Understanding the General Principles of the Double Skin Façade System

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Double skin façade systems are employed increasingly in high profile buildings, designed by famous Architects, using acclaimed engineering consultants, and being touted as an exemplary "green" building strategy. It is a new technology that is more often found in high-end European and Pacific Rim architecture, and far less often in North American building. For the majority of mainstream architects, double skin technology remains elusive. From perspectives of both knowledge and budget, double skin systems are often beyond the scope of most commercially driven, North American projects. The question arises as to whether or not double skin buildings truly are more environmentally responsible and sustainable. Is North American commercial architecture missing out on potential energy and environmental savings?

The Double Skin Façade is based on the notion of exterior walls that respond dynamically to varying ambient conditions, and that can incorporate a range of integrated sun-shading, natural ventilation, and thermal insulation devices or strategies. Early modern architects such as Le Corbusier, with his "mur-neutralisant"[5], and Alvar Aalto, in the window design of the Paimio Sanitorium, explored this new building technology. Early solar passive design exemplified in the "trombe" wall, is also viewed as a precursor to modern double skin systems.[6] Only recently has double skin technology become analogous with explorations in transparent and glass architecture, and moreover, acclaimed as environmentally "responsible" design.

This paper represents the findings of a team of upper level B.Arch. and Masters students who have conducted an initial investigation into double skin cladding systems.

CLASSIFICATION OF DOUBLE SKIN FAÇADE SYSTEMS BY TYPE:

The double skin façade is normally a pair of glass "skins" separated by an air corridor. The main layer of glass is usually insulating. The air space between the layers of glass acts as insulation against temperature extremes, winds, and sound. Sun-shading devices are often located between the two skins. All elements can be arranged differently into numbers of permutations and combinations of both solid and diaphanous membranes.[7]

As there are numerous variations in the construction types for double skin facades, it is necessary to create a classification system in order to assess and compare the merits of the various systems as well as the “environmental success” of one building’s skin versus another. In North American based typology three types of general systems are recognized. [8] These refer to the method of classification contained in the Architectural Record Continuing Education article titled, “Using Multiple Glass Skins to Clad Buildings”, by Werner Lang and Thomas Herzog. Lang and Herzog cite three basic system types: Buffer System, Extract Air System and Twin Face System. The three systems vary significantly with respect to ventilation method and their ability to reduce overall energy consumption.

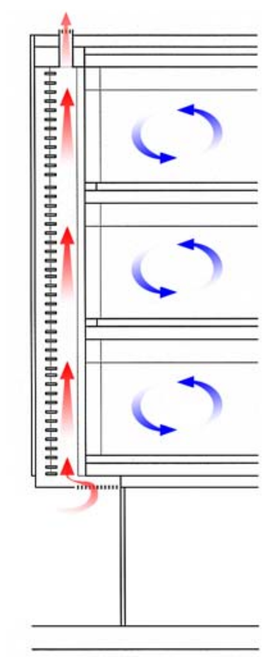

Figure 1:
Buffer System

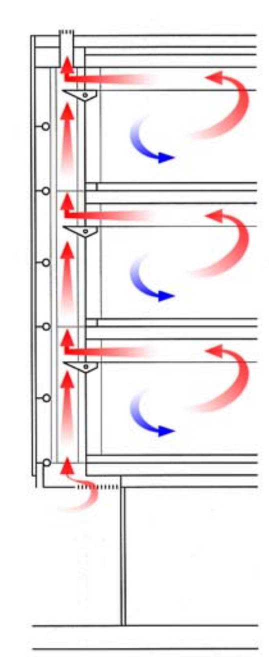

Figure 2:
Extract-Air System

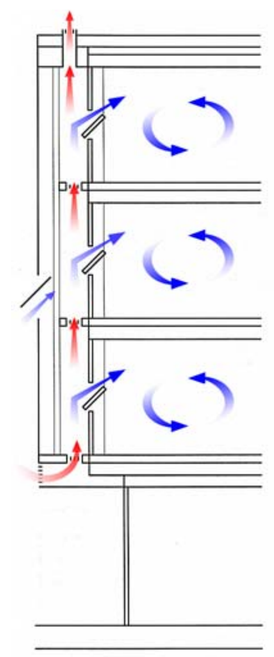

Figure 3:
Twin-Face System

Buffer System:
These façades date back some 100 years and are still used. They predate insulating glass and were invented to maintain daylight into buildings while increasing insulating and sound properties of the wall system. They use two layers of single glazing spaced 250 to 900 mm apart, sealed and allowing fresh air into the building through additional controlled means – either a separate HVAC system or box type windows which cut through the overall double skin. Shading devices can be included in the cavity. A modern example of this type is the Occidental Chemical/Hooker Building in Niagara Falls, New York. This building allows fresh air intake at the base of the cavity and exhausts air at the top.

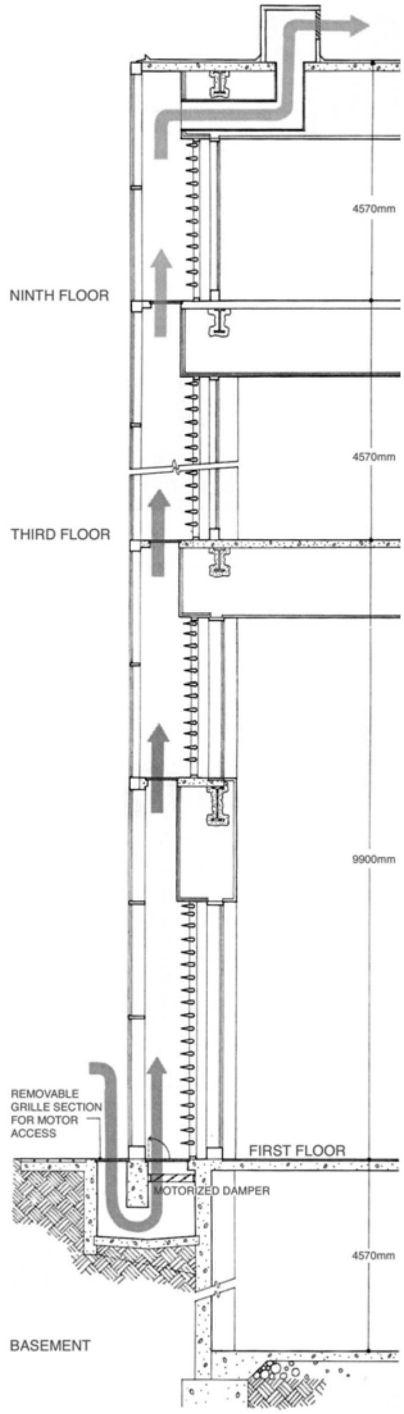

Figure 4:

Wall section of the Hooker Chemical Building illustrating a classic buffer façade application that does not allow for fresh air nor mixes the cavity air with the mechanical system.

Extract Air System:

These are comprised of a second single layer of glazing placed on the interior of a main façade of double-glazing (thermopane units). The air space between the two layers of glazing becomes part of the HVAC system. The heated "used" air between the glazing layers is extracted through the cavity with the use of fans and thereby tempers the inner layer of glazing while the outer layer of insulating glass minimizes heat-transmission loss. Fresh air is supplied by HVAC and precludes natural ventilation. The air contained within the system is used by the HVAC system. These systems tend not to reduce energy requirements as fresh air changes must be supplied mechanically. Occupants are prevented from adjusting the temperature of their individual spaces. Shading devices are often mounted in the cavity. Again the space between the layers of glass ranges from around 150 mm to 900 mm and is a function of the space needed to access the cavity for cleaning as well as the dimension of the shading devices. This system is used where natural ventilation is not possible (for example in locations with high noise, wind or fumes).

Twin Face System:
This system consists of a conventional curtain wall or thermal mass wall system inside a single glazed building skin. This outer glazing may be safety or laminated glass or insulating glass. Shading devices may be included. These systems must have an interior space of at least 500 to 600 mm to permit cleaning. These systems may be distinguished from both Buffer and Extract Air systems by their inclusion of openings in the skin to allow for natural ventilation. The single-glazed outer skin is used primarily for protection of the air cavity contents (shading devices) from weather. With this system, the internal skin offers the insulating properties to minimize heat loss. The outer glass skin is used to block/slow the wind in high-rise situations and allow interior openings and access to fresh air without the associated noise or turbulence.

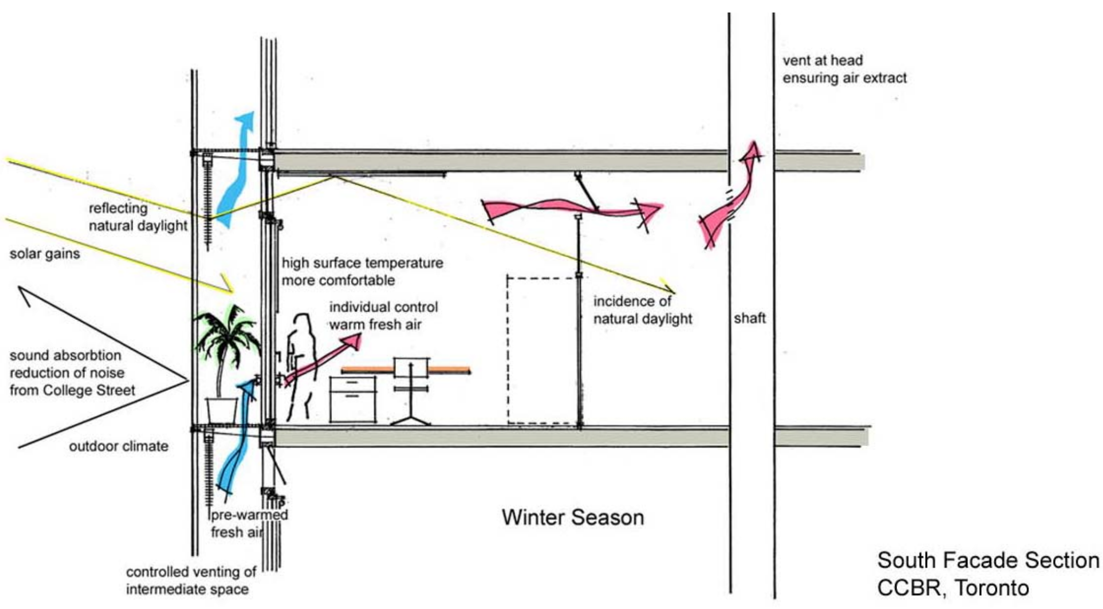

Figure 5:
Winter condition of the south façade of the CCBR at University of Toronto

Windows on the interior façade can be opened, while ventilation openings in the outer skin moderate temperature extremes within the façade. The use of windows can allow for night-time cooling of the interior thereby lessening cooling loads of the building's HVAC system. For sound control, the openings in the outer skin can be staggered or placed remotely from the windows on the interior façade. The Telus Building in Vancouver and the proposed CCBR at the University of Toronto would all typify the Twin-Face type.

The above classification system presumes a façade comprised principally of glass layers. The students investigated "other" methods of using double skin systems, that included more opaque elements, and screen elements that are used to control the amount of heat, solar gain, and ventilation in buildings. It was recognized that these buildings did not conform to the three primary categories. A fourth category was added that could accommodate variations of the twin-face and extract-air systems.

Hybrid System:
The hybrid system combines various aspects of the above systems and is used to classify building systems that do not "fit" into a precise category. Such buildings may use a layer of screens or non-glazed materials on either the inside or outside of the primary environmental barrier. The Tjibaou Center in New Caledonia by Renzo Piano may be used to characterize this type of Hybrid system.

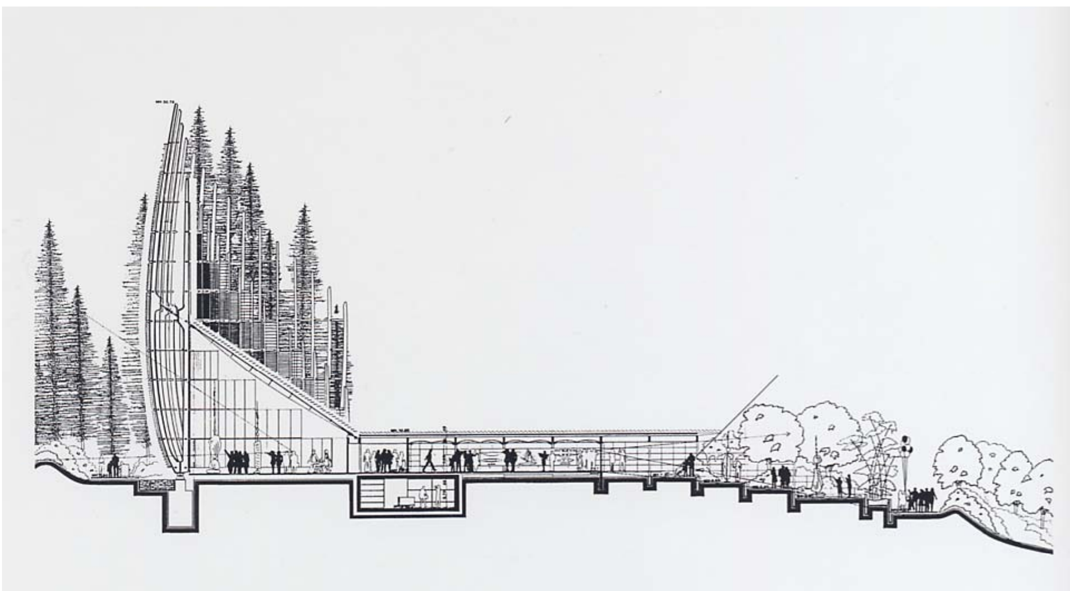

Figure 6:
Cross section of the Tjibaou Center by Piano illustrating the use of a hybrid system

The Air Space:
Appropriate design of the air space is crucial to the double façade. Variations allow for improved airflow, sound control and other benefits. The actual size of the airspace (non leasable area), not the expense of the additional glass layer, can be the economic factor that deters commercial implementation of these systems. The cavity in the Occidental Chemical building is 1.5 m wide. The cavity in the Caisse du Depot et Placement in Montreal is 150 mm wide. As a result of the reduction in air space with, to the casual

observer and office occupant, the wall section at the CDP does not greatly differ from a traditional façade system that incorporated both fixed and operable glazing panels.

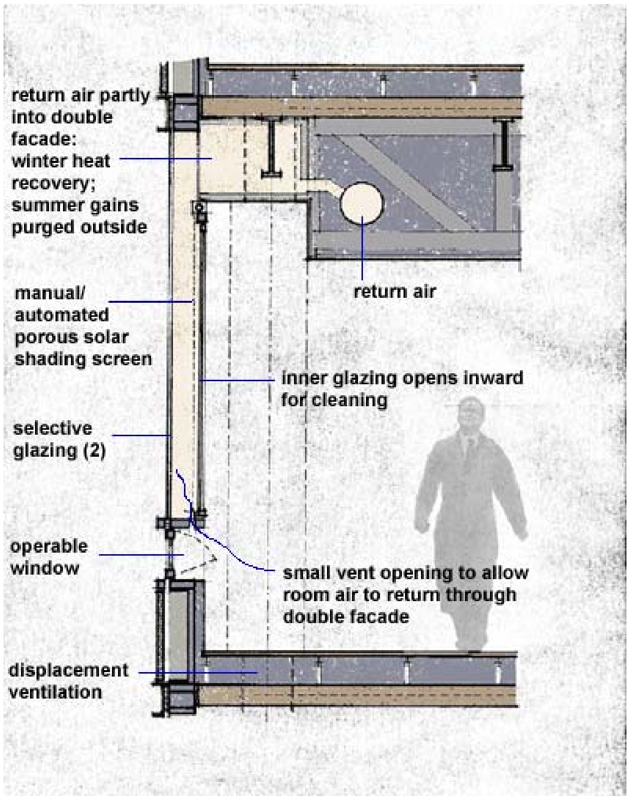

Figure 7:
Wall section detail of the CDP

Figure 8:
Interior view of the office space

The air cavity can be continuous vertically (undivided) across the entire facade to draw air upward using natural physics principals (hot air rises), divided by floor (best for fire protection, heat and sound transmission), or be divided vertically into bays to the optimize the stack effect.

The Undivided Air Space:

The undivided façade benefits from the stack effect. On warm days hot air collects at the top of the air space. Openings at the top of the cavity siphon out warm air and cooler replacement air is drawn in from the outside. However, without openings at the top of the cavity, offices on the top floors can suffer from overheating due to the accumulation of hot air in the cavity adjacent to their space. The undivided air space can be transformed into atria, allowing people to occupy this "environmentally variable interstitial space".[9] The atria/air cavity can be used programmatically for spaces with low occupancy (meeting rooms or cafeterias). Plants are used in these spaces to filter and moisten the air as well as act as shading devices.

The Divided Air Space:

The divided air space can reduce over-heating on upper floors as well as noise, fire and smoke transmission. Floor-by-floor divisions add construction simplicity of a repeating unit and in turn can produce economic savings. Corridor façades (commonly used in twin-face façades) have fresh air and exhaust intakes on every floor allowing for maximum natural ventilation. Shaft facades (divided into vertical bays across the wall), draw air across the façade through openings allowing better natural ventilation. However, the shaft façade becomes problematic for fire-protection, sound transmission and the mixing of fresh and foul air.[10]

Cleaning the Air Space:
The design of the air space also impacts cleaning. The continuous cavity, as can be seen in both the Hooker and Telus buildings, uses either a bosun's chair or platform, similar to a window-washing rig, to access the interior of the space for cleaning. Any louvers that are located within the cavity must be able to be moved to facilitate access. In some air spaces designers put open grates at each floor level. These still permit airflow through the space but provide a platform upon which to stand when cleaning the cavity floor by floor. In some instances, where the cavity is more divided, the interior windows, whether operable for ventilation or not, will function as access panels for cleaning crews to enter the space for maintenance. Where there has to be occupation of the air space for cleaning, the interior clear dimension is usually in the 600 to 900 mm range. Where the dimensions are small, cleaning is done from within the office space and requires that interior window panels open fully to provide adequate access for cleaning.

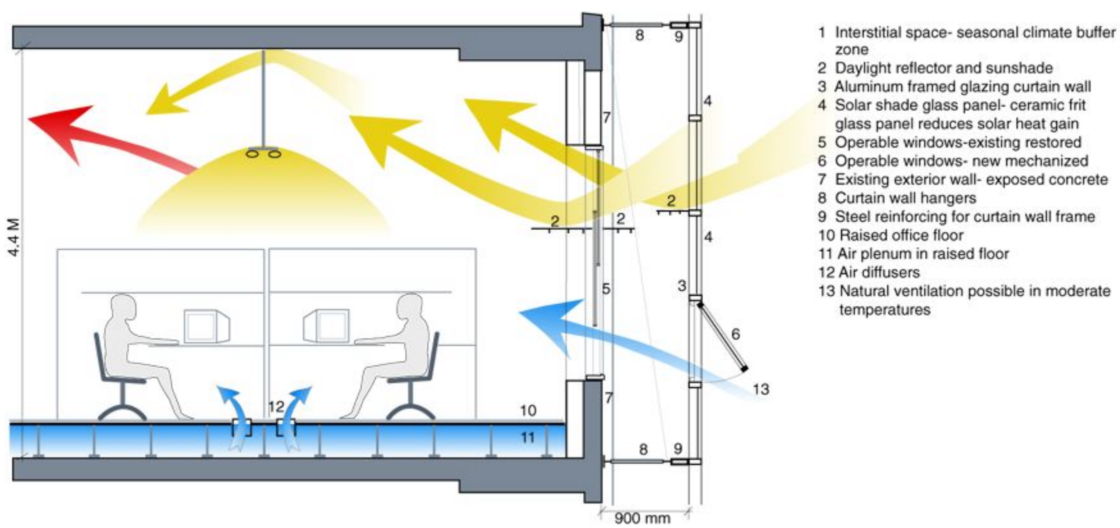

Figure 9:
The room section at Telus, Vancouver

If the aesthetic drive behind the use of the fully glazed double façade is key, maintenance is critical. Research would indicate that full cleaning is carried out anywhere from 2 to 4 times a year and is a function of the cleanliness of the air that is passing through the space. Where the early design of the Hooker building (1983) provided a continuous cavity and fully open grilles at the base for continuous intake air, the Telus Building (2001), includes timed dampers to close off the air intakes at the base during times of peak traffic.

One of the chief concerns with cold climate implementation of the double façade system is the potential for build up of condensation in the additional air space. It is essential for high volume air-flow of warmed air through the cavity to prevent/evaporate any condensation that may occur. The CDP uses the air space for hot-air return, feeding the used air to the return air system at the top of each window cavity. [Fig. 7]

THE DYNAMIC BUFFER ZONE: A CANADIAN RESEARCH RESPONSE

Canadian researchers, under the original direction of the late Kirby Garden, have developed a variation of the classic glazed double façade system. The initial application for this system is in the retrofit of existing (historic) buildings with exterior uninsulated masonry cavity walls. In this system, dry conditioned air is forced into and out of the interstitial cavity spaces by means of a dedicated mechanical system in a way to constantly ensure positive pressure within the cavities relative to their environments. This eliminates moisture accumulation from either the interior or exterior sources within the assemblies. These assemblies can then be maintained at relatively constant temperatures, distanced from the dewpoint, minimize freeze thaw damage and maintain comfort levels on the interior.

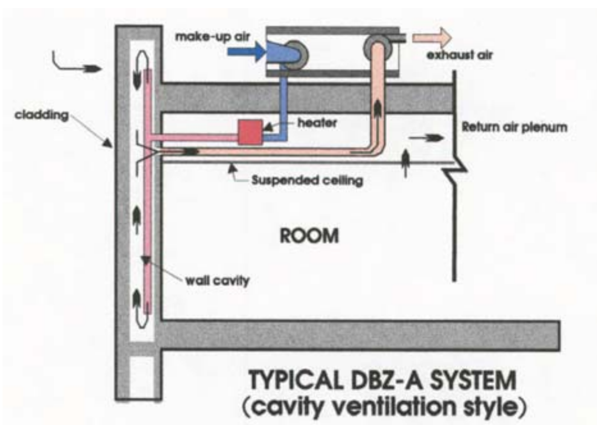

Figure 10:
DBZ with ventilated cavity

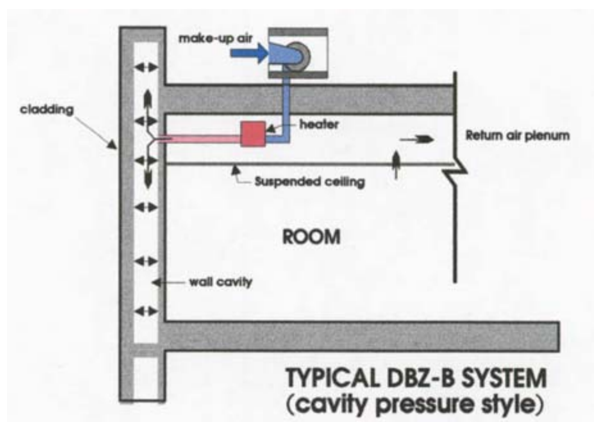

Figure 11:
DBZ with pressurized cavity

In the ventilated cavity system [Fig. 10] the construction cavities are ventilated with dry outdoor air and pressure relieved/controlled through a return or exhaust system. In the pressurized cavity system [Fig. 11] the construction cavities are pressurized slightly above the indoor pressure of the building with preheated outdoor air without a pressure relief or return air system. The pressurized system has been more successfully applied partly as a result of its less complicated/equipment intensive design.[11]

THE COMPONENTS OF DOUBLE SKINS FAÇADES AND PASSIVE DESIGN: [12]

The double skin façade incorporates the passive design strategies of natural ventilation, daylighting and solar heat gain into the fabric of the high-rise building. These are the key components of the double skin façade in respect to energy efficiency and comfort that are controlled by the occupants of certain types of double skin façades.

Natural Ventilation:
Natural ventilation allows the inhabitant access to air-flow that can be used to cool and ventilate the space. This passive use of air currents over mechanical means of air-conditioning reduces the energy consumption of the building and in turn reduces the CO_2 output of the building in the operational phase of the building. The exterior glazing of the double skin creates a layer of air next to the exterior wall of the building that is not affected by high velocity wind. This buffer zone, a key component to the double skin façade, is typically the region accessible by the inhabitants for natural ventilation. In some instances the use of operable windows in the exterior glazing skin is also used for natural ventilation. These operable windows would be subject to the high velocity winds prevalent at the higher altitudes of multistory buildings.

> "*The reduction of wind pressure by the addition of the extra pane of glass means that the windows can be opened even in the uppermost floors of a high-rise building. Natural ventilation of offices by fresh air is much more acceptable to the building's users and it has the additional benefits of reducing investment in air handling systems and also reducing energy consumption."* [13]

A typical strategy of the double skin façade is to compartmentalize the buffer zone into separate regions with air supplied by grilles or vents at each level or individual zone, as in the Stadttor building in Duddeldorfer by Petzinka, Pink and Partners. This compartmentalization eliminates the impact of noise, sound, smoke and heat transfer from one section, level or room to the next area. The use of vents or grilles allows for the control of the incoming air by reducing air velocity, protecting from rain and reducing noise transmission from the exterior. It is this control that allows occupant access to natural ventilation in high-rise constructions.

> "*most effective ways to reduce building services energy consumption is to "exploit natural means and depend less on mechanical techniques"* [14]

Solar Heat Gain:
The control of solar heat gain with the double skin façade is obtained through the use of shading devices contained in the air cavity, typically horizontal blinds, as well as the ability of the cavity itself to absorb some of the incoming solar radiation. Various configurations for these horizontal blind shading devices exist; they can either be fixed elements or, typically, operable units that are either controlled by the occupant or by sensors within the building. On multistory building unprotected external devices are expensive because of installation costs and safety concerns. They are typically fixed and not usually effective for all sun angle conditions especially with low sun angles in the morning or late afternoon. The double skin is important because it offers protection from the elements for the shading devices. The most effective manner to keep incoming solar radiation from heating a room above comfort levels is to prevent heat from initially entering the space. External shading devices are the most efficient means of reducing solar heat gain in a highly glazed building. The horizontal blind allows for continued use of daylighting and maintains some of the view to the exterior.

The air space itself has the ability to draw off some of the initial solar radiation captured in this zone. Convection currents carry the heated air upwards and would then be extracted to the exterior through the venting arrangement at the top of the cavity.

> "*A double-skin façade also reduces heat losses because the reduced speed of the air flow and the increased temperature of the air in the cavity lowers the rate of heat transfer on the surface of the glass. This has the effect of maintaining higher surface temperatures on the inside of the glass, which in turn means that the space close to the window can be better utilized as a result of increased thermal comfort conditions"* [15]

This aspect of the buffer zone allows for the increased use of the perimeter zone of the space that typically requires heating or cooling mechanisms against the exposed glazing. Also, with the use of improved solar heat transmission values for glazing the absorption and reflection of heat can be manipulated to minimize solar heat gain. This can be accomplished through the use of what is referred to as 'spectrally selective glazing';

> *"Spectral Selectivity refers to the ability of a glazing material to respond differently to different wavelengths of solar energy – in other words, to admit visible light while rejecting unwanted invisible infrared heat. Newer products on the market have achieved this characteristic, permitting much clearer glass than previously available for solar control glazing. A glazing with a relatively high visible transmittance and a low solar heat gain coefficient indicates that a glazing is selective. Spectrally selective glazing use special absorbing tints or coatings, and are typically either neutral in color or have a blue or blue/green appearance. An ideal spectrally selective glazing admits only the part of the sun's energy that is useful for daylighting."* [16]

The air space and integrated solar shading devices control the solar heat gains that would typically require the use of mechanical means of air conditioning and air extraction.

Daylighting:

Daylighting is important in two ways; first it reduces the amount of electrical lighting required and second is that the quality of light from daylight is preferential to electrical lighting. The double skin façade with its increased glazing coverage improves the access to daylighting in the space. Also important to daylight penetration is floor to ceiling height and floor plan depth.

> *"Good lighting of the workplace is one of the main factors of indoor comfort that can positively influence health and productivity of office personnel. Natural light, its variations and its spectral composition are of great importance for well-being and mental health. Natural light is a fundamental component of our life, helping our body to produce vitamin "D", an important anticancer element."* [17]

The increased daylighting component of the completely glazed façade introduces excessive glare and heat at certain times of the day. These increases require further measures in design to combat their negative effects. Solar shading devices are designed into the air space to decrease solar heat gain through the glazing and reduce the amount of glare caused by the increased access to daylighting.

ENVIRONMENTAL CLAIMS: AN ONGOING DISPUTE

Investigation into double skin systems finds that researchers and practitioners are clearly divided into two opposing camps. The camp in the middle is fairly skeptical and seems to be waiting to be firmly convinced before making a commitment.

The "Pro" camp finds the systems to be environmentally "responsible", netting overall energy savings. The high profile buildings that have used double skin systems for their facades have been pronounced to be "green". The environmental engineers that have been involved in the design and construction of these buildings claim to have test data to substantiate their statements. Some "numbers" have been published that would indicate that significant energy savings are possible. In these articles, energy savings include both mechanical plant (hard costs) and energy to be expended (ongoing operating costs). These savings alone seem to be used to justify the approach.

> *"It is well understood that the double skin façade presents the many advantages over the conventional (single skin) façade. This research, performed by Franklin Andrews, Professor Michael Wigginton of the University of Plymouth and Battle McCarthy, on behalf of the United Kingdom Department of Environment, Transport and Regions has shown that double skin buildings are able to reduce energy consumption by 65%, running costs by 65% and cut CO^2 emissions by 50%, in the cold temperate climate prevalent in the United Kingdom when compared to advanced single skin building. Cost exercises have shown that buildings employing a double skin may cost as little as 2.5% based on Gross internal floor area."* [18] *Battle McCarthy, Environmental Engineers.*

The "Con" camp is skeptical about the "gross" environmental benefits of the double skin system. For some, a significant aspect of the problem emanates from using the glass tower building type as the flagship for this supposedly "green" or environmental building technology.

> *Responding to the concerns of ecologically responsible design, Foster, Kaplicky and Rogers, among others, have incorporated innovative cladding techniques to improve energy efficiency, natural ventilation and natural lighting in their recent architectural projects . These projects have been acclaimed by the architectural press as the leading edge of a new 'green' architecture (Chevin, 1994; Foster, 1993; Russell, 1992a; Welsh, 1993). Most remarkable however, is that these 'green' projects are introduced in the guise of the glass-tower, a form often interpreted as an enemy of ecological sustainability (Vale, 1991, p170; Szokolay 1989).* [19]

There is also concern that whereas significant improvements in tower type building performance may have been achieved in some of the more renowned case studies (such as RWE, Helicon, ING), not all developers that might like to adopt the double skin façade will have either the budget or the engineering assistance to detail and construct the building to achieve the same performance levels.

> *Green-glass-tower as a design concept is flawed both mythologically and technically. Moreover green-glass-towers provide dangerous exemplars to lesser designers, or developers with budgets of more modest proportions. The possibility of uncritical replication of this aesthetic following iconic design procedures (Broadbent, 1973), without sufficient consideration of the complex environmental problems inherent to the glass- tower, render an alliance of ecologically responsible design and glass-tower a risky proposition.* [20]

The opponents additionally cite a wide range of quantities that must be accounted for in determining a final savings value, including, embodied energy, maintenance, life-cycle/durability of the system, mechanical savings (operating cost as well as physical plant), and additional floor area. The bottom line seems to be in the basis of comparison of the insulating value of the double skin system to what sort of wall. Some of the statistics that have been published by the "pro" side compare the double skin system (which is often comprised of a high level Thermopane curtain wall system with an additional glass layer) to a mid level curtain wall system. Comparing a double façade system to a high level curtain wall that uses spectrally selective daylighting would result in a fairer point of departure. Some of the more firmly entrenched in this camp would suggest that the provision of a space to house extensive sun shading devices safely away from the elements would not be an issue at all if such excessive glazing were completely avoided. This is particularly sited as an issue when looking at east and west facing façades.

> *"Reducing cooling load can best be achieved, in approximate order of effectiveness, by using opaque wall elements, shading, and/or solar-control coatings. Many analyses of DF's begin with the assumption that 100% of the vertical enclosure must be transparent. This eliminates the possibility of the most effective means of reducing cooling load."* [21]

The "pro" camp seems to have access to more statistics than does the "con" camp. Indeed, one of the most difficult aspects the students have found in their research has been in finding reliable (independent) statistics upon which to base *any* comparisons. The problem of the availability of relevant, reliable statistics stems from: the lack of published test data; the pro camp is comprised largely of engineering companies that have been retained to design these buildings (i.e. their livelihood has a vested interest in the increase in this market and much of the data seems to be guarded); and, the absence of an agreed base case from which to compare results.

ECONOMIC CONSIDERATIONS: [22]

In the end, there are many different factors that must be weighed when considering the double-skin façade. The particular financial, ecological and social framework of each building must all be taken into account when examining each case study.

Hard Economy: Capital Investment

In Europe double skin façades are twice as expensive as regular cladding systems. In the U.S. they can be four or five times the cost.[23] Cost increases in North America are due to engineering costs (mechanical and structural), the amount of special glass required, and the unfamiliarity of tradespeople with these systems, leading to higher installation costs. In Europe energy (utility) costs are much higher and therefore offset the original investment with a faster return. If the design process fully integrates mechanical and architectural concerns from the beginning, these systems often require less mechanical (HVAC) systems and this also can compensate for the cost of the second façade.

Significant studies in sustainable architectural design have shown that statistically, operating costs (which are largely based on heating, cooling), far exceed the monetary and environmental capital cost of buildings.[24] If double skin buildings can indeed reduce overall long-term operating/energy costs by a reasonable amount, then perhaps the increased initial capital costs can be justified.

Again, whether or not the double skin façade is the "best" choice of system for decreasing energy costs depends upon a complex set of comparative choices. A building comprised of solid, highly insulated walls, will obviously result in much lower energy and maintenance costs, but do little to achieve daylighting and raise workplace design standards.

Social Costs:

The goal of these systems is not only to be environmentally "responsible" but also to greatly improve working conditions for the occupants of these buildings through access to day lighting, natural ventilation and greater control over the workplace atmosphere. Social costs such as employee satisfaction and productivity become factors in calculating cost because content, healthy employees produce and accomplish more. Depending on labor costs, the investment might be worthwhile.[25] Studies of the positive economic benefits of daylighting have already been conducted. Much data has been gathered on the Lockheed Building in California indicating a significant reduction in employee absenteeism that translates quite directly into economic benefits for the employer.

This social ideal is exemplified in the German concept of "Grünkultur" (green culture). This concept is so fundamental to their architectural expression that it has become synonymous with their cultural environmental consciousness and consequently translated into legislation for quality of life. For example, German law mandates that every workstation in new commercial buildings be in direct sunlight.[26] The typical distance from the window to the core is limited, ensuring that all workers are within a maximum distance to a window. The design of office buildings has changed then to preclude the typical ring of perimeter closed offices and the interior windowless open office plan. North America seems to lag behind Europe in mandating the same standards for quality of workspace. Perhaps this is another reason why there are very few double façades in North America.

Other Cost Considerations

When entering the discussion regarding environmental "costing" there are many different factors that require consideration. The extra materials used in constructing the façade (essentially the addition of a whole second building envelope) can be seen as being too excessive to balance the energy cost savings. The embodied energy contained in the double skin system is significantly higher than in an advanced standard curtain wall system -- in some cases double the materials.

Operational costs associated with these systems are lower, however there are much higher maintenance costs. The air cavity must be cleaned because of the air movement within the space circulates dust particles more quickly. A recent visit to the Hooker Building in Niagara Falls, New York, allowed us to take a close-up look at the cavity of this close to 20-year-old building. The construction of the new "Aquarium Attraction" that will directly connect to this building resulted in the unplanned for intake of much construction dust into the cavity. The sun shading louvers were obviously excessively dirty. As a result, the intake grilles at the base of this continuous height cavity have been closed off, causing the HVAC system to malfunction. An interview with security people at the building revealed that the building was always either too hot or too cold.

Life cycle costing must also be taken into account. Many buildings with double skin façades incorporate high-tech mechanics that tend to have a higher failure rate and repair cost. These same mechanics also necessitate higher replacement costs (for example wiring must be replaced after a certain number of years. The more wiring, the higher the costs). Our interview with people at the Hooker Building revealed that the electronic devices controlling the automatic function of the shading louvers failed approximately four years ago. It has not been fixed. Consequently, the majority of the louvers on all four facades have been fixed in a horizontal position, which is most appropriate only for south facing elevations. Tenants have added vertical blinds behind the primary building louvers to continue to have control over shading.

Retrofitting and recyclability are also important factors. The majority of these buildings are corporate in nature. If a company expands they may be required to add additional office space. Are these buildings suitable for expansion? Where retrofitting and recyclability has proven to be the driving force behind the success of the project is in the case of the Telus Building in Vancouver, B.C. The existing building owned by Telus, which was of solid masonry exterior wall construction with "punched" double hung wood windows was cleaned, retained, and clad with a new exterior fully glazed skin. The use of the double skin allowed for the salvaging of the existing structure and the upgrading of the quality of the interior environment. Lower operational costs are also expected.

The Dynamic Buffer Zone approach is also more expensive than a traditional façade system, however it is being targeted at the reuse of historic load bearing masonry and stone buildings. These buildings will rapidly degrade if reused without a hard approach to moisture protection and environmental control of the exfiltration and infiltration aspects of wall performance.

The location of these buildings is also important in relation to the proximity of their occupants' homes. If these buildings are located too remotely, the environmental savings associated with the design and construction of the building itself may not balance the transportation energy costs of their users. The net environmental benefits of two buildings that use precisely the same double skin construction method, may be grossly different if one is located in the city center, on a transit line and the other replaces farmland, is surrounded by a sea of asphalt parking and is inaccessible by public transit. Such complex environmental assessments are best carried out with comprehensive tools such as LEED or BREAM.

DOUBLE SKIN FAÇADES AS A SUSTAINABLE STRATEGY FOR HIGH-RISE BUILDINGS: [27]

Double skin façades technology is a starting point to develop a strategy to integrate high-rise commercial buildings into the realm of sustainable architecture. Not as a comprehensive solution but as a component of an integrated system of building design. Accepting the premise that the fully glazed office tower is not an effective design in terms of energy efficiency in the first place, the introduction of adaptive management strategies and passive energy design with the double skin façade, increases the potential of this building design to come more in line with sustainable architecture.

Double skin façades do offer a potential solution to the glazed office tower in terms of climatic control. The advantages of this system are; improved occupant control over local environment with operable windows for natural ventilation behind the exterior glazing, the ability to control the shading device allows the occupant to modify the incoming solar radiation for either heating or lighting requirements. Both of these strategies introduce the idea of passive design strategies into the modern office tower. Typically the office tower is a major consumer of energy in its' operational phase. These design interventions reduce the overall energy consumption by including passive design concepts and energy efficient strategies. The issue at hand is whether or not they are appropriate or complete solutions for energy efficiency or whether they are tactics to compensate for the lack of sustainability of the design of modern office towers. The design of the façade still seems to lack the idea of climatic response in the design of "elevationally undifferentiated" façades. Climatic design considerations would entail considering the regional and microclimatic conditions of building design. Each individual building sits in a climatic region: cold, temperate, hot-humid or hot-arid. The modernist response to design negates regional considerations through technological sophistication or compensation.

In terms of sustainable design the twin-face façade offers strategies for use and control of solar heat gain, increased daylight and moderation of temperature differences. It is the only system at present that offers a range of natural ventilation strategies to the occupants. The ability to engage and control these environmental aspects inevitably leads to increased energy efficiency. The argument is that numerous and less intensive strategies are also available to serve the same purpose. Then why use the double skin façade? No other system maximizes daylighting with integral solar heat gain control, blinds and buffer zone. Potential green house effect in the buffer zone can be used for heat production and exchange. Natural ventilation for high-rise conditions reduces air-conditioning loads.

The concept of regional response in building design offers more benign solutions that would further enhance concepts of sustainability by promoting climatic responses such as solar availability, weather patterns, urban design considerations, and other issues that deal with specific regional differences versus a technological solution that operates on universal conventions.

LOOKING TO THE FUTURE:

When looking for/at case studies, it was found that the most common type of true double façade was the Twin-Face system. The buffer façade seemed to represent a type of system that is to be found in older, more historic models and that has been subsequently modified. From the point of view of construction, it remains the least "technical" and is used in instances where simple environmental buffering is desired. The Extract Air system is not commonly used. From a mechanical viewpoint the Extract Air system is more complex than the buffer system and is less favored as it excludes natural ventilation. The Twin-Face system, in its variety of configurations and being the only base system that actively make use of natural ventilation strategies and includes some sort of operable windows, is currently preferred.

Although in its preliminary stages, early results would indicate that double skin façade systems do not win when evaluated on a totally "hard", economics/statistics based, scoring system. Some of the systems fair better when judged on certain "softer" environmental criteria that are more difficult to measure. These would include: daylighting, solar control, access to and control of natural ventilation, and resultant employee satisfaction and productivity.

The depth of this initial investigation was limited by timeframe, access to proprietary information, access to actual dollar costs for both the capital and maintenance aspects of the systems, and actual performance data for the systems in use. To continue this investigation in a more scientific vein it would be necessary to set a firm "base case" building/wall type upon which to create a comprehensive set of statistical comparisons.

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A full report of the case study information may be found at:
http://www.fes.uwaterloo.ca/architecture/faculty_projects/terri/ds/title.html

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IMAGE CREDITS:

Figure 1: Kate Harrison: Buffer Façade Diagram
Figure 2: Kate Harrison: Extract Air Façade Diagram
Figure 3: Kate Harrison: Twin Face Façade Diagram
Figure 4: Kate Harrison: Hooker Chemical Building Section.

Figure 5: CCBR University of Toronto. Double Façade Report Draft. April 2002. Behnisch, Behnish & Partner with Architects Alliance. p. 4

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Figure 7: André Potvin, Université du Laval, Extracted from Powerpoint Presentation on the design of the CDP

Figure 8: photo, Terri Meyer Boake

Figure 9: Andrew Chatham: Room section at Telus, Vancouver

Figure 10: Verification of Dynamic Buffer Zone (DBZ) Wall Assembly Performance Using Infrared Photography. Antonio Colantonio, Public Works and Government Services Canada, Technology Directorate, Rick Quirouette, Quirouette Building Specialists Limited. 2002. p. 2

Figure 11: Verification of Dynamic Buffer Zone (DBZ) Wall Assembly Performance Using Infrared Photography. Antonio Colantonio, Public Works and Government Services Canada, Technology Directorate, Rick Quirouette, Quirouette Building Specialists Limited. 2002. p. 3