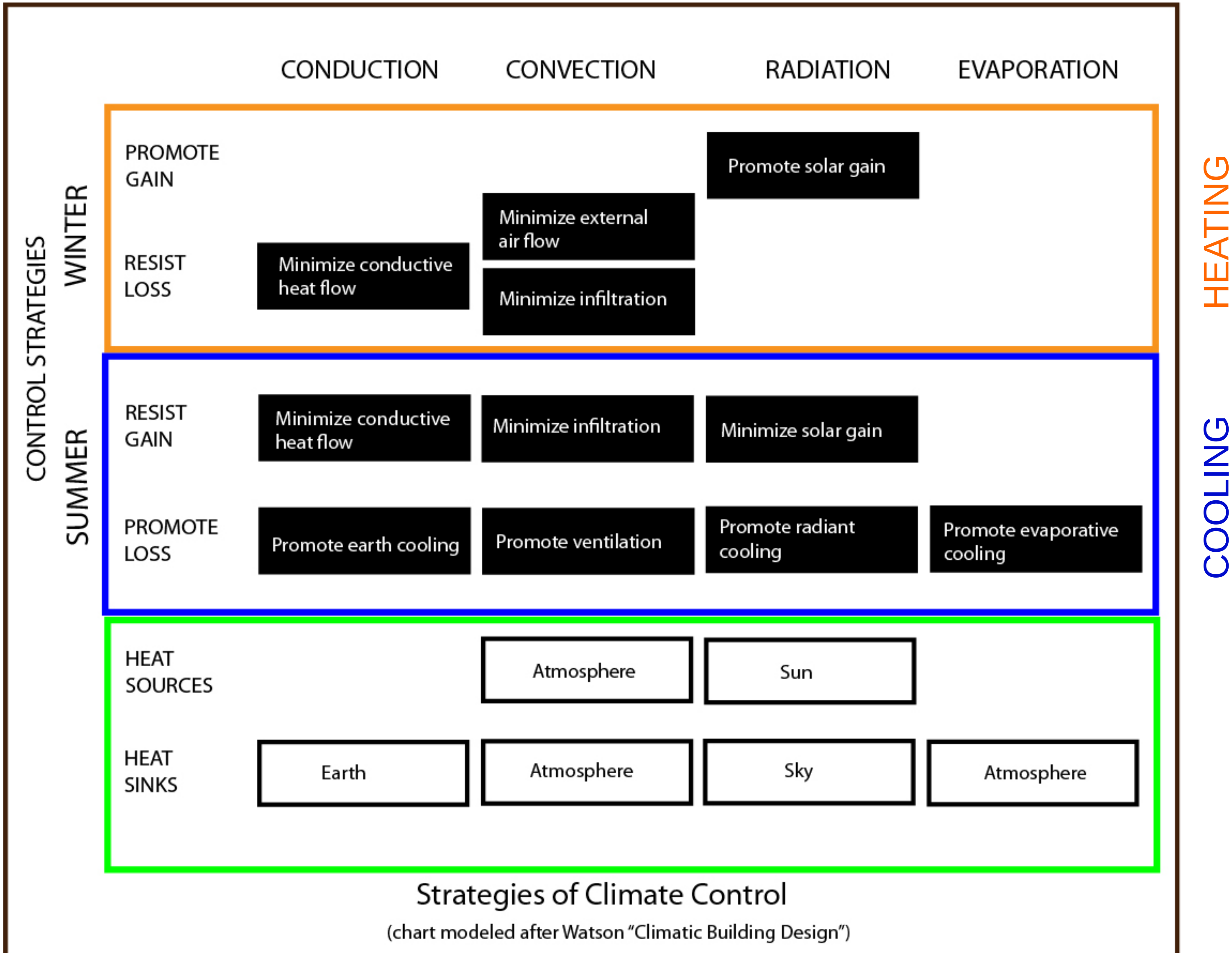
#1 - Reduce loads/demand first (conservation, passive design, daylighting, shading, orientation, etc.)

#2 - **Meet loads efficiently and *effectively*** (energy efficient lighting, high-efficiency Mechanical Electrical and Plumbing equipment, controls, etc.)

#3 - **Use renewables to meet energy needs** (doing the above steps *before* will result in the need for much smaller renewable energy systems, making carbon neutrality achievable.)

Use purchased Offsets as a *last resort* when all other means have been looked at on site, or where the scope of building exceeds the site available resources.

Begin with Passive Strategies for Climate Control to Reduce Energy Requirements



Strategies of Climate Control

(chart modeled after Watson "Climatic Building Design")

Carbon Reduction: The Tier Approach

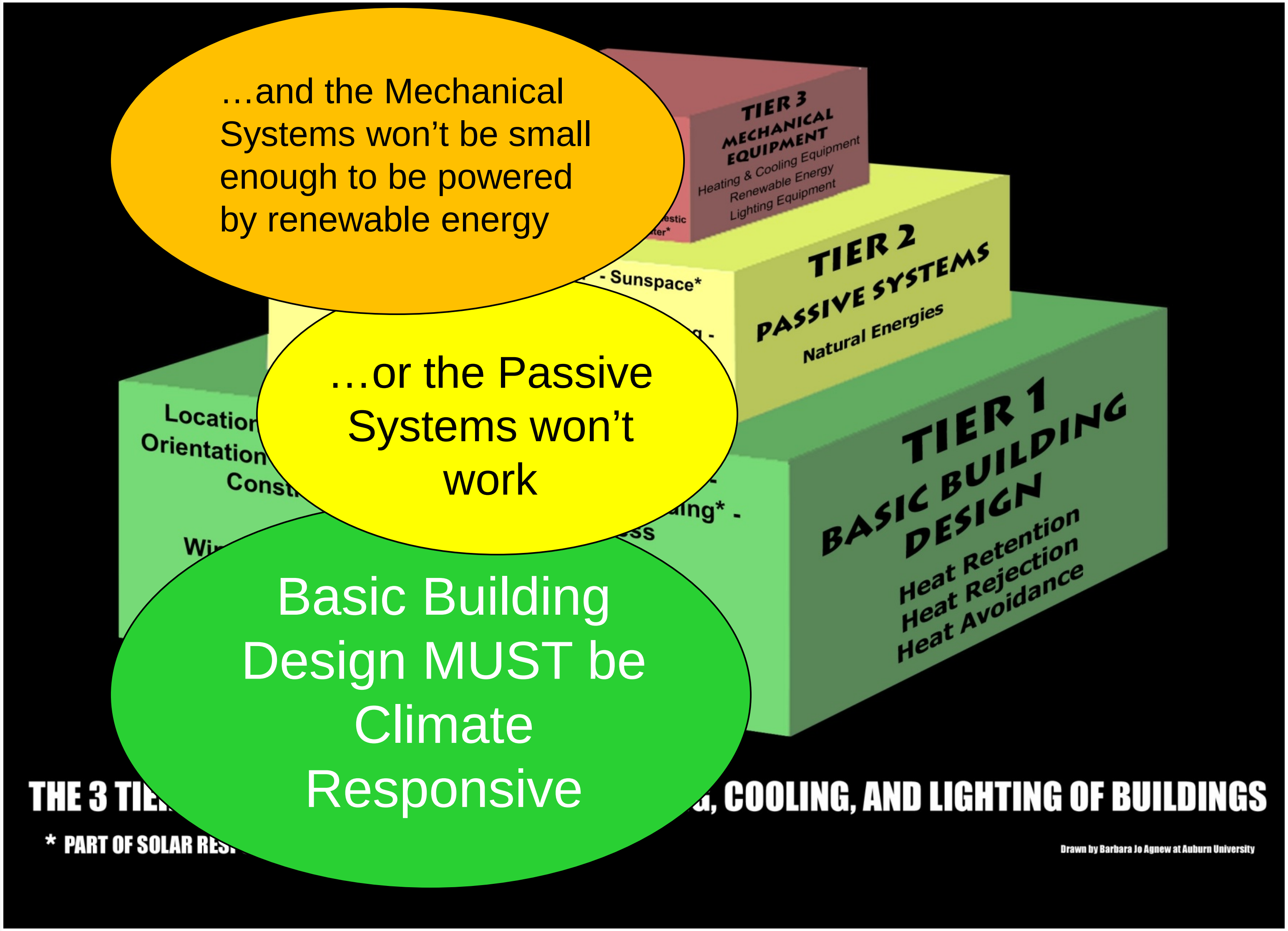
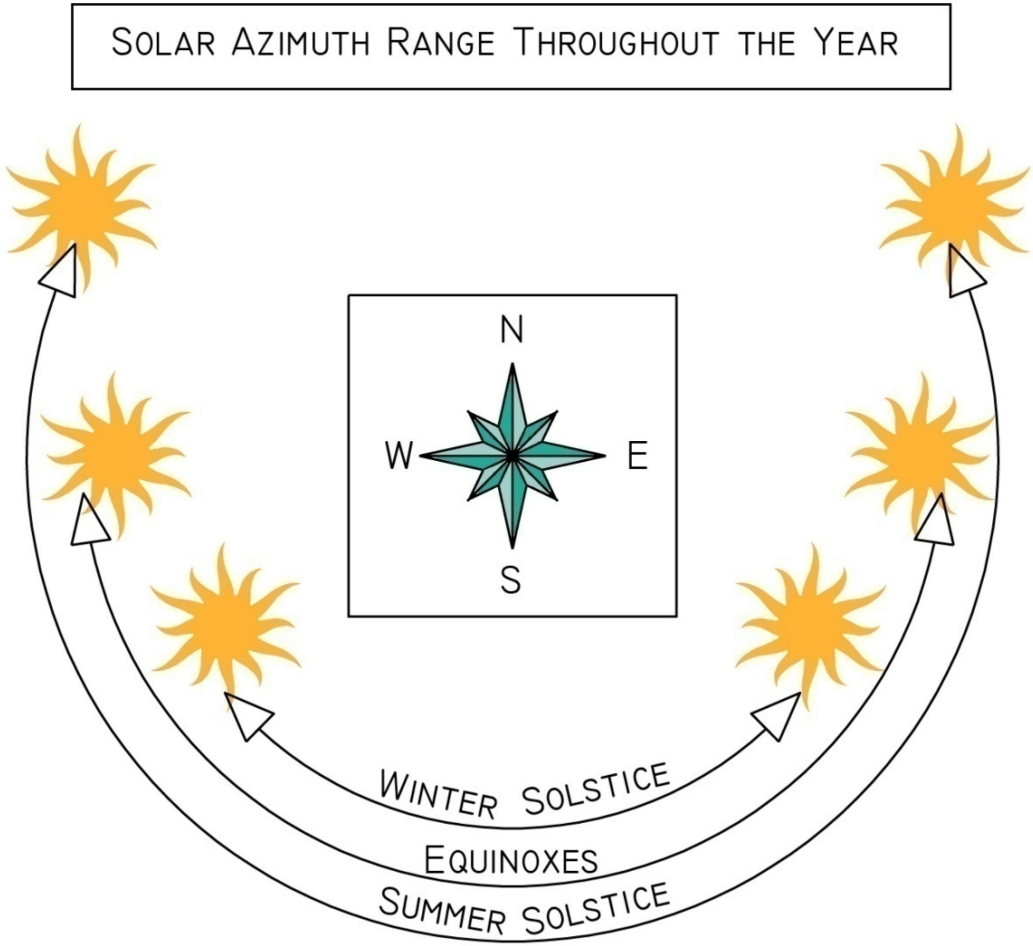


Image: Norbert Lechner, "Heating, Cooling, Lighting"

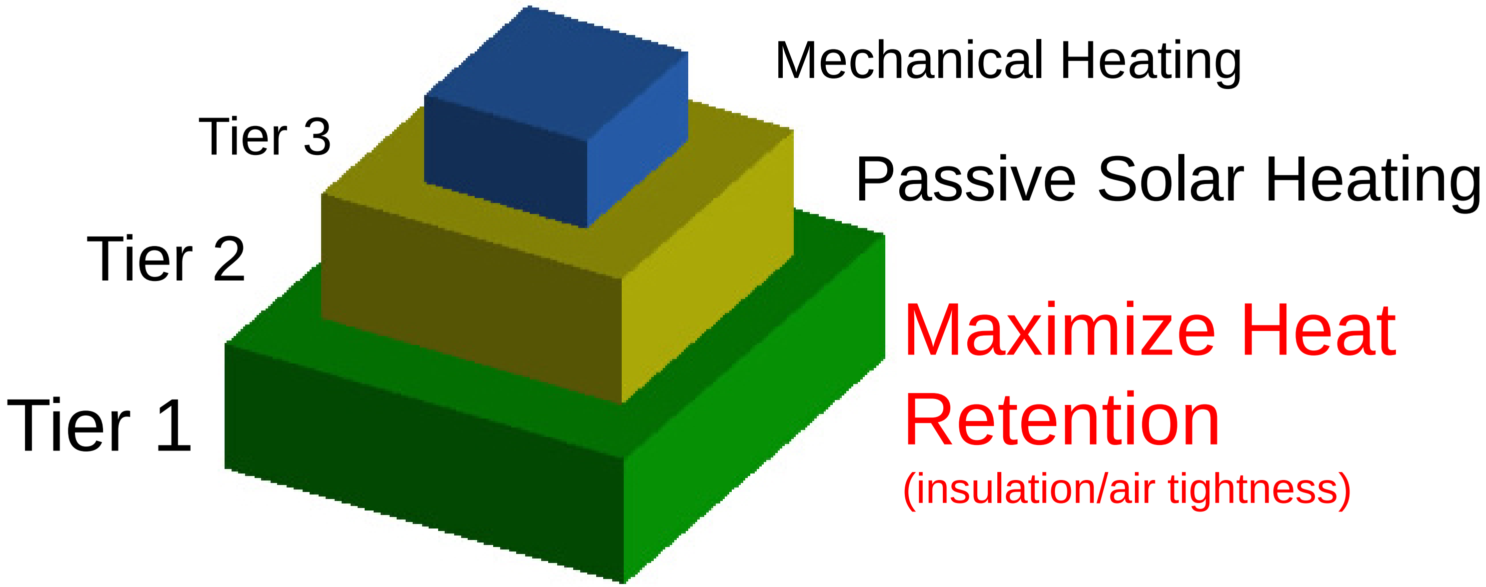
#1 Starting Point – Locate the SUN



… and exploit its full potential!

Reduce loads: Passive Strategies

The tiered approach to reducing carbon for **HEATING**:



First reduce the overall energy required, then maximize the amount of energy required for mechanical heating that comes from renewable sources.

Source: Lechner. Heating, Cooling, Lighting.

Passive Heating Strategies:
Maximize Heat Retention

1. Super insulated envelope (*as high as <u>double</u> current standards*)
2. Tight envelope / controlled air changes
3. Provide thermal mass **inside** of thermal insulation to store heat
4. Top quality windows with high R-values – up to triple glazed with argon fill and low-e coatings on two surfaces

Premise – what you don't "lose" you don't have to create or power…. So make sure that you keep it! *(…NEGAwatts)*

Passive Heating Strategies:
Maximize Solar Gain

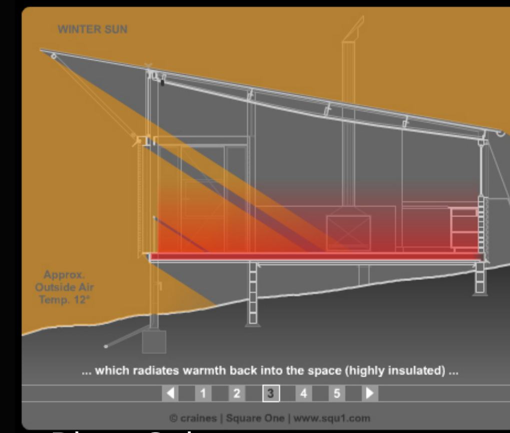
1. primarily south facing windows
2. proportion windows to suit thermal mass and size of room(s)

3 MAIN STRATEGIES:

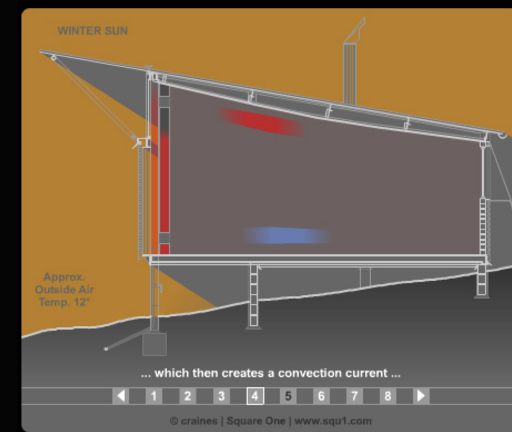
Direct Gain (most architectural)

Thermal Storage Wall

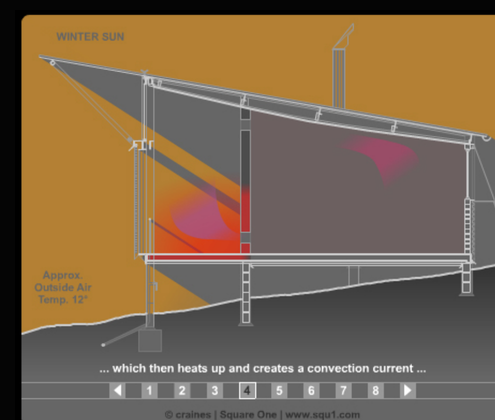
Sunspace



Direct Gain



Trombe Wall



Sun Space

Source: Square One Archives (http://squ1.com/archive/)

Thermal Mass is Critical!

To ensure comfort to the occupants….

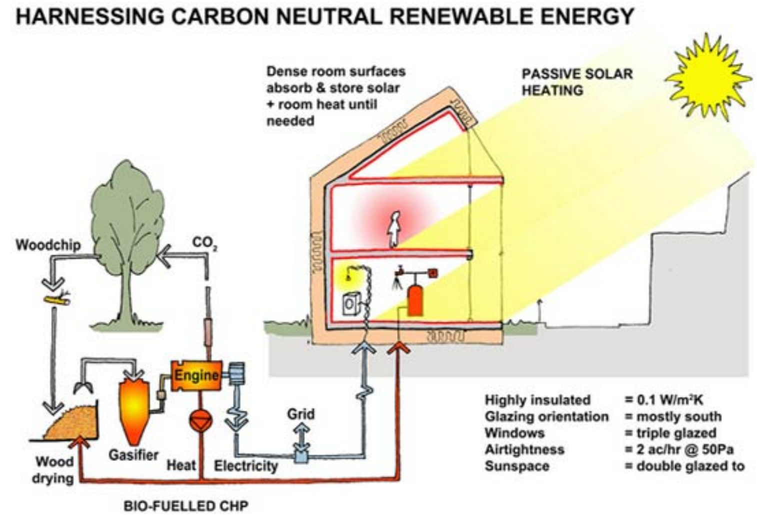
People are 80% water so if they are the only thermal sink in the room, they will be the target.

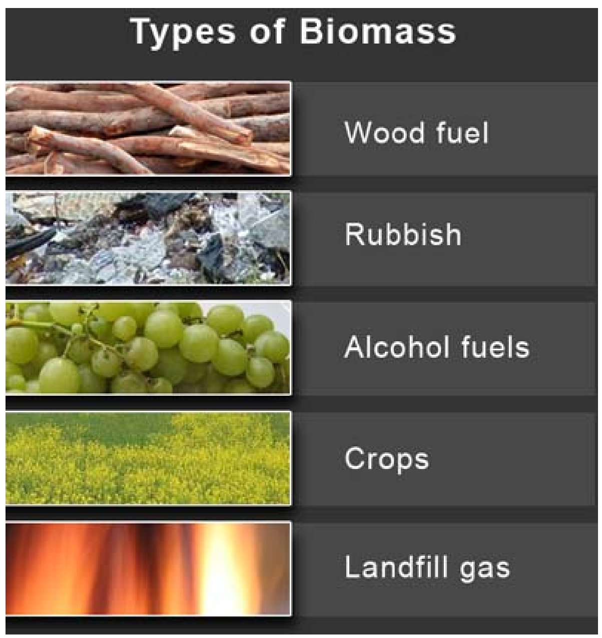
And to store the FREE energy for slow release distribution….

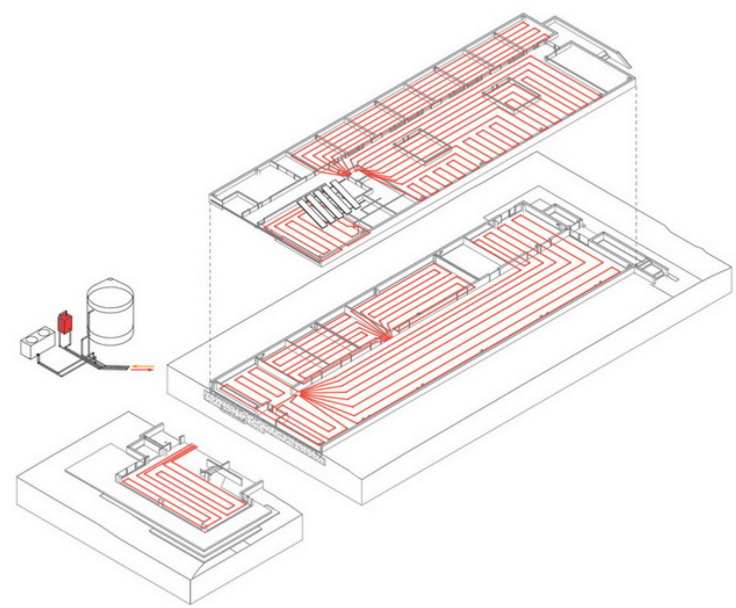
Aldo Leopold Legacy Center: Concrete floors complement the insulative wood walls

Passive Heating Strategies:
Use Renewables for Additional Heating

- Combined heat and power
- Biomass
- Geo exchange systems
- Radiant heating systems
- <u>Verify carbon status of source</u>

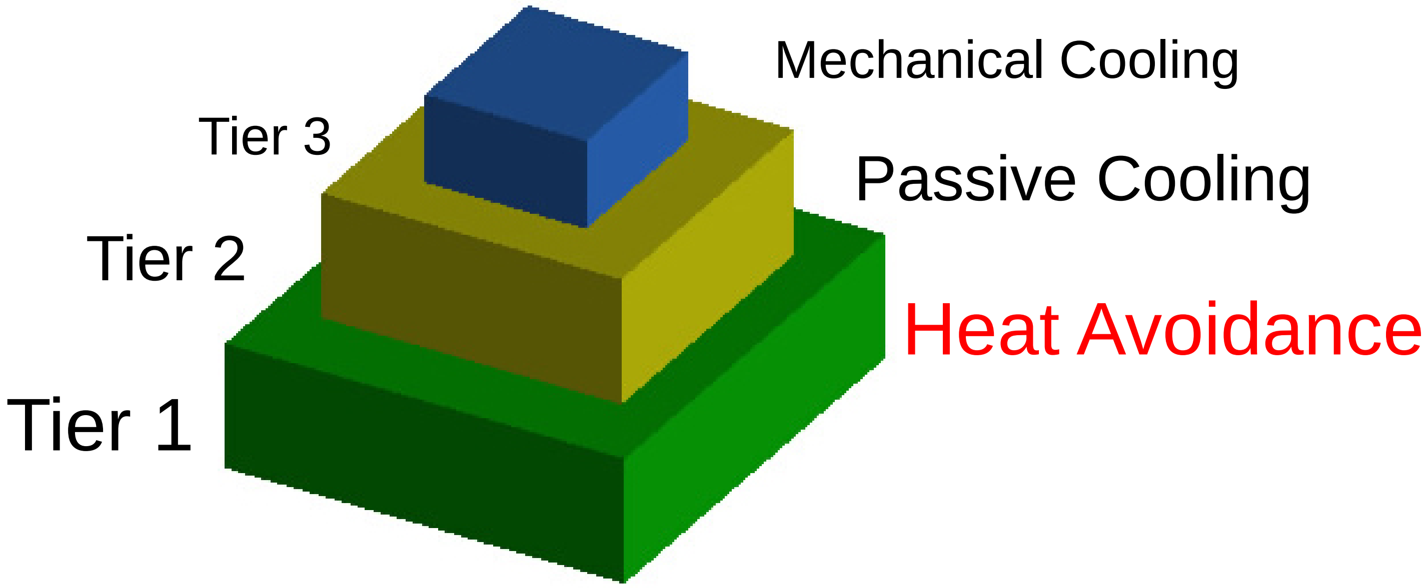






Reduce loads: Passive Strategies

The tiered approach to reducing carbon for COOLING:



Maximize the amount of energy required for mechanical cooling that comes from renewable sources.

Source: Lechner. Heating, Cooling, Lighting.

Passive Cooling Strategies:
Heat Avoidance

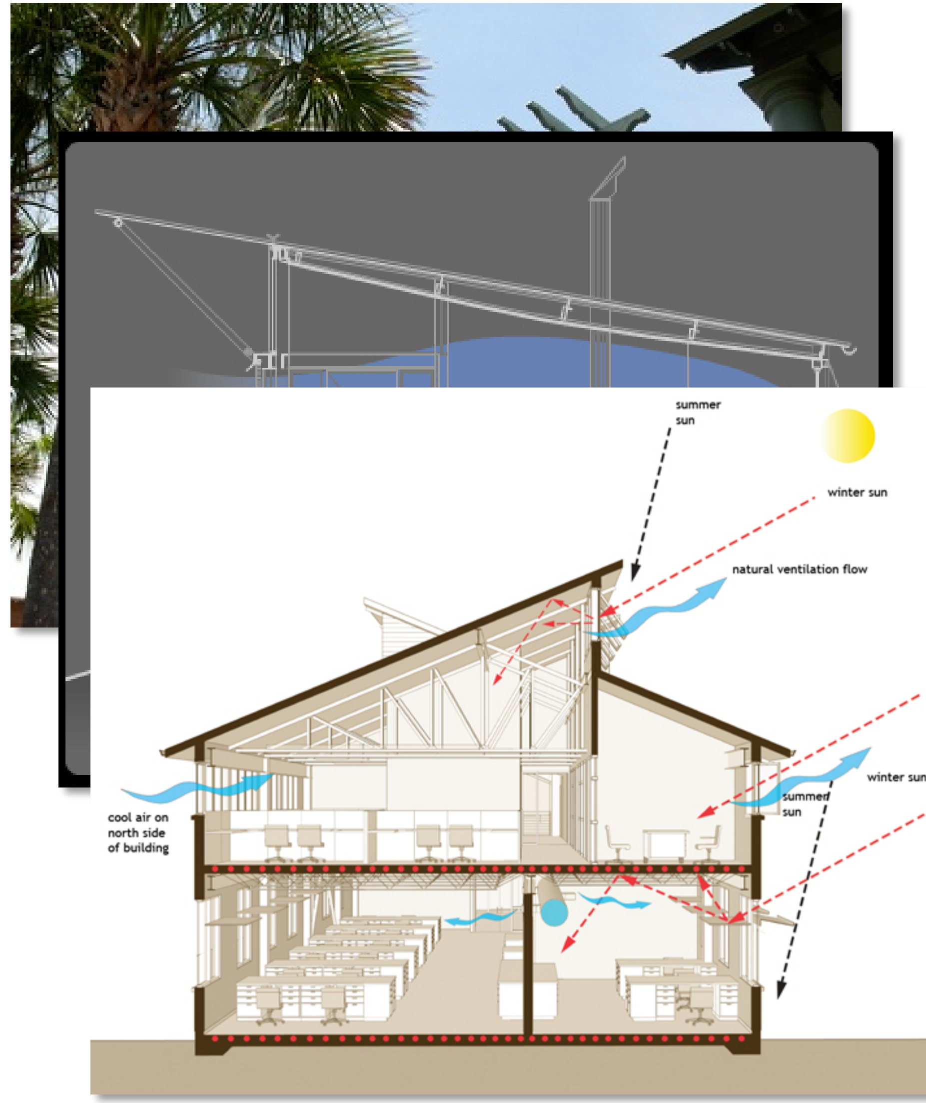
1. shade windows from the sun during hot months
2. design materials and plantings to <u>cool the local microclimate</u>
3. locate trees and trellis' to shade east and west façades during morning and afternoon low sun

If you don't invite the heat in, you don't have to get rid of it…..

Passive Cooling Strategies:

Passive Cooling

1. design for maximum ventilation
2. design plans as open as possible for unrestricted air flow
3. use easily operable windows at low levels with high level clerestory windows to induce stack effect cooling

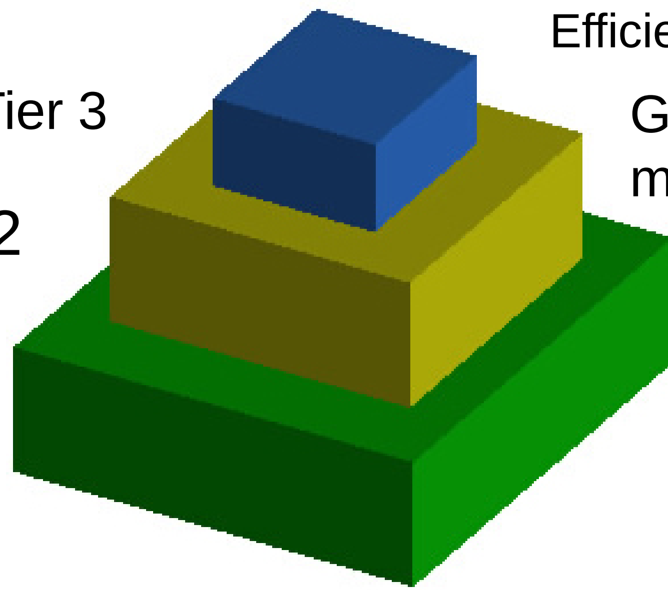


Passive Cooling Strategies:
Use Innovative Means for Cooling

1. wind cowls
2. solar chimneys
3. water features

Reduce loads: Daylighting

The tiered approach to reducing carbon with **DAYLIGHTING**:



Tier 3 — Efficient artificial Lighting w/ sensors

Tier 2 — Glare, color, reflectivity and material concerns

Tier 1 — Orientation and planning of building to allow light to reach maximum no. of spaces

Use energy efficient fixtures!

Maximize the amount of energy/electricity required for artificial lighting that comes from renewable sources.

Source: Lechner. Heating, Cooling, Lighting.

Passive Lighting Strategies:
Orientation and building planning

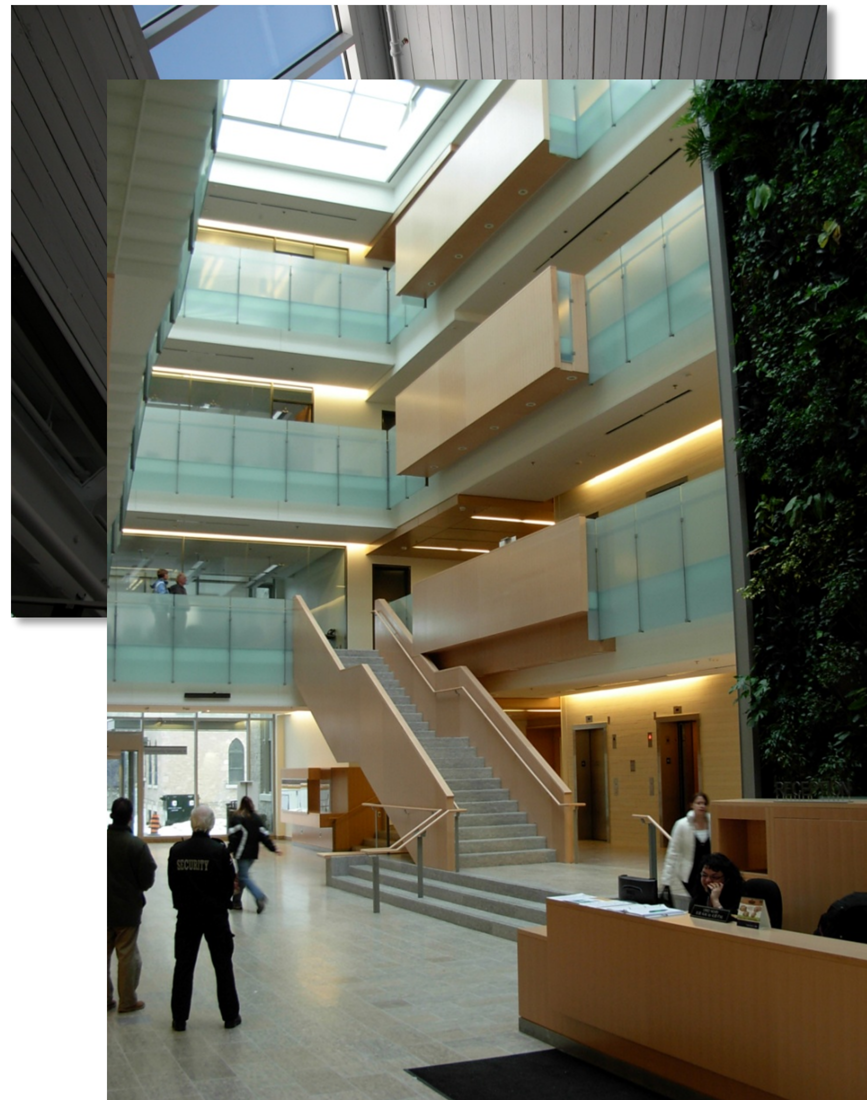
- start with solar geometry
- understand context, sky dome, adjacent buildings and potential overshadowing
- be able to differentiate between sunlight (heat) and daylight (seeing)
- understand occupancy/use requirements
- maximize areas served by daylight
- explore different glazing strategies: side, clerestory, top
- consider light shelves and reflected light

-*(will be looking at daylighting in detail later in the term)*

Passive Lighting Strategies:

Glare, color, reflectivity and materials

- incorporate light dynamics
- avoid glare
- understand the function of material selection; ie. reflectivity and surface qualities
- balance color and reflectivity with amount of daylight provided



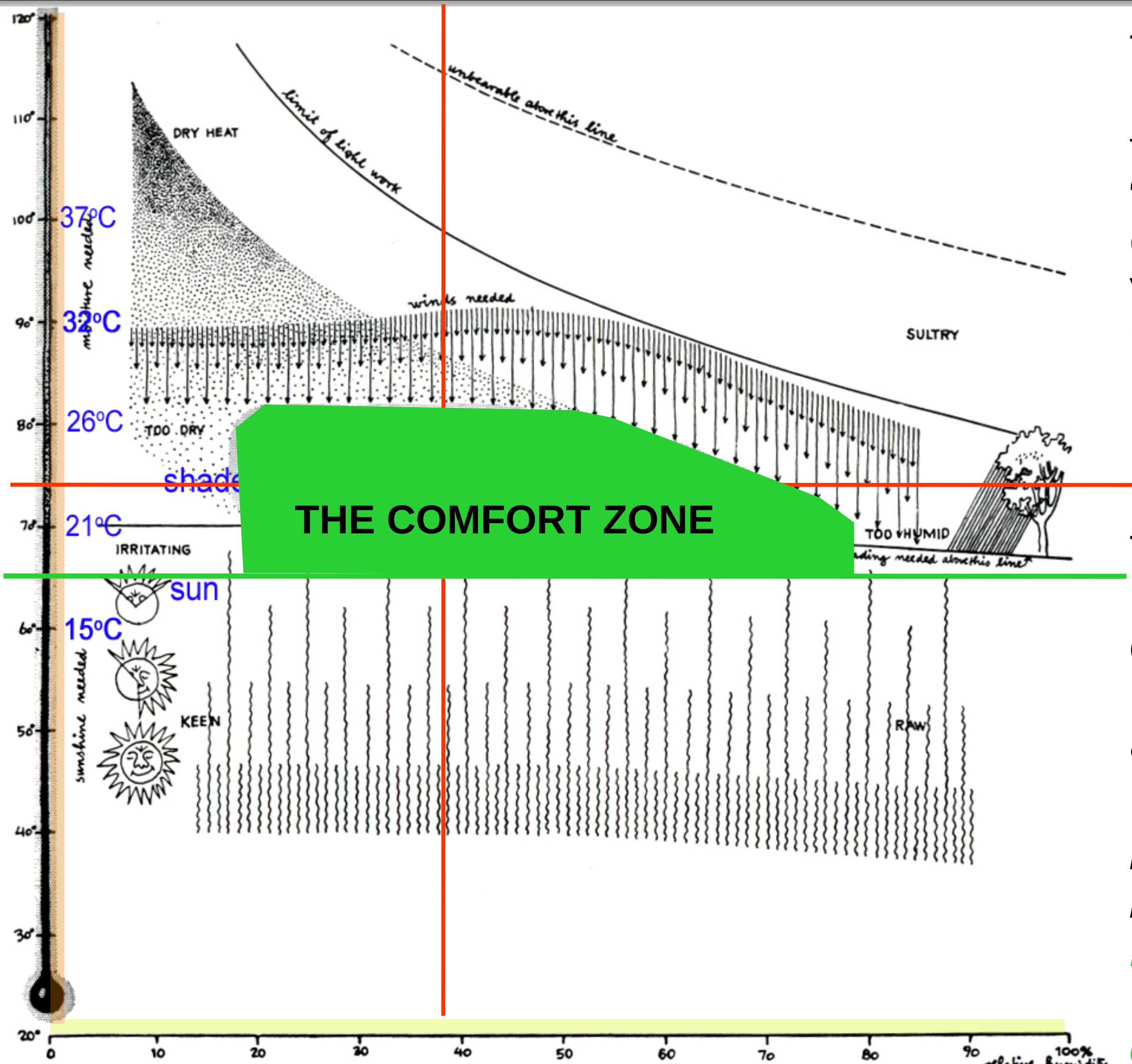
Passive Lighting Strategies:
Energy efficiency and renewables

- use energy efficient light fixtures (and effectively!)
- use occupant sensors *combined with light level sensors*
- aim to only have lights switch on only when daylight is insufficient
- provide electricity via renewable means: wind, PV, Combined Heat and Power plants

Lights on due to occupant sensors when there is adequate daylight – WASTES ENERGY!

REDUCING OPERATING ENERGY

Designing to the **Comfort Zone** vs. Comfort Point:



46. Schematic bioclimatic index.

This famous illustration is taken from “Design with Climate”, by Victor Olgyay, published in 1963.

This is the finite point of expected comfort for 100% mechanical heating and cooling.

To achieve CN, we must work within the broader area AND DECREASE the “line” to 18C – point of calculation of heating degree days.

Passive Bio-climatic Design:
COMFORT ZONE

Comfort expectations may have to be reassessed to allow for the wider “zone” that is characteristic of buildings that are not exclusively controlled via mechanical systems.

Creation of new **“buffer spaces”** to make a hierarchy of comfort levels within buildings.

Require **higher occupant involvement** to adjust the building to modify the temperature and air flow.

Climate as the Starting Point
for a
Climate Responsive Design

North American Bio-climatic Design:

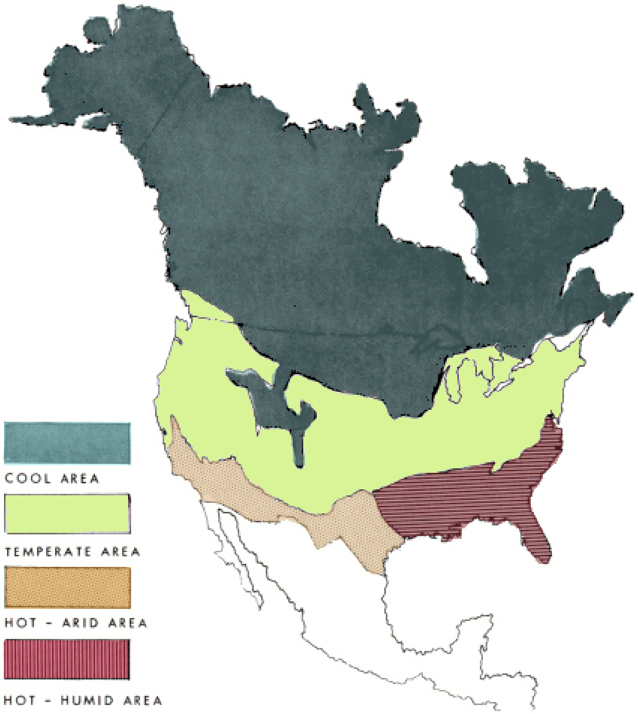
Design must first acknowledge regional, local and microclimate impacts on the building and site.

COLD

TEMPERATE

HOT-ARID

HOT-HUMID

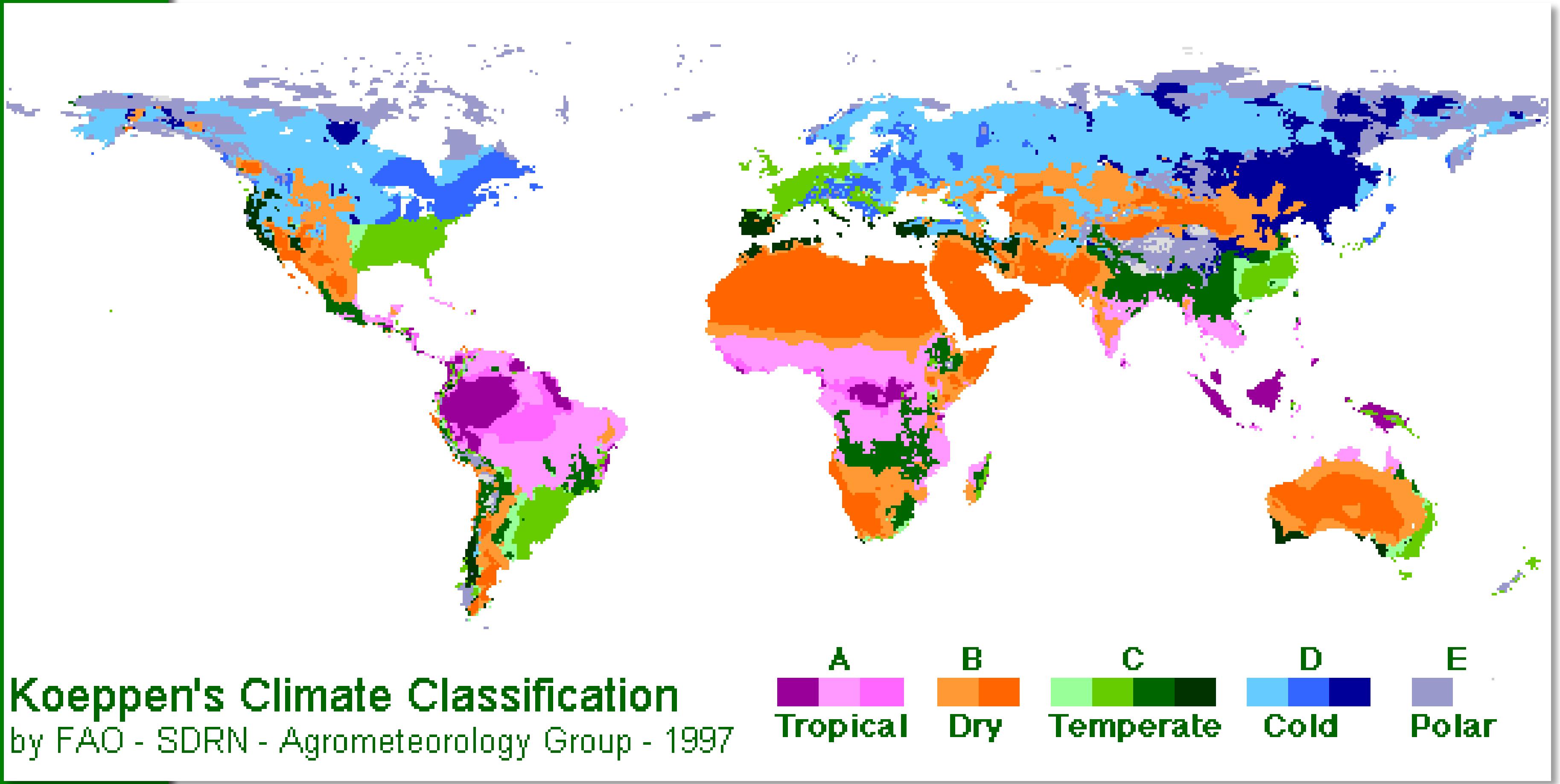


11. Regional climate zones of the North American continent.

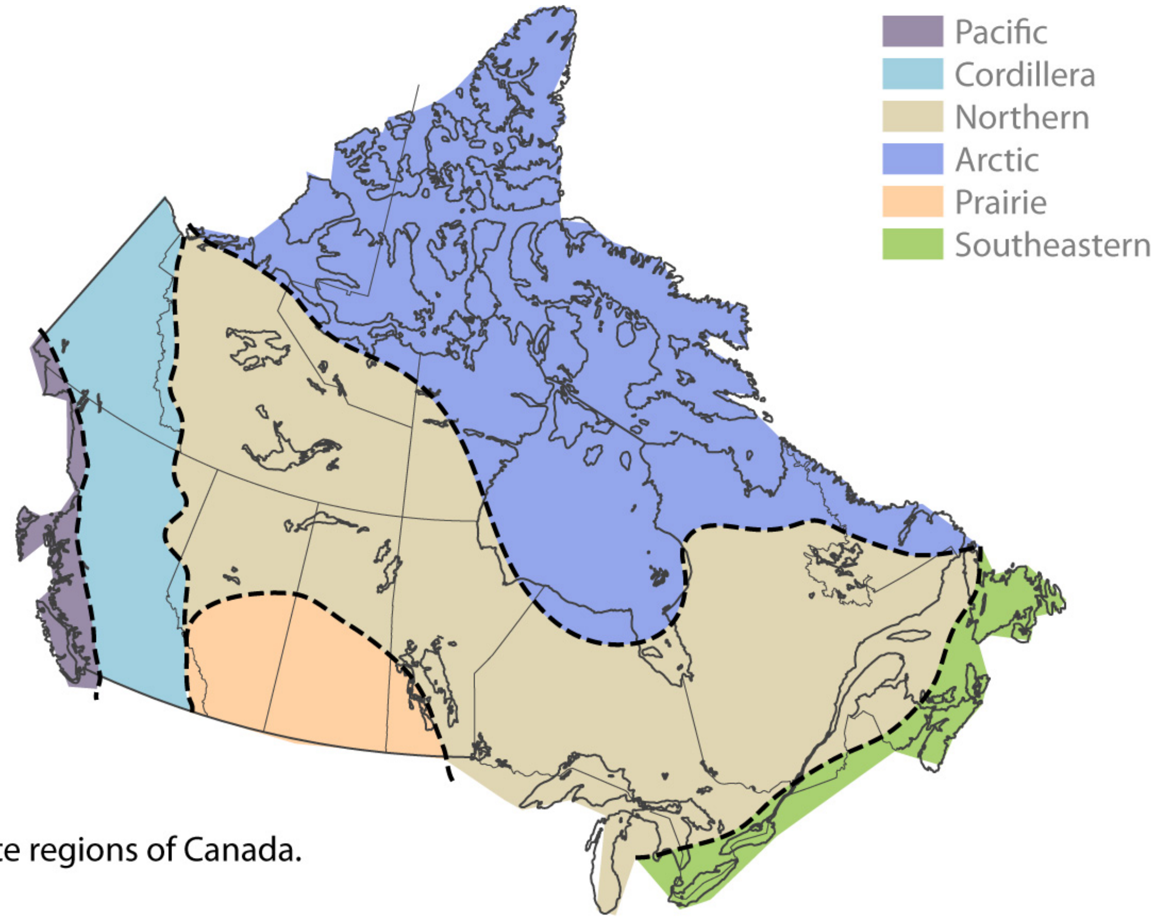
Image: 1963 “Design With Climate”, Victor Olgyay.

Global Bio-climatic Design:

Design must first acknowledge regional, local and microclimate impacts on the building and site.



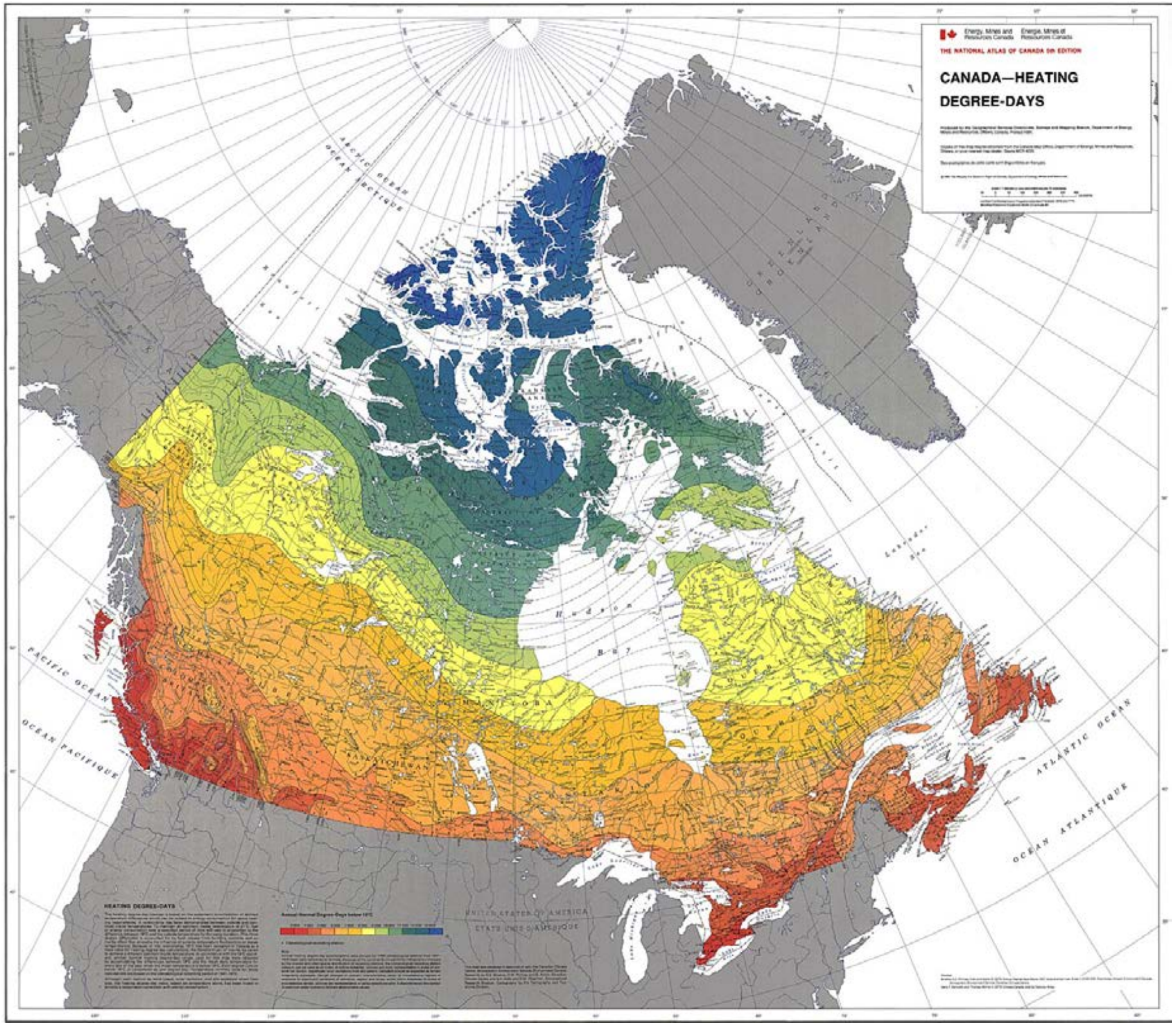
The climate regions of Canada



Climate regions of Canada.

Even within Canada, there exist variations in climate, enough to require very different envelope design practices and regulations. This mostly concerns insulation and water penetration, as well as humidity concerns.

Heating and Cooling Degree Days



This map shows the annual sum of heating degree days (an indicator of building heating needs). Data for period 1941 to 1970. **Determine if the climate is *heating* or *cooling* dominated** …this will set out your primary strategy.

The Goal is Reduction

CLIMATE AS THE STARTING POINT

FOR RETHINKING ARCHITECTURAL DESIGN

Bio-climatic Design: HOT-ARID

Where **very high summer temperatures** with great fluctuation predominate with **dry conditions** throughout the year. **Cooling degrees days greatly exceed heating degree days.**

RULES:

- SOLAR AVOIDANCE: keep DIRECT SOLAR GAIN out of the building
- avoid daytime ventilation
- promote nighttime flushing with cool evening air
- achieve daylighting by reflectance and use of LIGHT non-heat absorbing colours
- create a cooler MICROCLIMATE by using light / lightweight materials
- respect the DIURNAL CYCLE
- use heavy mass for walls and DO NOT INSULATE

Traditional House in Egypt

Bio-climatic Design: HOT-HUMID

Where **warm to hot** stable conditions predominate with **high humidity** throughout the year. **Cooling degrees days** **greatly exceed heating degree days.**

RULES:

- **SOLAR AVOIDANCE** : large roofs with overhangs that shade walls and to allow windows open at all times
- **PROMOTE VENTILATION**
- **USE LIGHTWEIGHT MATERIALS** that do not hold heat and that will not promote condensation and dampness (mold/mildew)
- *eliminate basements and concrete*
- use STACK EFFECT to ventilate through high spaces
- use of COURTYARDS and semi-enclosed outside spaces
- use WATER FEATURES for cooling

House in Seaside, Florida

Bio-climatic Design: TEMPERATE

The summers are hot and humid, and the winters are cold. In much of the region the topography is generally flat, allowing cold winter winds to come in form the northwest and cool summer breezes to flow in from the southwest. **The four seasons are almost equally long.**

RULES:

- BALANCE strategies between COLD and HOT-HUMID
- maximize flexibility in order to be able to modify the envelope for varying climatic conditions
- understand the natural benefits of SOLAR ANGLES that shade during the warm months and allow for heating during the cool months

IslandWood Residence, Seattle, WA

Bio-climatic Design: COLD

Where **winter** is the dominant season and concerns for conserving heat predominate all other concerns. **Heating degree days greatly exceed cooling degree days**.

RULES:

- First **INSULATE**
- *exceed* CODE requirements (DOUBLE??)
- minimize infiltration (build tight to reduce air changes)
- Then **INSOLATE**
- **ORIENT AND SITE THE BUILDING PROPERLY FOR THE SUN**
- maximize south facing windows for easier control
- fenestrate for **DIRECT GAIN**
- apply **THERMAL MASS** inside the building envelope to store the FREE SOLAR HEAT
- create a sheltered MICROCLIMATE to make it LESS cold

YMCA Environmental Learning Centre, Paradise Lake, Ontario

Reduce, Renew, Offset

And, a *paradigm shift* from the recycling 3Rs…

Reduce - build less, protect natural ecosystems, build smarter, build efficiently

Renew - use renewable energy, restore native ecosystems, replenish natural building materials, use recycled and recyclable materials

Offset - compensate for the carbon you can't reasonably eliminate, focus on local offset projects

Net impact reduction of the project!

source: www.buildcarbonneutral.org

The Importance of Impact Reduction:

If the **impact** of the building is NOT reduced, it may be *impossible* to reduce the CO_2 to zero. Because:

Site and location matter.

- **Design for bio-regional site and climate**
- **Orientation for passive heating, cooling and daylighting**
- Brownfield or conserved ecosystem?
- Urban, suburban or rural?
- Ability to restore or regenerate ecosystems
- All determine *potential* for carbon sequestration on site

The buildings at IslandWood are located with a “solar meadow” to their south to take advantage of solar heating and daylighting.

7 Impacts source: www.buildcarbonneutral.org

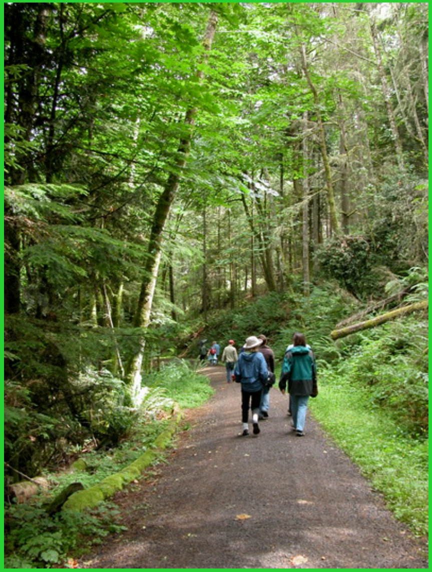
Disturbance is impact.

- Protect existing soil and vegetation
- Design foundations to minimize impact
- Minimize moving of soil
- Disturbance changes existing ecosystems, natural habitats and changes water flow and absorption
- Disturbed soil releases carbon
- Disturbance can kill trees, lowering site potential for carbon reduction
- Look at the potential for reusing materials on site

Difficult foundations for a treed, sloped site for the Grand House Student Cooperative in Cambridge, Ontario, Canada

Natural ecosystems sequester carbon.

- Carbon is naturally stored below ground and is released when soil is disturbed
- Proper treatment of the landscape can keep this carbon in place *(sequestration)*
- Proper treatment of the landscape can be designed to store/accumulate/sequester more carbon over time
- Verify landscape design type with your *eco-region* – use of indigenous plant material requires less maintenance/water – healthy plants absorb more CO_2
- Possible to use the natural ecosystems on your site to assist in lowering the carbon footprint of your project



The natural site is preserved at IslandWood, Bainbridge Island.

Smaller is better.

- ***Simple!***…**less** building results in **less** embodied carbon; i.e. **less** carbon from materials used in the project, **less** requirements for heating, cooling and electricity….

- Re-examine the building program to see what is *really* required

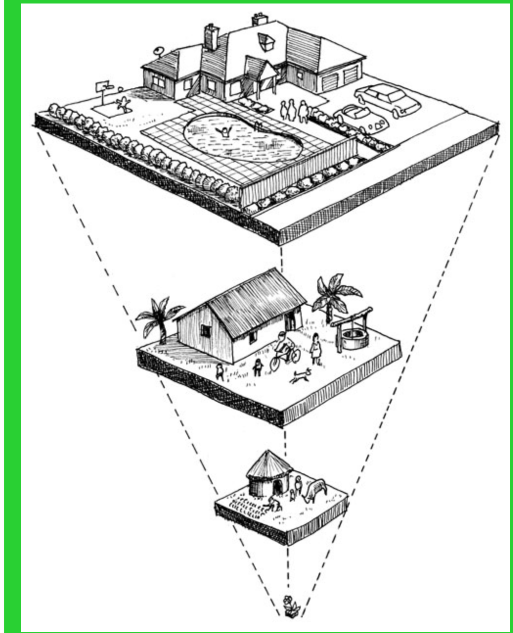
- How is the space to be used?

- Can the program benefit from more inventive double uses of spaces?

- Can you take advantage of outdoor or more seasonally used spaces?

- **How much building do you *really* need?**

- **Inference of LIFESTYLE changes**



Calculating your "ecological footprint"

… can naturally extend to an understanding of your "carbon footprint"

Source: http://www.cycleoflife.ca/kids/education.htm

Buildings can help to sequester carbon.

- The materials that you choose can help to reduce your carbon footprint.

- Wood from certified renewable sources, wood harvested from your property, or wood salvaged from demolition and saved from the landfill can often be considered net carbon sinks.

- Planting new trees can help to compensate for the carbon released during essential material transport

- Incorporating *green roofs* and *living walls* can assist in carbon sequestration

Green roof at White Rock Operations Center, White Rock, B.C.

Green roof at Vancouver Public Library

Material choice matters.

- Material choice can reduce your building's *embodied* carbon footprint.
- Where did the material come from?
- Is it local?
- Did it require a lot of energy to extract it or to get it to your building?
- Can it be replaced at the source?
- Was it recycled or have significant post consumer recycled content?
- Can it be recycled or reused *easily;* i.e. with minimal additional energy?
- Is the material durable or will it need to be replaced *(lifecycle analysis)?*

Note: many of these concerns are similar to what you might already be looking at in LEED™

Foster's GLA – may claim to be high performance, but it uses many high energy materials.

Green on the Grand, Canada's first C-2000 building chose to import special windows from a distance rather than employ shading devices to control solar gain and glare.

Reuse to reduce impact.

- Reuse of a building, part of a building or elements reduces the carbon impact by avoidance of using new materials.
- Make the changes necessary to improve the operational carbon footprint of an old building, before building new.
- Is there an existing building or Brownfield site that suits your needs?
- Can you adapt a building or site with minimal change?
- Design for disassembly (Dfd) and eventual reuse to offset future carbon use

The School of Architecture at Waterloo is a reused factory on a remediated Brownfield site.

All of the wood cladding at the YMCA Environmental Learning Center, Paradise Lake, Ontario was salvaged from the demolition of an existing building.