RAIC SYLLABUS

D9A Thesis Research Paper

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SUSTAINABLE LIVING DESIGN IN THE EDMONTON CONTEXT

NET-ZERO MURB

TABLE OF CONTENTS

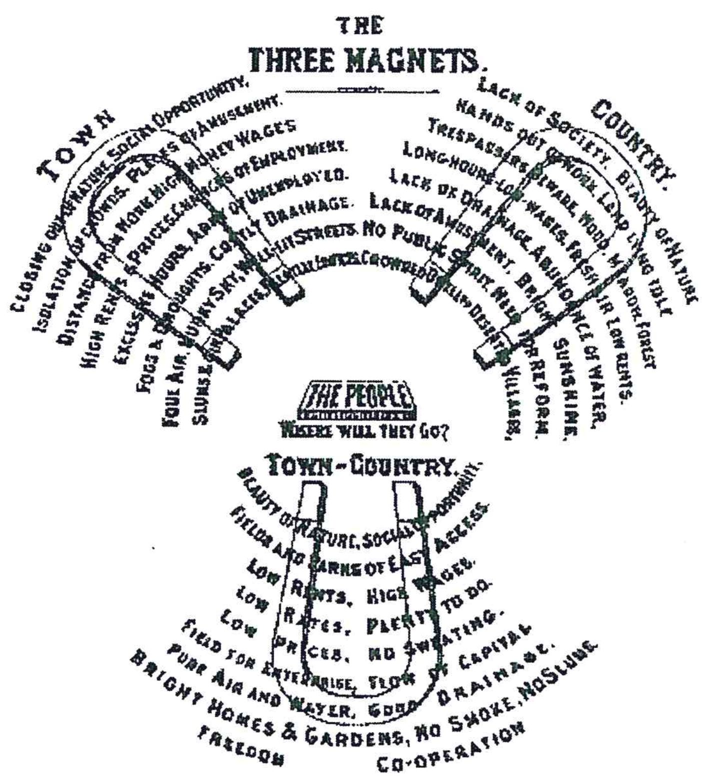
PREAMBLE

Over the Twentieth Century, North American Cities have devolved from distinctive urban centres, developed in the context of geography, local climate, and proximity to nearby resources, into 'Edge Cities'. Almost everywhere, we see these sprawling suburban areas at the edge of, and competing with, their original urban cores in a ubiquitous pattern of housing and strip malls. The conversion of valuable agricultural land and the resources consumed in building and living in these ever expanding non-places is clearly a problem for sustainability.

The genesis of this phenomenon was an ideal known as the Garden City. It was inspired by a utopian novel, *Looking Backward* by Edward Bellamy, and promoted by an Englishman, Sir Ebenezer Howard. His 1898 book entitled *Tomorrow; a Peaceful Path to Social Reform* sought to ease the social and economic urban maladies of the time.

It was reissued in 1902 as *Garden Cities of Tomorrow*, and described new developments housing 32,000 people on 6,000 acres. The concentric plan had six radial boulevards 120 ft. wide, with public parks and open spaces. The Garden city would be self-sufficient and when fully populated, another would be developed nearby. Howard's vision was for a cluster of several Garden Cities as satellites of a central city of 50,000 all linked by road and rail.[1]

What rather happened is that, self-sufficiency forgotten, our suburbs have become the source of cheap land for families, isolated from the advantages and dangers of the city, but still dependent on it for services and income. The personal vehicle and plentiful cheap fuel have been the catalyst for their vast proliferation. The results are long commutes, and the necessity to drive to every daily destination. The CO_2 generated as a result contributes to our world crisis of greenhouse gas, and the low density of suburbs is a threat to our future agricultural land base.



[1] www.britannica.com/EBchecked/topic/273428/Sir-Ebenezer-Howard

INTRODUCTION

The motivation for this dissertation is the present and future crisis of world climate change and the profound dangers posed by our persistent use of fossil fuels in our day-to-day lives. The 2030 Challenge, initiated by Ed Mazria and endorsed by the RAIC contends that 46.8% of CO_2 emissions in North America are tied directly to the built environment - the buildings in which we live, work, learn, seek recreation, are born, and die. In their construction, operation, maintenance, and demolition our buildings burn fossil fuels for power, heating, and cooling. They emit CO_2 particles into the atmosphere contributing to the rising levels of greenhouse gases (GHG's). These constitute a barrier to the Planet's re-radiation of the solar heat constantly arriving. The result is rising average global temperatures. Current levels of CO_2, having just gone over 391.7 ppm, have not been present in our atmosphere in the last 15 million years.[2]

Global average temperatures at that time were 3 to 6 degrees C warmer than they are now and sea levels were 22 to 38 M higher. There were no ice caps. Those conditions were present at the end of that high carbon era when the CO_2 atmospheric content was declining. At present, CO_2 levels are increasing rapidly, at about 3% per year[3], now very likely as a result of human activity. This trajectory will take us very quickly beyond that former intensity into a state of climate alteration with long-lasting and potentially disastrous consequences.These would include increases in extreme weather events, extensive loss of species, massive human migrations triggered by drought and flooding, and the breakdown of existing systems of agriculture, government, and civil society.

The Intergovernmental Panel on Climate Change is an organization established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). It provides clear scientific analysis on the current state of knowledge of climate change and its potential and socio-economic impacts.[4] It collects, compiles, and assesses the most recent scientific technical and socio-economic information produced world wide, relevant to the understanding of climate change.(ibid.) The IPCC's latest report, released in 2007, is a compilation of data taken from observations made over the previous ten years. Although this data makes it clear that anthropogenic CO_2 content in the atmosphere is at dangerous levels and that its consequences are accelerating. The results predicted are in fact occurring much sooner than predicted. The years 2000 to 2010 saw a 33% global increase in released CO_2 over the previous decade.

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[2] www.physorg.com Aradhna Tripati, Oct.8, 2011 Science, journal

[3] *Global and Regional Drivers of Accelerating CO2 Emissions* Raupach •, Maryland, Ciais 2007 **http://www.pnas.org/content/104/24/10288.short**

[4] **http://www.ipcc.ch/organization/organization.shtml#.T3ml4Hh91UQ**

THE ROLE OF ARCHITECTURE

The challenge of our time is to slow and halt this carbon catastrophe. Designing our buildings to much higher performance standards is vital to the solution. If we manage to convert our systems to use the sun's energy to power our activities and comforts, we will significantly slow the increase in GHGs. Atmospheric levels will rise more slowly and, with similar resolve in other energy applications, eventually start to reverse to safer intensities. This seems an overwhelming task, but to begin this technical and architectural pursuit is urgent .

The 2030 Challenge calls for reductions in CO_2 emissions for all buildings, new and existing, and to target zero emissions by 2030 through an annual graduated reduction. We are now into year seven of the Challenge, and as yet there are no net zero buildings larger than individual residences in Edmonton, and only a few in all of Canada. This study will focus on medium rise residential structures, with or without retail and service components, as a building type suitable to sustainable urban renewal in Edmonton. Research will review the performance and construction details of selected buildings operating at or close to net zero CO_2 emissions, in environmental conditions comparable to Alberta's. Design strategies that reduce energy use and increase occupant comfort will be examined for their value in a net zero CO_2 building for Edmonton.

'Net Zero' can be a deceptive term. Zero CO_2 emission is the ultimate solution, but there is scant possibility of quickly achieving that goal in locals where yearly temperatures vary by 75ºC. During the transition we will still rely on conventional sources of heat and power, but reduce their use progressively. The 'net' in the equation allows us to burn carbon fuel as long as we procure it in a manner that does not add to the planet's GHG burden. If we burn ancient stored carbon, i.e. fossil fuel, we transfer its securely buried storage to the atmosphere, and thus to the oceans, with very negative results.

ENERGY SOURCES

Presently in Alberta, we are still heavy users of coal, oil, and Natural gas. There is a significant wind energy sector based in the southern foothills, but so far it is only suppling a few percent of the province's needs. There is no nuclear production, and only a very minor geothermal heating component which ironically relies on large draws of electricity (coal fired) to run compressors and pumps.

Analysis of the ways in which carbon neutrality is achieved in a reference building will be examined to ensure that CO_2 production, in the thesis project is actually being reduced rather than simply being transferred off site. In Canada, 13% of electricity is supplied by coal burning generators.[5] In Alberta, the level is 53%, the highest of all provinces. In absolute numbers Alberta produced 6217 Mw from coal in 2011. Ontario's production was 6329 Mw, with 3.5 times Alberta's population.[6] Table 1. below shows the CO_2 emission intensity of various fuels. Coal has the highest rates, about double that of natural gas. So producing power in a building with a NG on-site generator will be a significant improvement, but is only a stopgap strategy, even though the heat of generation can also be used.

Table 1.[7] **Mass of carbon dioxide emitted per quantity of energy for various fuels**

Fuel name	CO_2 emitted (lbs/10^6 Btu)	CO_2 emitted (g/10^6 J)
Natural gas	117	50.30
Liquefied petroleum gas	139	59.76
Propane	139	59.76
Aviation gasoline	153	65.78
Automobile gasoline	156	67.07
Kerosene	159	68.36
Fuel oil	161	69.22
Tires/tire derived fuel	189	81.26
Wood & wood waste	195	83.83
Coal (bituminous)	205	88.13
Coal (sub-bituminous)	213	91.57
Coal (lignite)	215	92.43
Petroleum coke	225	96.73
Coal (anthracite)	227	97.59

The anomaly in Table 1 is wood. While it has a fairly high intensity of emission, it is not a fossil fuel. It seems to be a viable solution, and it can replace natural gas for producing both power and heat. It is current in its production its embodied energy has been typically gathered by trees within the last century, and on the whole, the amount of energy being converted to CO_2 by burning wood in a year is exceeded by the total amount of sunlight stored in growing trees. That

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[5] *Coal-Fired Power Generation – An Overview.* National Energy Board of Canada. 10/28/2011

[6] *Population by Province*, Statistics Canada. 9/28/2011

[7] *"Voluntary Reporting of Greenhouse Gases Program".* U.S. Energy Information Administration. 8/21/2009.

is a good definition of net zero energy. But we must also factor in the energy, mostly from fossil fuels, needed to harvest, process, and transport wood to its point of use. So even though in Alberta waste wood is now a problem for landfill, and large quantities of it are exported for use elsewhere, sustainable wood energy use has limits. It will only achieve the net zero goal to the point where that surplus of supply of current energy is surpassed. If the volume of wood burnt to produce heat and power becomes so large that tree growth in a year is not enough to supply it, we will eventually have to cut down all the world's forests. This would happen quite quickly if wood became the world's chosen fuel.

This being a clearly unacceptable path to go down, we can only use wood for fuel to the extent that is sustainable, and within that constraint, must also be mindful that its harvest does not compromise habitat or waterways. Similar limits likely apply to other biomass fuels. The costs to Earth's ecosystems in growing, harvesting, and burning biomass fuels must always be calculated and assessed for sustainability. In the end, wood and other biofuels are also only stopgap alternatives. The Edmonton Airport Lands development concept by Busby Perkins & Will proposes to use a central biomass co-generation plant to initially supply all power to the project, but which will be replaced with deep well geothermal generation as the development reaches a critical occupancy and the technology is further refined to be generally viable. The expectation is that the geothermal plant will be capable of providing power needed by all 30,000 residents and commercial services as well as supplying additional power to surrounding communities.

The energy to be tapped in this technology[8] is primal heat from the initial formation of the planet, still abundantly stored beneath the Earth's mantle and reachable at depths as shallow as three kilometers. By drilling into it, fracturing the rock, and pumping water through it and back to the surface, fluid temperatures of 235ºC can be obtained and used to generate steam and electricity, and then used secondarily to heat buildings. The technology exists and is in use, but still lacks certain pump efficiencies to be widely utilized. In Alberta the source is as close to the surface as any on Earth and it seems only a matter of political interest whether it will soon come into play.

Other non-solar sources of heat that do not emit CO_2 include nuclear fission, with its inherent dangers, nuclear fusion, not yet achieved, chemical reactions such as burning hydrogen, and tidal energy. It is solar power, which includes wind and hydro among its progenies, that is available in abundance in Alberta and is now able to compete on an economical footing with fossil fuels. Paired with efficient building envelopes and proper orientation, solar PV panel arrays can achieve net zero energy use and CO_2 production. They are initially expensive to install, but their efficiency is improving by about 3% per year and their cost is dropping steadily as production increases. They are made economical in Alberta because they can, by legislation, be

[8] http://featured.matternetwork.com/2008/10/deep-geothermal-untapped-energy-source.cfm .YALE ENVIRONMENT 360

fed into the existing power grid, from which power can be drawn back to fill solar shortages at night or on cloudy days. When sun is abundant and power needs are low, as in summer, PV power flows into the grid for credit at double the retail rate, to the owner, augmenting the supply of conventional electricity to power others' demands. The expected usable life of a PV panel is 40 years. The initial investment necessary to install them can be recouped within about twenty years from money saved on purchased electricity. At that point PV becomes free to the owner. Further efficiency of on site power generation lies in the absence of generation and transmission losses and failures. The delivered electric energy is only about 1/3 of the energy burned at a remote generating plant (Ueno and Straube, 2010 Building Science Digest). Most of that loss is waste heat dumped into the atmosphere by cooling processes.

Solar panels of a different type can heat domestic water. These operate at all atmospheric temperatures and can heat water to 150°C in clear conditions at the lowest outdoor temperatures. In general, they can supply about 50% of the hot water needed in a typical residential building and can supplement wash water and radiant heat systems.

Solar heat can also be harvested passively with properly sized and oriented windows. When combined with a thermal mass within the building, heat is stored during sunlight hours and slowly released to the living/working spaces over night. This can be a problem in warm weather, but is controllable with exterior shade devices and carefully designed natural ventilation.

THE PROBLEM OF WASTE

The technical solutions are well established and evolving rapidly, but the transition to their use as replacements for fossil fuels is a difficult matter on many fronts. Politically, there is huge investment in fossil fuels and the systems that rely on them, and there are deeply entrenched attitudes around them against change. In Canada, this is most obviously demonstrated in the political stance of the federal Conservative government, which places economic growth above all other priorities, and regards the environmental movement as an enemy of the country, listing environmentalists with terrorists in its enhanced security strategy. A mainstay of the fossil fuel camp is the accepted mantra that alternative energy technologies cannot possibly replace them. This is certainly true when looked at without also considering the immensely wasteful ways in which, economically and socially, we conduct our industrial processes and daily lives.

Over the last two hundred years, Western society has developed a culture of wealth built on cheap energy. The ready abundance of oil, coal, and gas and the availability of developable land has, until lately, led us to view the material aspects of our lives as entirely disposable. Human ambition and ingenuity has converted the Earth's stores of energy into fabulous amounts of wealth, and concentrated economic and social power in the hands of those most willing and able to exploit land and energy to their own advantage. Cheap energy has promoted design and production of goods, infrastructure, and buildings that place economic growth at a higher priority than careful and conservative use of the planet's natural resources. Waste has not been a serious consideration until lately and in the developed world we have come to expect that we are entitled to any comfort, luxury, or amusement we desire without concern for the waste of resources that results. Architecture which produces stylish and clever visuals but ignores excessive heat loss and heat gain is still permitted by building codes and admired by the media, regardless of the imprudent waste. The life cycle costs of such buildings are unaffordable, but short-term economic thinking justifies them to owners who can make a quick profit in their turnover. The idea of 'greening' these buildings by adding solar or geothermal hardware or efficient lighting and appliances is futile. Sadly, the newly in-vogue 'green building' movement can as much as anything *"allow us to pretend we are saving the world, when, in reality, we are only ratcheting up consumption in an unprecedented frenzy"*[9]. We must consider all aspects of the way we live and work and the buildings that accommodate us. The efficiency of the building envelope is critical as the first strategy in creating a low energy, non-CO_2 emissive structure.

THE EFFICIENT BUILDING ENVELOPE

Building envelope efficiency is a measure of the energy embodied in materials used, fuel burned in their transport to the building site, energy consumed in the erection of the structure, and that used in the heating and cooling of the building over it's serviceable life. Equally important to the efficient performance of a building are the skill and quality of workmanship employed in assembly. If in design and planning the total use of energy is minimized, it then becomes practical to add the systems hardware to capture solar energy for power and heat, and to effectively ventilate the building with minimal heat loss in winter and heat gain in summer.

The Air Barrier

The greatest heat loss in a typical cold climate building results from air infiltration through openings and gaps in the walls. Therefore the impermeability of the wall assembly is more critical than the amount of insulation in minimizing heat loss. Insulation is an important factor in controlling heat gain, but may be secondary to shading, surface reflectance, and the heat absorption coefficient of exterior wall colour. The key to avoiding air infiltration through a wall assembly is the air barrier, a membrane applied to the cold side of wall insulation. It must be continuous over the wall and sealed at all openings such as windows, doors, service penetrations, balconies, guard walls, or any other attachments. The ideal barrier is a roll-on liquid compound, but sheet barriers can be effective if they are suitably overlapped and taped at all

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[9] *Green Screens: Modernism's Secret Garden*, Sumrell & Varnelis. Essay included in *Design Ecologies, Essays on the Nature of Design, Tilder & Blostein, Prinston Architectural Press 2008.*

edges. Window and door openings can be sealed around their perimeters with expanding foam, or backer rod and caulking, if the air barrier is taped over the sealant to the jambs. The barrier must be tightly adhered to the wall or insulation surface. If it is loose and allowed to billow between fasteners, unequal air pressure on either side of it will eventually, through slapping action, break down its ability to prevent air passage.

While a perfect air barrier functions very effectively to prevent heat loss to infiltration of cold air, it will cause an accumulation of stale, unhealthy air and high moisture levels inside a sealed building. Opening windows even slightly in cold weather will help, but this reintroduces air infiltration and nullifies the air barrier's purpose. An active ventilation system with heat exchangers is an essential supplement to the system. A heat recovery ventilator will capture up to 80% of the heat in exhausted air and transfer it to pre-heat incoming fresh air. Because it provides a steady supply of fresh dry air, it also functions as a humidity control.

A perfect air barrier also serves to keep warm interior air from entering the insulation in a wall with loose or batt insulation installed between studs. Such a wall must by code have a vapour barrier, but these membranes can never be completely impervious because of the many pipe, wire, and fastener penetrations needed to finish the wall. Warm air will migrate through these small openings especially in a condition of a pressurized interior, typical where forced air heating is used. As warm air moves through insulation, either by diffusion or convection, it is cooled towards the cold side of the wall and the moisture in it condenses. The amount of moisture deposited in a wall over one winter in this way can be quite damaging in terms of wet rot and mould growing in the wall. However, if the air barrier is wholly resistant to air penetration, interior air cannot enter the wall as none can leave it to equalize the pressure.

A wall system with both an air barrier and a vapour barrier and insulation in the wall cavity can experience severe moisture problems. If condensation forming in such a wall cannot dry either to the inside or outside, failure of the building from toxic mould will eventually result. It would be better to dispense with the vapour barrier so moisture can then dry to the inside, but few existing codes have been updated to deal with impermeable air barriers and most still require vapour barriers. One solution to this problem is to apply all insulation to the exterior of the structure as is common in commercial buildings.

Glazing

Windows are essential to the spaces we live in. They bring natural light, fresh air, and the sun's warmth into our homes. They connect us visually and aurally to the human and natural worlds and make us aware of the changing light through each day and each season. Their orientation and proper installation are of prime significance in envelope efficiency. Residential windows are available in wood, vinyl, fibreglass, and aluminum, and with different glazing options, coatings, glazing spacer bars, and fill gasses. Aluminum frames are the strongest of these and are therefore the usual choice for curtain wall systems and high wind loads. The frames are not very resistant to heat transfer as aluminum is an excellent conductor and most systems are not insulated, relying on only a thin layer of neoprene for a thermal break. Fibreglass jambs and sashes are very strong and can serve a curtain wall function in reduced wind loads. Because the jambs and sashes are made from glass fibres, the coefficient of expansion matches the glazing. As well, some manufacturers fill the frame extrusions with polyurethane foam, giving them an insulative value about three times that of wood. Vinyl has very low strength, a very high coefficient of expansion, is rarely insulated, and is made from petroleum chemicals and cannot be recycled. Steel is built into the frames of better vinyl windows to strengthen them, but this exacerbates the heat transfer problem. Low cost is the principal attraction for vinyl windows, but this does not justify their use in sustainable building and they cannot be considered as suitable in this study.

Windows are rated by their manufacturers for heat transfer resistance R-value and for its inverse U-value. 'U' is a measure of heat transfer in which the value 1 = 1 BTU of heat moving through 1 square foot of a stated membrane (e.g. wall, roof, window, etc.) The lower the U-value, the higher is the insulating capability.

These ratings are commonly taken from measurements at the centre of the glazing panes where the heat transfer is usually the lowest. It is therefore necessary to ascertain the average U-value of the entire window. The highest values will be found at the perimeter of sealed glazing units where the spacer bar holds the inner and outer panes together and seals the gas between panes. Aluminum bar has been the standard for decades, but being an excellent conductor, it performs very poorly at retaining heat.

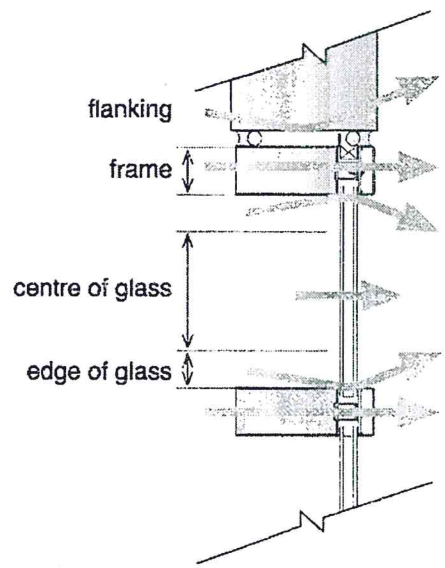


Figure 1. Conductive thermal flows through different parts of an aluminum window unit. The least flow is at the centre of the glass.
SOURCE: RAY COLE

The result manifests, at low temperatures, as interior condensation. Warm interior air contacting the glazing's cold perimeter deposits moisture as it cools on contact. It indicates heat loss but it can also cause damage, if enough moisture collects to run down the window frames and the wall below. 'Warm edge' technology, non-metallic spacer bar, has been developed over the last twenty years and after several problems and failure lawsuits, has become a reliable product which should be specified to improve overall thermal efficiency.

Metallic coatings

Multiple glazing offers the best opportunity for highly efficient windows in very cold and hot climates, especially as they can be filled with inert gases (Figure 2.) and combined with multiple thermal coating layers. There is a range of coatings available and their use will add only about 5% to the cost of a window while they have the ability to double the thermal efficiency of the glass they are applied to. Comprising a microscopically thin, optically transparent layer of silver sandwiched between layers of anti-reflective metal oxide coatings, they are close to invisible. They can be variously formulated to block certain wavelengths of solar energy, and will select ultraviolet (UV), visible, or infrared (IR) rays. In cold climates infrared solar heat will warm interior spaces and materials when the sun is available, even at very low temperatures. Large expanses of glass with coatings that select a balance of infrared and visible light and that are oriented in the building to maximize sun exposure, will contribute significantly to heating, lighting, and the general enjoyment of a space. Coatings that reflect infrared wavelengths block a high percentage of solar heat and are effective in reducing chiller loads. They also slightly increase u-value, but in a cold climate they will curtail solar heat gain significantly in the heating seasons.

Recognizing that in Edmonton the heating season is generally nine months long, and that we enjoy relatively high amounts of sunlight, we have ideal conditions for passive solar heating using IR-emissive coatings with triple or better glazing systems. It has been argued that windows with these coatings should be the choice even on north facades if there is any potential for reflected solar lighting because if they are constructed with low U-values, the yearly heat gain can overcome the losses. Passive solar heating should be seen as an essential strategy in achieving a low energy heat regimen.

Coatings that select transmission of IR light waves will also allow the escape of radiated heat waves reflected back through the glass. But low u-value (< 0.15) attainable with multiple panes and coatings will minimize heat loss from conduction and convection. New developments in glazing which make possible the reliable insertion of plastic film layers between two layers of glass offer u-values of < 0.05 with three plastic membranes in a single glazing unit. Although the daily hours of sun exposure are few in mid-winter, the effect of highly efficient glazing over the heating season can be positive in the balance of heat gain and loss. U-values of < 0.05 make the insulating capacity of windows higher than current Alberta Building Code wall insulation requirements. Walls have almost zero ability to absorb UV rays, so carefully sun-oriented windows of this efficiency are highly functional for winter heating and reducing carbon emissions.

Figure 2. below compares the insulating effects of double and triple glazing, gas fills, and coatings. Two surface coatings are recommended for cold climate environments.

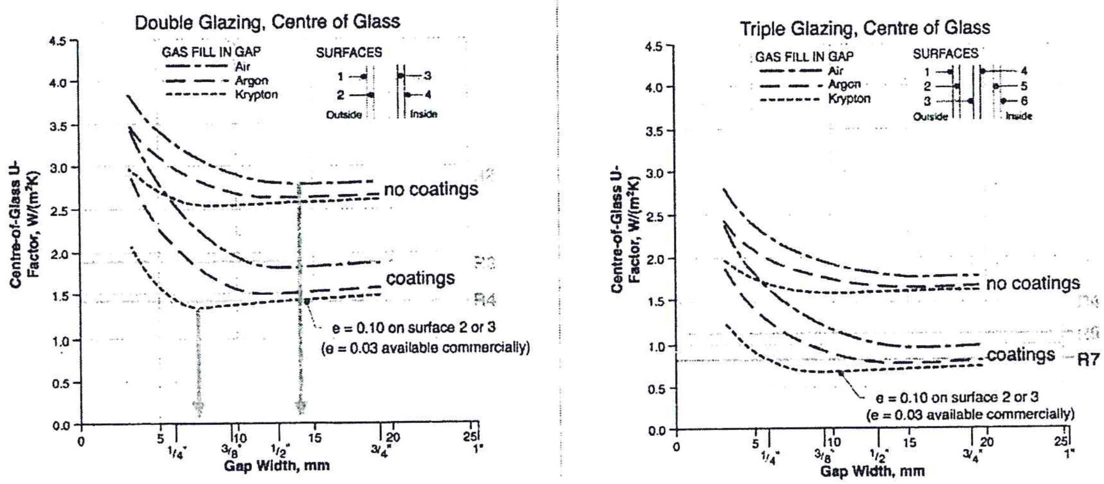


Figure 2. U-factor reductions resulting from multiple glazing panes with three different gas fills and coatings.[10]

Shading and Ventilation

Excessive solar heat gain becomes a problem in summer, and creates the need for air conditioning to keep indoor temperatures tolerable. Sun aspect is low in winter so the most effective system will incorporate shading to block summer sun, but allow winter sun angles to reach all the glazing. West glazing should be less extensive than south and east because the sun's angle becomes lower late in the day when temperatures are highest, and penetrate below shading. This is most pronounced in September/October when sun aspect is lower and shade trees have shed their leaves. Shading can consist of wide roof projections, wall mounted shade awnings, operating shutters, and trees, to name a few. Interior shades can also reduce over heating by preventing solar radiation from heating floors, walls, and furniture within a room even though the heat has penetrated the glass.

Orienting a multiple unit building so that many apartments have only west glazing and no natural cross-draughting, demands innovative design thinking to overcome heat control problems. A double-skinned envelope system with a continuous vertical space between glazed curtain walls can allow venting of excess warm air in summer and control heat loss in the colder months. The significant costs of such a system, however, will likely put it beyond the budget limits of most residential projects. Considering the shape of the exterior wall surface and segmenting it carefully

[10] *Sustainable Design for Canadian Buildings 303,* UBC course text, Dr. Ray Cole

may be the best strategy. Angling wall segments so that the windows do not face southwest sun, for instance, can eliminate an excess of heat gain but still allow natural light penetration.

Natural warm weather ventilation can be enhanced by the use of fenestrated cupolas, called solar chimneys, typically built on the roof as the highest structure on the building. These must be open to all or most of the building spaces below so that warm interior air can rise into them. The top of a stairwell is a logical location, but others can be as effective. The chimneys must have high openings: closable louvers or windows through which rising air can escape. The effect will be enhanced if it contains south glazing, which will intensify the draught in the column. The system is completed by fresh air openings in the walls of the building, ideally low on the north walls: windows which can be opened to draw cooler fresh air into the building to replace the warmer air being flushed by natural convection through the cupola. The use of exterior earth-cooled ducting, installed below grade to route fresh air into the building will provide cooler air than that taken in through windows. This system is a major component used in the 22 storey Manitoba Hydro Place in Winnipeg, but will work equally well in any size of building. In winter the chimney remains closed and, aided by fans, supplies air warmed by its south glazing to lower floors or the parking basement.

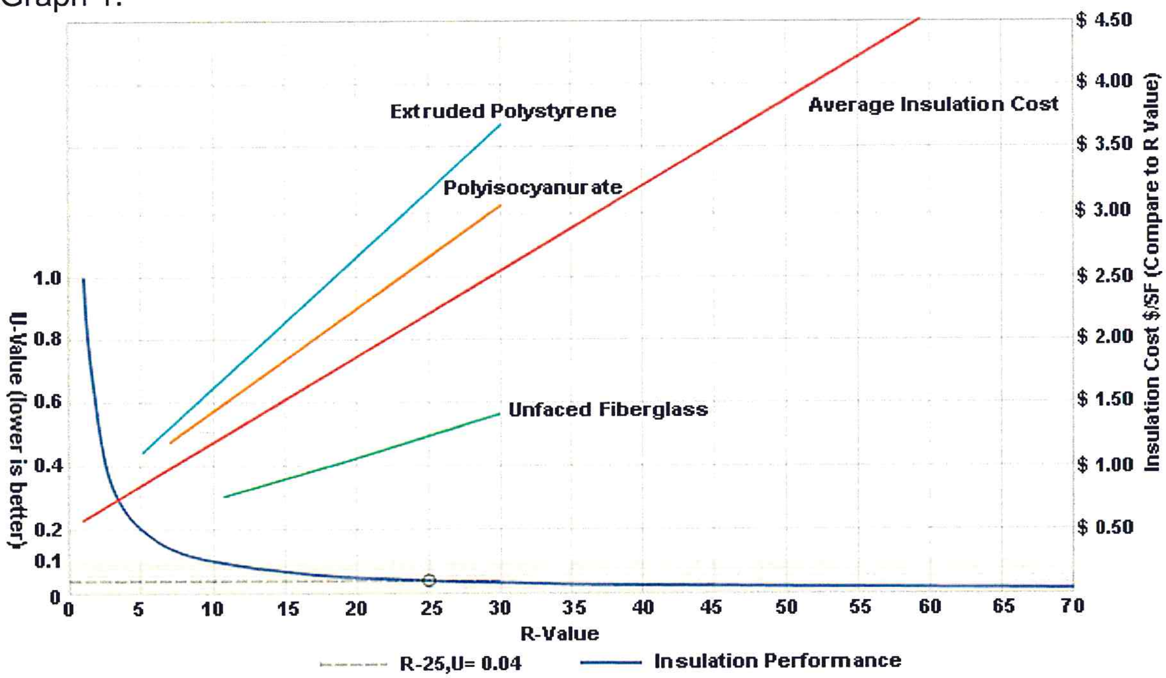
In a multi-unit building, all of the suites will need separate duct systems to handle the incoming and exhausted air without mixing between units. Because it is also desirable for efficiency to have separate HRV units in each suite, the ducting can be adapted to serve both functions. The intended result of installing solar chimneys is to reduce or eliminate the need for energy consuming chiller systems.

Insulation

If a building is constructed with a perfect air barrier, properly installed and oriented high-performance, coated glazing, and a carefully balanced ventilation system, the proper level of insulation will accomplish the efficiency needed to reduce energy consumption to heat and cool the interior to very low levels. Demonstration projects built in Western Canada since the oil crisis of the 1970's have installed as low as U-0.018 heat transfer in 16" walls, and U-0.01 in roofs built to accommodate 30" of cellulose insulation. These extreme levels are used more to earn points in a system of accreditation such as LEED (Leadership in Energy and Environmental Design) than to attain a level of effective insulation without unnecessary expenditure. The ASHREA Graph 1. below shows the diminishing returns of adding insulation to a roof past a point at which the increase in performance becomes negligible. For instance, R-25 fibreglass insulation appears to cost $1.25/ sq. ft. The U-value is 0.04 or 1/25 BTU /hr./sq. ft. Doubling the amount to R-50 - $2.50/sq. ft. - will increase the heat transfer resistance by only U-0.02, or 2%. Perhaps that money could be invested more wisely in other areas, such as walls.

We can use the graph to analyze walls if we realize that the R-values in the X-axis must be read as the average value in a wall that may have windows and heat bridges in the structural material that can reduce the effective value of the whole wall. A framed wall will have studs typically spaced at 16". Over eight feet of 2 x 6 (R-20) wall 8' high, the solid wood of the studs will equal 5 x 1 ½" = 7 ½", or 7.18%. The top and bottom plates contribute 4 ½" / 96" = 4.69%. Together in a wall segment with no windows this is 11.87% of the wall with an R-value of 1.25 per inch X 5 ½" = 6.88. The average value is then 18.44. The framing for a window will add, depending on the window size, another two studs, result R-18 avg. If high performance windows with an average value of R-5 occupy 35% of the wall, the average wall insulation value then drops to about R-13.5. So increasing the amount and cost of insulation in a stud wall makes sense. R-35 nominal insulation, a cost increase of about 62%, will yield R-19 average, about 28% increase in heat transfer resistance.

Graph 1.



SOURCE: HOLT ARCHITECTS ITHACA, NY

A further consideration is convection air currents, which can occur within wall insulation types that allow air to move through them. Fibreglass batts are air permeable - fibreglass is used to filter moving air in furnaces - and in a 5 ½" wall with an extreme temperature difference inside to out, the air in the insulation next to the cold surface will drop as it cools (see Figure 3. below). Warm air on the opposite side will rise and, upon reaching the top barrier of the wall cavity, move outward to replace the dropping cold air. It will cool as it drops to the bottom where it then follows the current back to the inner warm surface. By this convective movement of air, warmth is carried to the cold side and lost, with the resultant condensed moisture deposited against the outer sheathing. This will cause mould and deterioration of the wall unless it can be dried in warmer weather if the outer sheathing is permeable enough to allow this. It is obvious that this condition seriously lowers the functional value of the insulation.

Fibreglass insulation shows in the graph as being the least expensive, but if installed as described above, the actual value in the wall at cold temperatures may be as little as half its stated value.

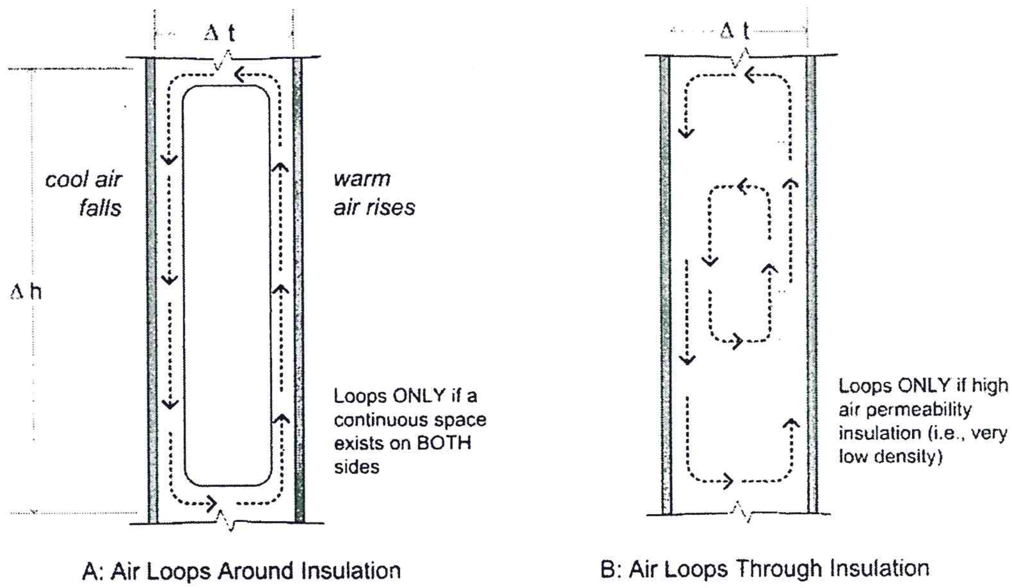


Figure 3. Low density insulation convection loops.

When compared with polyisocyanurate panels (R-6 / inch) that when applied on the outside of the wall can eliminate heat bridges, the cost of R-30 overall insulation is about the same. The inherent air-tightness of ridged panels installed edge-to- edge increases the advantage of this type of insulation.

Where a wall structure comprises studs and sheathing, combining exterior panel insulation with loose fibre between studs will likely achieve the best result at low cost (Figure 4, p. 17). Rather than using fibreglass batts, which commonly result in voids in continuity due to careless installation, blown-in cellulose with an added internal adhesive completely fills the wall and resists air movement into or within the wall cavity. The stated R-value /inch is 3.79, so a 2 x 6 wall with cellulose covered by sheathing and 2 ½" polyisocyanurate panels would provide R-36, or U-0.028 thermal resistance (3 times the present Alberta code for wall insulation), everywhere except at windows and doors. The air barrier would be excellent and the presence of moisture in the wall would be kept at a safe level by the less than 10% moisture absorption of the cellulose. It also functions well for roof insulation because of resistance to air movement, complete filling around structural members, pipes, and wiring, and its low cost.

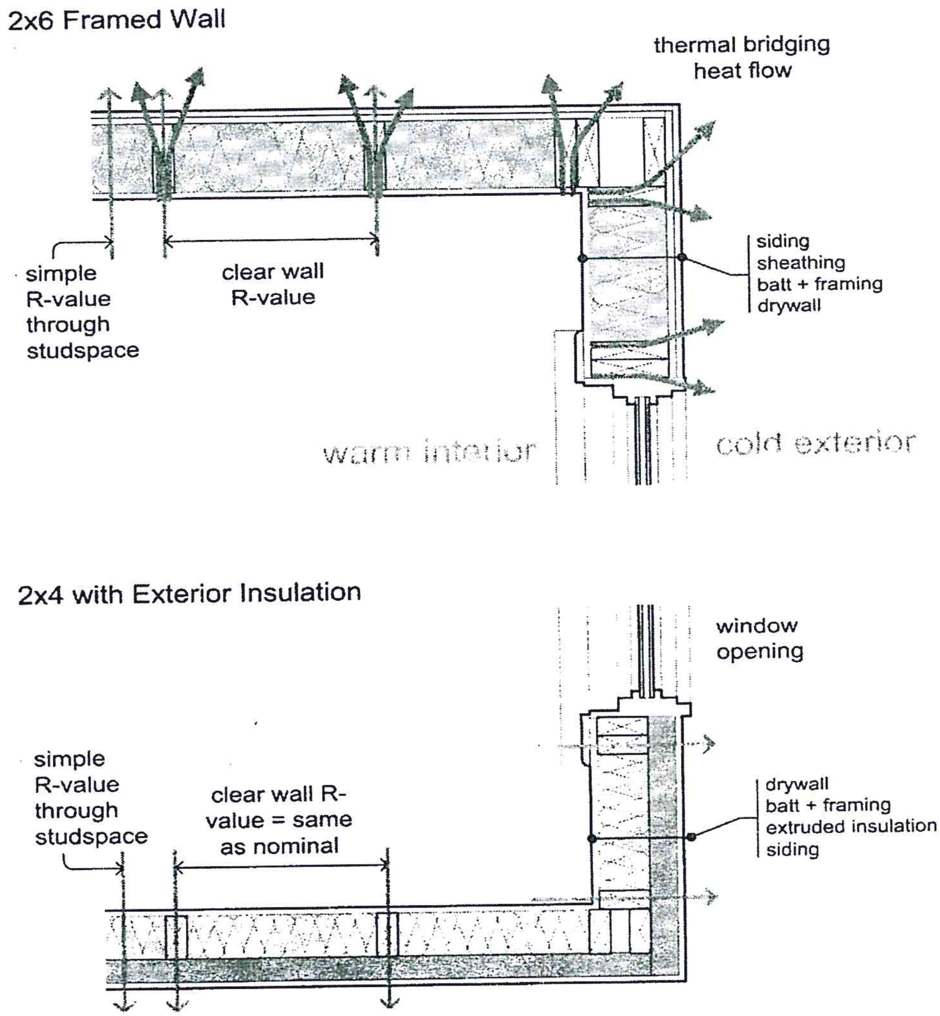


Figure 4. The effect of external continuous insulation over an insulated stud wall.

Framing material

I have used calculations for wood rather than for steel framing. Although steel has been extensively used for residential curtain wall and commercial construction in cold climates, it is a mistake in terms of energy efficiency. The excellent conductive property of steel puts it in the league of super heat bridges. Figure 5. illustrates the comparative heat loss in various insulated walls with wood framing. The graph implies that the stud spaces are insulated; EPS is extruded polystyrene, here applied to the exterior. The lower values in all the steel applications result solely from heat being conducted to the exterior through the steel. Only in the case of 100% exterior insulation should steel be considered. The need to consider cost as an important factor in energy efficient design probably eliminates this specification in most circumstances.

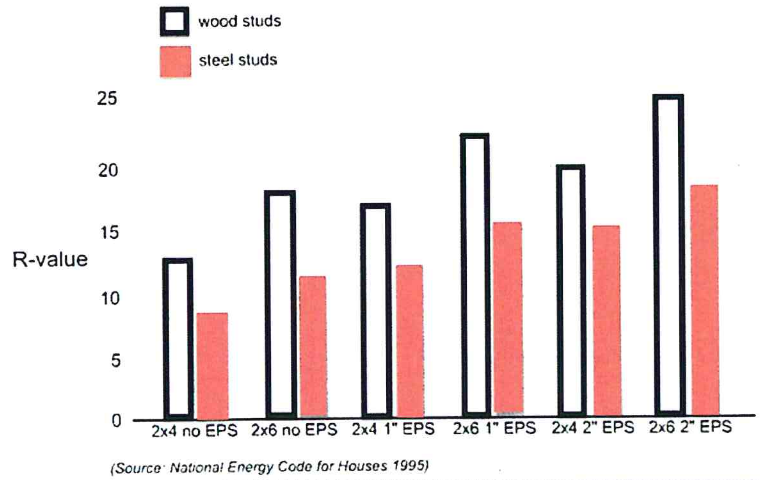


Figure 5. Relative thermal performance of wood and steel framing.

Below Grade Insulation

If spaces below grade are heated, it is also necessary to insulate the foundation walls and floor slabs. If concrete is insulated on the exterior its mass serves as a heat sink, moderating interior temperature flux. The value of this, however, is not high as below grade spaces are not subject to extreme changes in outdoor temperatures and wind. The interior side of walls in any finished space will need to be lined with framing to carry cables and pipes and to provide a smooth and even interior surface. As this framing affords an insulation space, it is better to consider proper insulation and moisture sealing on the warm side of walls. Figure 6. below illustrates this strategy: a continuous layer of EPS panel on inside of the walls, around the perimeter of the floor slab, and between the slab and the concrete footing and soil, all of which eliminates any heat bridge from the interior to the soil. This 2" of EPS contributes U-0.1 (R-10) to insulating the interior space. In addition, the framing can be used to add insulation to an effective level of U-0.033 (R-30). This arrangement will allow moisture to enter the wall from which it can only dry to the inside. The usual vapour barrier has been left out to promote this drying, with latex paint as a breathable vapour retarder. The under-slab insulation makes the use of radiant floor heat practical as heat loss by conduction into the soil can be closely controlled. Increasing the under-slab thickness of EPS to 4 or 6 inches with radiant heat is an economical strategy to maximize the heating function.

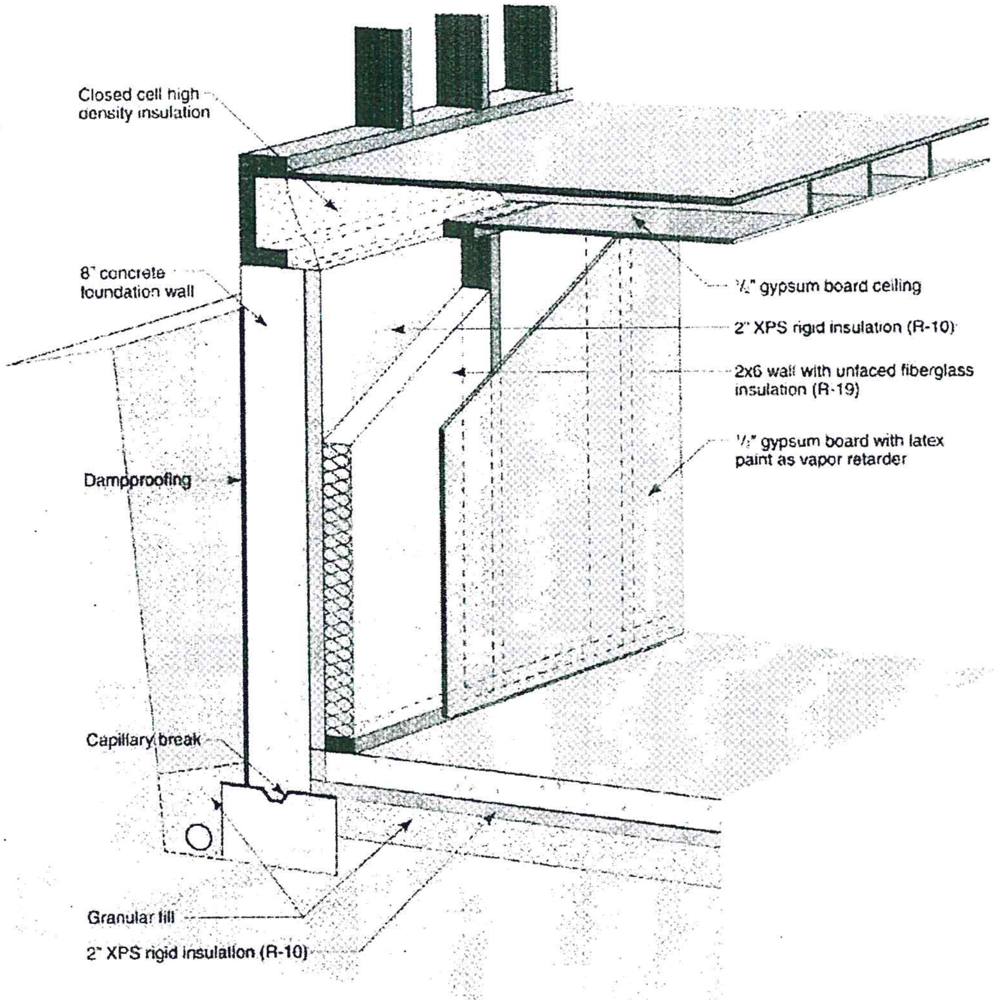


Figure 6. An example of thermally blocked foundation insulation.

THE MEANS TO NET ZERO

Working with these principles will produce buildings which, in the climate of Edmonton, ensure that the purchased energy required to heat and cool and properly ventilate interior spaces will be reduced to as low as 30 – 40% of that required in normal code-compliant buildings. Further reductions can come from education, inducements, and devices that will reduce plug loads in individual suites and commercial operations. Automatic controls, LED lighting, ECM motors, high efficiency appliances, constant computer display of energy draws, and the desire to adjust lifestyle to lower consumption, can all contribute to a dramatic lowering of energy use without compromising comfort, convenience, or happiness. The rest of the Net Zero equation will have to come from on-site active generation of renewable energy.

Most of the energy available to us has and does originate in our sun. Thermal energy contained within the planet's core and molecular energy released in the process of nuclear breakdown, are the exceptions. Deep well geothermal heat generation (see page 6 above) is still in its infancy and not generally available yet. Reactors processing uranium or plutonium produce usable energy at a cost to our environment and pose unacceptable dangers to life in accidental plant malfunctions. But wind, solar, and tidal energy are all constantly available and the state of development of these technologies has progressed now to the point of being practical. Tidal is not available to Edmonton and wind in the region is not sufficient for reliable generation. "*The average wind speed in Edmonton is about 18 km/h or about 5 m/s annually at 50 metres above the ground.*"[11]

SOLAR PV

Solar panels are the best resource now available for reliable and affordable on-site generation of electricity and hot water. Edmonton has very high sun exposure, 2300 hours per year according to Environment Canada, and has the potential to produce 1245 kWh/kW of installed solar panel per year.[12] This efficiency will depend on orientation, the mounted angle of the panels, and shading by trees and/or other buildings. CMHC statistics show that an apartment of 95 square metres in Canada uses an average of 41 Gj of electric energy per year. Consumption of electric energy by province has Alberta at 1.2 times the average. Using these numbers we can assume that an average apartment dwelling in Edmonton will consume 48.9 Gj of electricity per year, equivalent to 13,583 kWh. Divided by 1245 kWh/kW one 95 M^2 apartment requires 11 kW of panel capacity to supply all of its power.

What size of panel array would this be? The three most common types of solar cells are distinguished by the type of silicon used in them: monocrystalline, polycrystalline, and amorphous. Monocrystalline cells produce the most electricity per unit area and amorphous cells the least. Monocrystalline cells of 250W capacity, present cost $1.50/W, are 17 ft^2. Eleven kW / 250W x 17 ft^2 = 748 ft^2 = 69.5 M^2.

In a multi-storey building, it becomes difficult to mount enough panels. Compared with a two storey residence, a four storey building will have only half the roof area available for panels to serve an equal floor area. A MURB (multi unit residential building) of four stories will, for the sake of calculation, have 4 – 95m^2 units stacked vertically sharing 95m^2 of roof. The calculation above requires 69.5m^2 x 4 = 278m^2 or about three times as much flat roof area as is available. The accepted rule for mounting angle of solar panels is equal to latitude of location, 53° at Edmonton. CMHC contends that varying the angle by up to 15° will not effectively reduce the efficiency of the

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[11] http://www.edmonton.ca/environmental/documents/Renewable_Energy_2010-03.pdf
[12] http://www.cmhc-schl.gc.ca/odpub/pdf/63890.pdf?lang=en, table 2

panel, so we can calculate available panel area with an installation of 38° above horizontal. Figure 7. Shows three alternatives for roof mounting of panels.

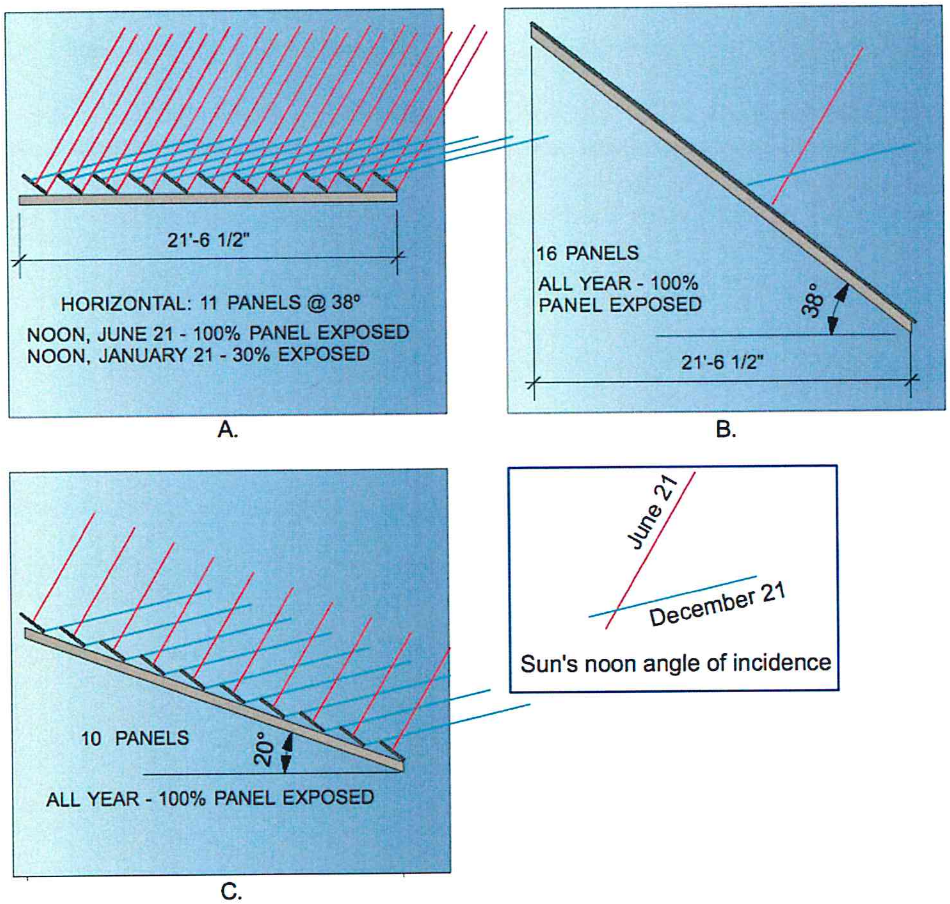


Fig. 7 Comparison of the effect of angle of roof on panels mounted 38° from horizontal.

In Case A. we have a flat roof with eleven panels mounted at 38° on racks. They are fully exposed to the sun at its maximum azimuth, but are shaded by the adjacent panel by about 2/3 at the winter solstice. For comparison, we could use the formula: sun hrs./day x exposure = daily generation

June 21: 16.7 x 100 = 1670
Dec. 21 7.3 x 33 = 254 •average daily = 1924/2 = 962
962 x 11 panels = 10,582 units.

In Case B. we have a roof of the same horizontal width set at 38° with 16 panels mounted flat against it. 100% of the panels are exposed year round.

June 21: 16.7 x 100 = 1670
Dec. 21 7.3 x 100 = 730 •average daily = 2400/2 = 1200
1200 x 16 panels = 19,200 units.

In Case C. we have a roof of the same horizontal width set at 20° with 10 panels mounted on racks 38° to horizontal and spaced so as not to shade each other. 100% of the panels are exposed year round.

June 21: 16.7 x 100 = 1670

Dec. 21 7.3 x 100 = 730 •average daily = 2400/2 = 1200

1200 x 10 panels = 12,000 units.

This illustrates that that the high slope roof offers about 1.8 times the potential yearly generating power of panels on a flat roof covering an equal area of dwelling space, and 1.6 the potential of the 20° roof. As calculated on p.21, we need a ratio of 3:1 flat roof to floor area for generation of normal power draw over the year in a 4-storey MURB. Using a 38° roof (Case B.) we can reduce the area by 3/1.8 = 1.66 per unit of floor area. Therefore if we can reduce power draw in the units to 1.66/3, or 55%, of that normal in Alberta, the PV system could meet the annual electrical need. By the same calculation, the Case C. array would require a draw reduction to 1.13/3, or 37% of normal. In the flat roof (Case A.) the draw would need to be reduced to 33% of normal.

But we also need to account for snow cover on the panels in an Edmonton winter. Snow can reduce the panels' generation capability to almost nothing, and unless they are easily cleared after each snowfall, the already low winter power production could be miniscule. Panels will naturally shed snow during an increase in temperature if they are mounted at higher angles. It therefore follows that angles closer to the Case B. mount have an added advantage in winter if they cannot be easily and safely reached with a snow rake. In cases A. and C. snow will slide off the panels but be trapped beneath the panel below where over several snowfalls the accumulation will bury everything.

LOWERING ENERGY DEMAND

This takes us back to the problem of our wasteful, fully entitled living habits mentioned previously on page 8. Is it at all possible to reduce our consumption of energy in our everyday lives to 55 or even 33 percent of the present norm and make the use of solar panels a practical and affordable strategy? The designers of the Bullitt Center in Seattle, a net-zero office building of 4738 m^2, set out a number of strategies in the design and operation of the building to bring power use as low as possible. The chart in Fig. 8 below shows these strategies and the result.

The energy use is down to about 39% of what it would be in a normal building of this type and although it is an office building, this type of critical thinking can be employed in a MURB to analyze systems and find ways to engage the occupants to ensure success in the effort to live within renewable energy means. The most obvious difference between a building in Seattle and Edmonton would be heating load. The strategies for Edmonton must be reducing heat loss through the building envelope, maximizing winter solar heat gain, and a heating system fuelled by biofuels and PV.

But just as important is the modification of attitudes and expectations of the occupants who need to be on board with the determination to reduce wasteful production of CO^2. A perhaps surprising outcome of solar PV systems is peoples' response to the computer screen readouts of the minute-by-minute monitoring of energy draws. The screen can be located anywhere in the living space and will show exactly the change in power use occurring when a device is switched on or off. Thus an occupant can see the energy spike caused by a microwave oven, a halogen bulb, a clothes dryer, a computer, or any other electrical contrivance. They are made newly aware of when and how much electricity is flowing at their instigation and for many the reaction is to be much more careful in their habits, with a desire to avoid squandering what they know has a cost to them and the environment. This new consciousness then accompanies them in all their activities in and outside the home.

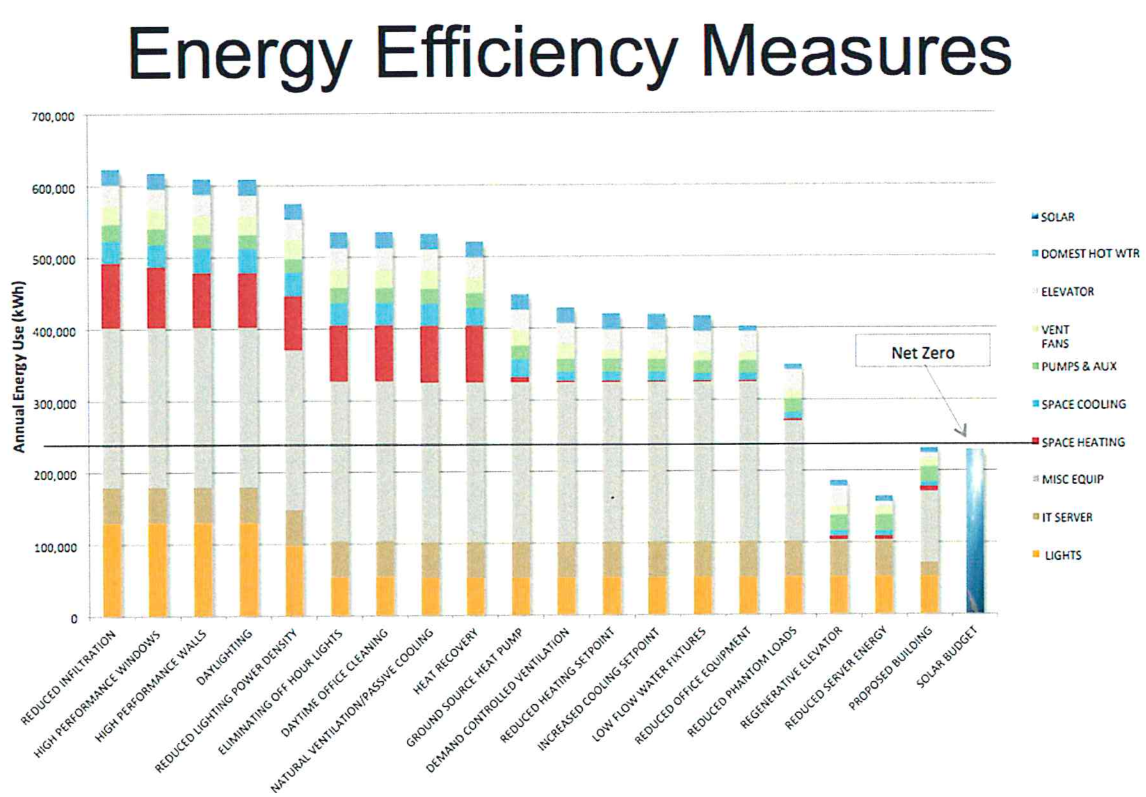


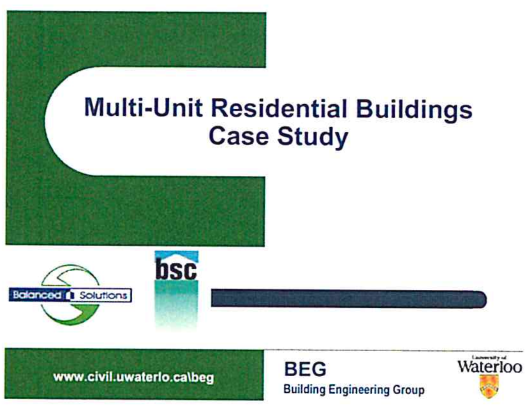
Figure 8. Bullitt Center reduction plan for energy draws.[13] (see a similar graph for an Edmonton MURB on p.54 below)

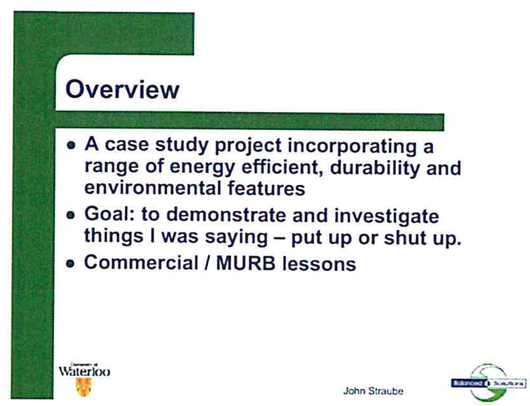
[13] *Illuminating the Path to Net Zero*; Suchara, Zachary, 2012 presentation, Banff Sessions

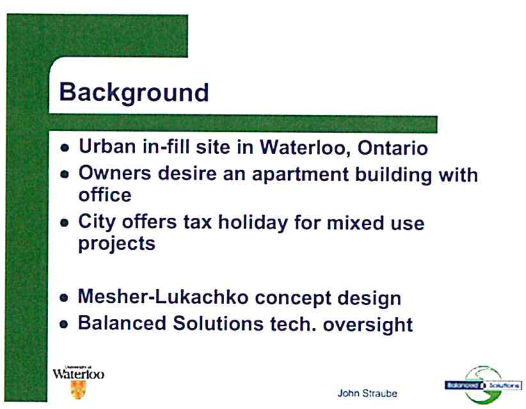
Case Studies

The buildings presented below have been selected as examples of low energy use in cold climates. Most of Canada's highest performing buildings in terms of energy consumption are located on BC's Pacific coast. Self-sufficient developments such as Dockside Green by Busby Perkins and Will are exemplary in their concept, design, and operation, but the advantage they have in climate over Edmonton's excludes comparison as useful models for emulation. Therefore the examples selected are located in winter locations, and taken together they offer a range of design strategies and results from which the design of a net zero energy MURB may be deduced and developed for Edmonton.

1. A RESIDENTIAL 5-STOREY BUILDING WITH OFFICES AND COMMERCIAL STREET LEVEL SPACE IN WATERLOO, ONTARIO







Straube Presentation Westford Symposium 2006 1

Concept and Constraints

- Parking and parking access limited site design, and building size
- Result: 5 storey building with 11 rental units and ground floor office space
- Lesson:
  Small size of building increases unit cost!
  - Elevator + 2 stairwells
  - Fire pump, standpipe and sprinkler systems

Waterloo

John Straube

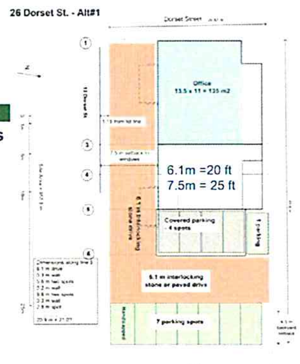
Existing Site – 66 ft

- Old house
- Urban infill

Waterloo

Site

- Most solar access maintained



Concept

Waterloo

Enclosure Concept

- CBD 50 (1964)
- Continuous
  - air barrier,
  - insulation, and
  - drainage plane behind
  - ventilated cladding
- Impact resistant, non-combustible finish
- Avoid thermal bridges!

Waterloo

John Straube

Commercial Enclosure: Simple Layers

- Structure
- Air Barrier
- Insulation
- Rain Control
- Finish

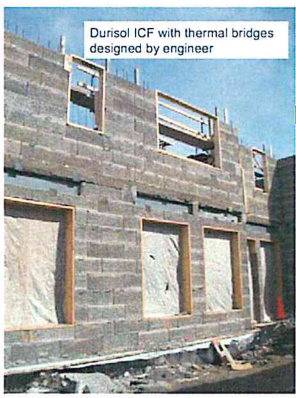
John Straube

Design

- 8” Durisol ICF
  - concrete structure, 4 hr+ fire rating
  - Allows services to be cut in
  - Provides thermal mass, some insulation
  - Huge hygric buffering to moderate interior RH
- Spray foam (insulation, air barrier, drain)
- Gap – drained and ventilated
- Cladding – stone, brick, Hardie

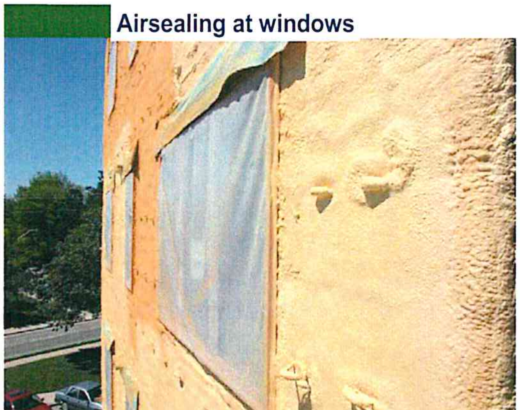
Waterloo

John Straube



John Straube

Airsealing at windows



John Straube

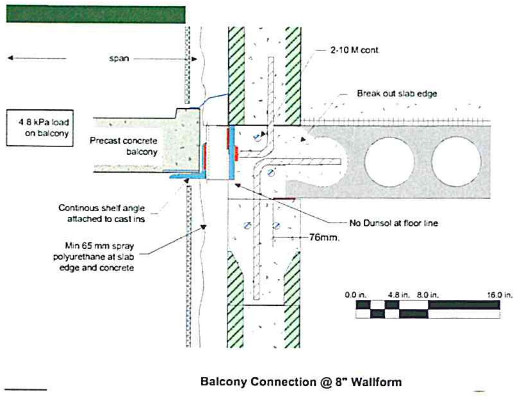
Results

- Blower door test before all finishing
  - To allow some chance to repair
  - 0.16 cfm/sf enclosure
  - 4000 cfm50
  - 1.1 ACH50

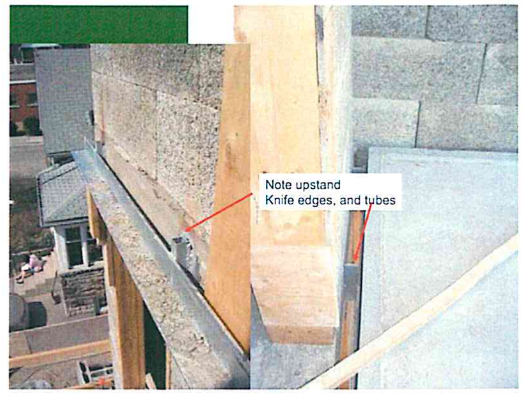
Waterloo

John Straube

5



Balcony Connection @ 8" Wallform



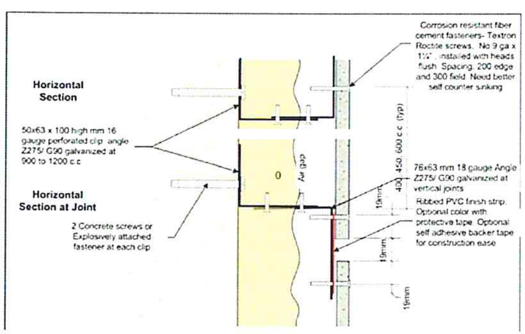
John Straube

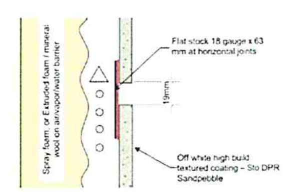
Cladding

- Desired light weight, impact resistant, non-combustible low cost cladding
- EIFS has does not meet these requirements
  - Transitions to spray foam? Draining?
- Developed fiber-cement panel system
- Elastomeric textured coating used to cover screws
- Special joint details

Waterloo

John Straube





Stucco-textured Ventilated and Drained Expressed Joint Cladding System on Thermally Broken Framing System Over 2-6" Exterior Insulation

Meeting the loads

- We reduced loads for 3 reasons
  - Reduce energy consumption
  - Reduce capital cost for mechanicals
  - Reduce capital cost for distribution
- This building's heating/cooling load could be reduced by 30-50% with either more money or more architectural intervention

Waterloo

John Straube

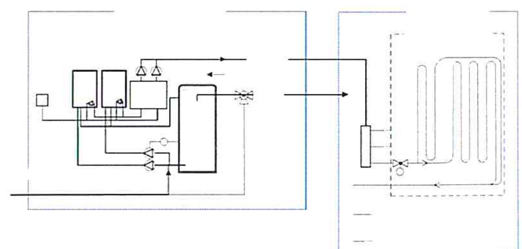
Mechanical System

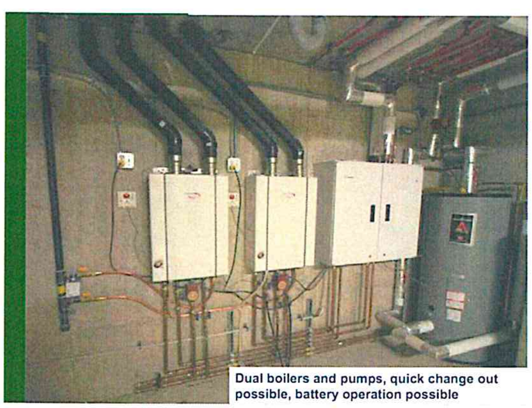
- Heating
  - Radiant heated floor system
- Cooling
  - Ductless mini-splits for cooling
- Ventilation
  - Single point power exhaust w/ passive distributed make-up

Waterloo

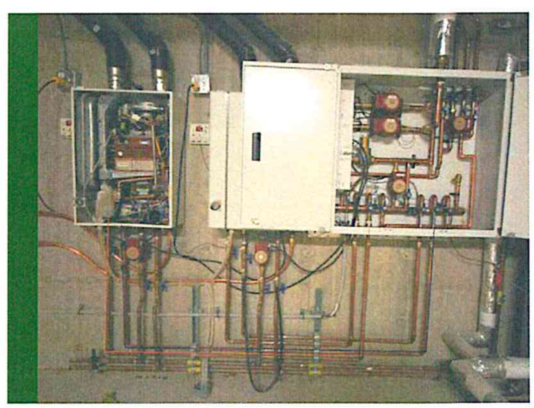
John Straube

Heating schematic





Dual boilers and pumps, quick change out possible, battery operation possible



Ventilation

- Isolation of suites was priority one
  - Better IAQ, better known ventilation rates
  - Sound control, no smoke/fire/odor issues
- Continuous exhaust from bathroom
  - Boost for showers, cooking, drier
- Heat recovery difficult/$ for small flows
- Passive air inlet
  - Will incoming air be cold?

Waterloo

John Straube

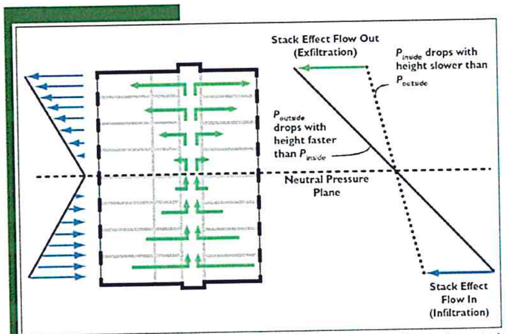
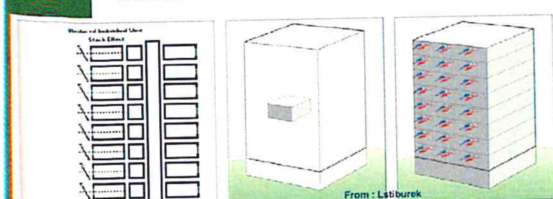
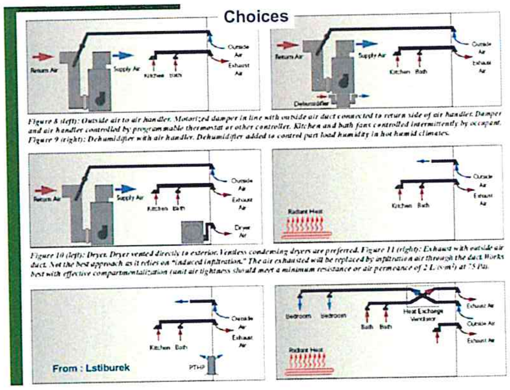


Figure 1: Stack effect. Interior airflows in tall buildings compromise smoke control, fire safety, indoor air quality, comfort and energy use.

Compartmentalization

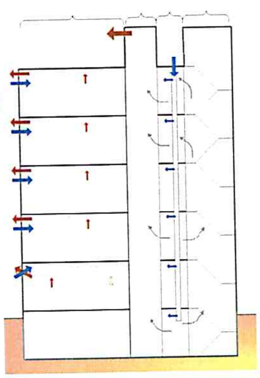
- Airselaed each apartment, lobby and stairwell





Our Choice

- Lowest capital
- Low energy
- HRV's would reduce energy



Waterloo

Waterloo

Elevator exhaust

Electrical

- CFL everywhere
- Efficient fans and few of them
- Motion sensors in stairwells (about 95% saving over CFL)
- Outdoor motion sensors for parking (enhanced security)

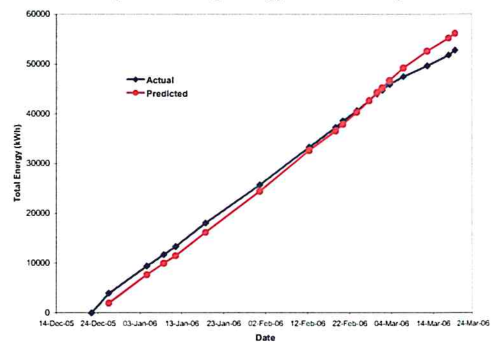
John Straube

Predicted Consumption

- Current MURB in Ontario about 250 kWh/m2/yr and office 300
- Projected 100 kWh/m2/yr= 33 kBtu/ft2/yr
- 75% is heating and cooling, 25% electric
- Monitoring is planned

John Straube

Space Heating Energy Use Dec05-Apr06



Sound control

- Floating floors of gypcrete on foam
- Airtight suite doors
- Durisol suite demising walls
- Only low sone (0.3) fans
- Airtight windows

John Straube

Green roof

- Occupant amentity, heat island reduction, neighborhood contribution
- Low cost? and simple
  - Inverted roof fully adhered (expensive)
  - Drainage mat
  - 4" Extruded foam
  - Water retention membrane (MS20)
  - Landscape cloth
  - Soil or pavers or gravel = ballast

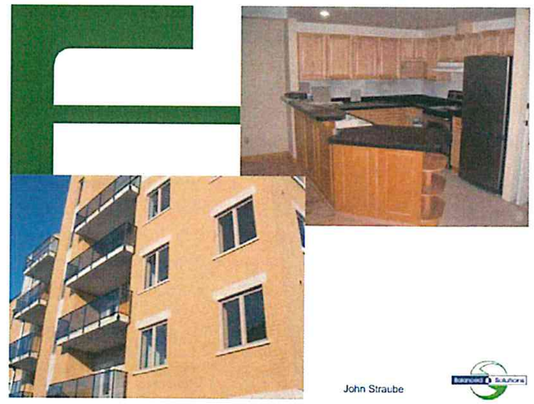
John Straube

Lessons Learned

- Can build durable, energy efficient for same or less than typical
- This requires many things
  - directed choices/trade-offs at concept stage
  - Committed owner / design team
  - Involvement in quality control and compromises throughout process
  - Do mockups, even for small jobs
  - There are many reasons why not, find the reason why.

Waterloo

John Straube



2. ABONDANCE MONTREAL, A SMALL NEW THREE STORY, 3 UNIT CONDOMINIUM.

EQuilibrium™

HEALTHY HOUSING
FOR A HEALTHY ENVIRONMENT

Project Profile:
Abondance Montréal: le Soleil—Montréal, Quebec

This Project Profile highlights Abondance Montréal: le Soleil, one of the winning entries in the Canada Mortgage and Housing Corporation (CMHC) EQuilibrium™ Sustainable Housing Demonstration Initiative - a national initiative to design, build and demonstrate sustainable homes throughout Canada[1].

Figure 1—Abondance Montréal: le Soleil

Key Features

- Urban infill project in an established metropolitan area close to amenities;
- Net-zero energy consumption target;
- Energy is conserved through advanced building envelope construction and air tightness, a geothermal heating system and energy-efficient appliances and lighting;
- Energy is produced using a solar photovoltaic array and solar hot water panels;
- Energy is recovered in a greywater heat recovery system and heat recovery ventilators;
- Rainwater is harvested from the roof for use in toilets.

Project Description

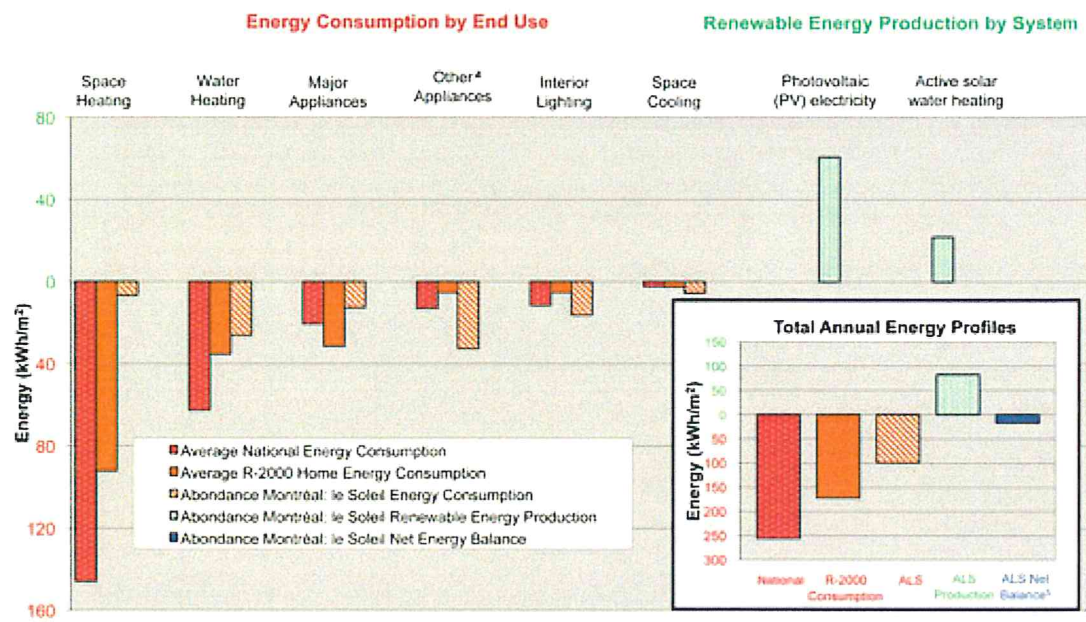
Abondance Montréal: le Soleil is a three story triplex condominium situated in Montréal's southwest borough of Verdun. It is a multi-family community revitalization project on the site of a former parking lot and car wash.

In keeping with the EQuilibrium™ Housing initiative, the developer, EcoCité Developments, in partnership with the builder Les Constructions Sodero Inc., designed and built this condominium project with the intent that it is healthy

[1] For more information on this initiative and the various EQuilibrium™ Housing projects, visit the CMHC website (www.cmhc.ca) and type the search keyword "EQuilibrium".

Canada

CMHC SCHL
HOME TO CANADIANS



1 Source for National and R-2000 Energy Data: Residential Secondary Energy by End Use, 2004. *Energy Use Handbook Data*. 1990 and 1998 to 2004. Natural Resources Canada. 2006.
2 R-2000 Home values are based on the Canadian Centre for Housing Technology (CCHT) houses built to an earlier R-2000 standard in the 1980s.
3 Values are predicted based on Natural Resources Canada's HOT2000 and RETScreen modeling software. Actual results may vary.
4 "Other Appliances" includes small appliances such as televisions and other consumer electronics, toasters, microwave ovens and vacuum cleaners.
5 Le Soleil Net Energy Balance = le Soleil Renewable Energy Production - le Soleil Energy Consumption

Figure 2—Comparison of Canadian National Average[1], R-2000 Home[2], and Predicted Abondance Montréal: le Soleil[3] (ALS) Annual Residential Energy Consumption and Production

and comfortable to live in, produces as much energy as it requires in a year, reduces energy use to a minimum, conserves resources, has low environmental impact, and is marketable to people interested in investing in sustainable homes.

Each of the three 79.3 m² (854 sq. ft.) apartments[2] is located on a separate level of the building. They share a rooftop terrace and rear courtyard and parking area. The basement contains the mechanical and storage rooms. Each apartment is based on an open-plan design and contains a living room, dining room and kitchen, a four piece bathroom, and a flexible space that can be used as two bedrooms, a bedroom and den or office, or one large bedroom. Le Soleil's annual energy requirements are predicted to be slightly more than the on-site production from renewable energy sources, which include passive and active solar heating systems and a solar photovoltaic (PV) electricity generating system. The apartments' energy requirements, on a per m² (sq. ft.) heated floor area basis, are predicted to be only 39% of the requirements for the average Canadian home.

[2] These figures represent the heated space area of the apartment. The total area of each suite, including exterior walls, is 94.4 m² (1016 sq. ft.). These figures do not include other areas such as the stairwell adjacent to, or the basement storage assigned to, the apartment.

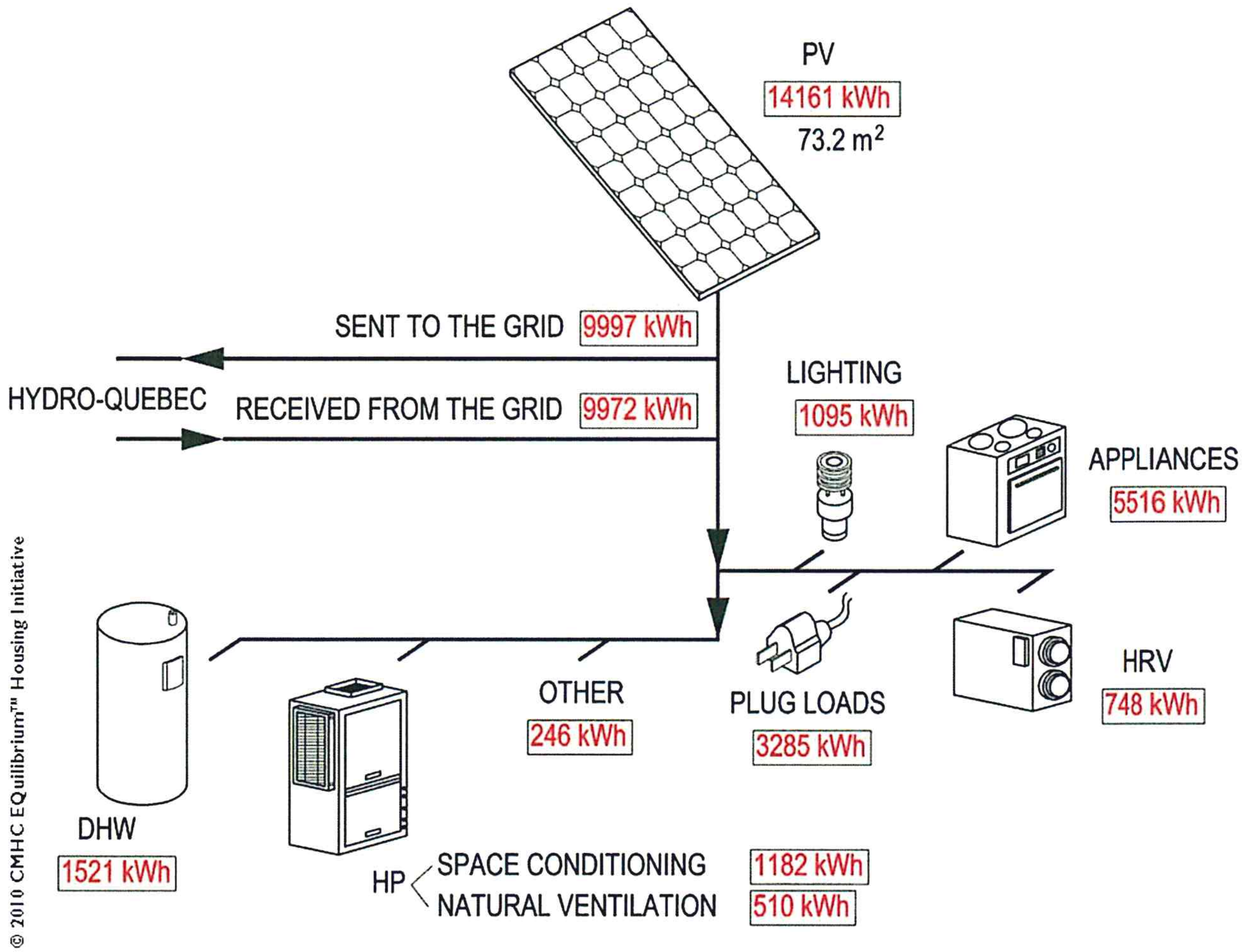


DIAGRAM OF ENERGY FLOWS FOR VARIOUS FUNCTIONS IN THE BUILDING AND THE BALANCE OF SUPPLY TO AND FROM THE GRID.

Le Soleil has a net-metering agreement with Hydro Quebec, whereby surplus electrical production fed into the utility grid will be credited against electricity supplied by the grid to the building.

During the first year of occupancy, the energy generation, energy and water consumption, and indoor air quality for the building will be monitored to assess performance.

Occupant Health and Comfort

Establishing and maintaining indoor air quality is an important goal for EQuilibrium™ homes. Materials selected for the le Soleil apartments help minimize indoor air pollutants, such as volatile organic compounds (VOCs) and other noxious chemicals. Urea-formaldehyde free plywood, oriented strand board (OSB) and cabinet materials were used throughout. Low and no VOC paints and flooring sealers were applied.

The airtight building envelope effectively minimizes uncontrolled air leakage, which enhances the durability and energy efficiency of the project. As the building is very airtight, heat recovery ventilators (HRVs) are installed in each apartment to ensure energy efficient indoor-outdoor air exchange. The HRVs also help control moisture and odours by exhausting air from the kitchens and bathrooms while delivering fresh air to the other rooms in the apartments. In the winter, the HRVs transfer heat from the outgoing exhaust air to warm the incoming fresh air. In the summer, the HRVs can cool the incoming warmer outdoor. This helps to ensure that the fresh air is delivered at a temperature that is comfortable. The HRVs also contain filters that can reduce the amount of airborne particulates that enter the apartments. A humidifier is provided in each unit to help maintain desired humidity levels in the winter.

The design, size and placement of the triple glazed aluminum windows ensures that the homes are well daylit, with maximal penetration of natural light into the main living areas, thereby reducing the need for artificial lighting. Blinds or curtains on the lower portion of the windows ensure that the levels of early morning and late afternoon sunlight in the homes can be easily controlled, which slightly reduces the space cooling requirements.

The highly insulated and well sealed windows and doors help to eliminate cold zones, drafts, and the penetration of street noise. The bedrooms are placed at the back of the building, away from the street and overlooking the rear courtyard. This further helps reduce street noise in the sleeping area. Noise transfer between the units is reduced using a floor assembly of materials resistant to sound transfer, including recycled wood fibre subfloor panels. Independent on-site testing of noise transfer reduction through the floors yielded an FIIC (field impact insulation class) of 59, which is very good.

Energy Efficiency

As an urban infill project, le Soleil's physical orientation and exterior façade were predetermined by the site and local architectural heritage. Given the site constraints that limited passive solar gain, an extremely well-insulated and air-tight building envelope, maximization of energy recovery, and reduced electrical consumption was required to meet the net zero energy target.

The building envelope is insulated with a spray applied polyurethane foam insulation which is composed of a soybean oil and 40% recycled plastic. This material also acts as the air and vapour barrier. The foam was applied to both the inside and outside of the building, providing insulation values in excess of R-40 in the walls and R-70 in the roof. By paying particular attention to the window installation and the sealing of other envelope penetrations, an excellent airtightness of 0.4 air-changes per hour at 50 Pa was achieved during the blower door test.

Heating and cooling is provided to each apartment by its own dedicated forced air ground source heat pump (GSHP) system. In the cooler months the GSHPs collect heat from deep in the ground to heat the apartments; in the warm summer months the GSHPs return excess heat to the ground to cool the apartments.

The GSHPs employ two-speed compressors that can operate at 40% capacity for increased efficiency under typical (partial load) heating and cooling conditions. The three GSHPs are connected to a shared ground loop consisting of two 76m (250 foot) deep closed-loop wells located under le Soleil's front yard. A 5kW back-up electric heating coil in the forced air ducting in each apartment helps ensure occupant comfort under extreme heating demands or in the case of a GSHP malfunction.

The combination of Le Soleil's highly insulated building envelope and the heat from passive solar gains, occupants, appliances and lighting may result in overheating of the apartments from time to time. To help limit the amount of air-conditioning required to maintain comfortable conditions, the forced air systems in each apartment can operate in a "free-cooling" mode that draws in outdoor air (by-passing the HRVs) to cool the apartments when outdoor temperatures are sufficiently cool (7°C - 21°C, 45°F - 70°F) and air-conditioning is required.

A variety of strategies were employed to further reduce le Soleil's day-to-day energy consumption. Highly energy-efficient appliances are provided with the apartments, along with a complete compact florescent lighting package. To further conserve electricity, a master switch by the front door of the apartment turns off all interior lighting and a selection of electric outlets. Devices, such as electronic equipment that continues to consume electricity when not in use, can be plugged into these outlets to reduce their small, but otherwise continuous electricity consumption. In addition, motion sensors and timers control lights in the common areas and stairwells, and the outdoor lighting.

Renewable Energy Production

The site orientation of le Soleil and the future construction of a four storey building immediately to the south of the triplex decrease the passive solar potential for the building. Le Soleil's windows face southeast, southwest or northeast, thereby decreasing the potential passive solar gain in comparison to that which could be realized if windows were south facing. However, even with these sub-optimal conditions, passive solar gain is predicted to contribute at least 35% of the building's space heating needs.

The 13.8 kW solar PV array is made up of sixty panels. These are mounted on an elevated roof-top steel structure that also provides shade to a portion of the accessible roof-top terrace. The PV array is predicted to generate 15,100 kWh annually. PV production is concentrated mostly in summer, while demand is distributed over the entire year. To respond to this, a net-metering arrangement is employed that allows le Soleil to send surplus energy to the Hydro Quebec grid when available (e.g. during the summer daylight hours), and to consume energy from the grid when needed. At the end of the year, the balance between total consumption and production is tallied to determine if the net-zero energy goal is met.

Up to 80% of le Soleil's domestic hot water needs are expected to be met by a rooftop array of six 1.2 m x 2.4 m (4' x 8') flat plate solar panels. In the summer months solar hot water production is expected to exceed demand and any surplus may eventually be sold to the adjacent building, potentially allowing le Soleil to become a net producer of energy.

Energy efficiency is further enhanced by recovering energy that would otherwise be lost. The HRVs in each apartment recover heat energy from the outgoing exhaust air and use it to heat the incoming fresh air to save on heating costs. Drain water heat recovery devices capture heat from the shower drains that would otherwise be lost to the sewer system and transfer this heat to the incoming cold water destined for the hot water tank, thereby reducing the domestic hot water energy consumption. When required, further heating of water is provided by the GSHP desuperheaters.

Resource Conservation

Le Soleil was designed to minimize natural resources consumed during construction, and over the building's lifetime. An important factor is the use of sustainably manufactured and recycled materials. For example, the building is framed with Forest Stewardship Council[3] (FSC) certified wood. The hardwood flooring, which is from a local mill, is also FSC certified. Locally-manufactured gypsum board contains 95% recycled materials.

Efficient use of materials includes engineered, open-web wood joists for the floor structure as well as as strategic design practices such as adjusting building dimensions (such a window opening) to help reduce the amount of natural resources required for the project and on-site lumber cuts and resulting material waste.

During construction, site erosion was controlled by creating sedimentation basins to reduce rain water runoff velocities and to retain ground water emanating from the GSHP wells during drilling. The builder, who is experienced in waste reduction, also had solid waste collected, sorted and recycled in order to meet or exceed Recyc-Québec's[4] minimum solid waste diversion target of 60%.

Le Soleil's apartments are designed with minimal load-bearing partitions, a strategy that maximizes the space's flexibility while meeting people's evolving needs over their building's lifetime. The floorplans can be left as an open space or easily modified to create one or two bedrooms, making the apartments well suited for couples and small families, as well as home-based professionals. This flexibility helps to limit the amount of renovation work and materials required to adapt the units as needed over time.

Reduced Environmental Impact

The project's urban setting offers its residents convenient access to a range of services and benefits that allow them to significantly reduce their transportation-related environmental footprint. Its close proximity to the metro, major bus routes, bike paths and a full service shopping concourse means that it is easy and practical to live without a car. For occasional longer trips, membership in a car-share program (with several nearby vehicles available for use) is included in the condominium fees.

To reduce municipal water consumption and waste water production, the apartments are fitted with low-flow plumbing fixtures and appliances. In addition, rainwater from the roof runoff is collected in a basement cistern, filtered and distributed through an independent plumbing network to non-potable end uses such as toilets. If the cistern is emptied, the network automatically transfers to the municipal water system as backup. This feature alone is estimated to reduce the annual consumption of potable toilet water by 75%.

3 For further information on the Canadian Forest Stewardship Council see http://www.fsccanada.org/default.htm

4 For further information on Recyc-Québec see http://www.recyc-quebec.gouv.qc.ca/client/fr/accueil.asp

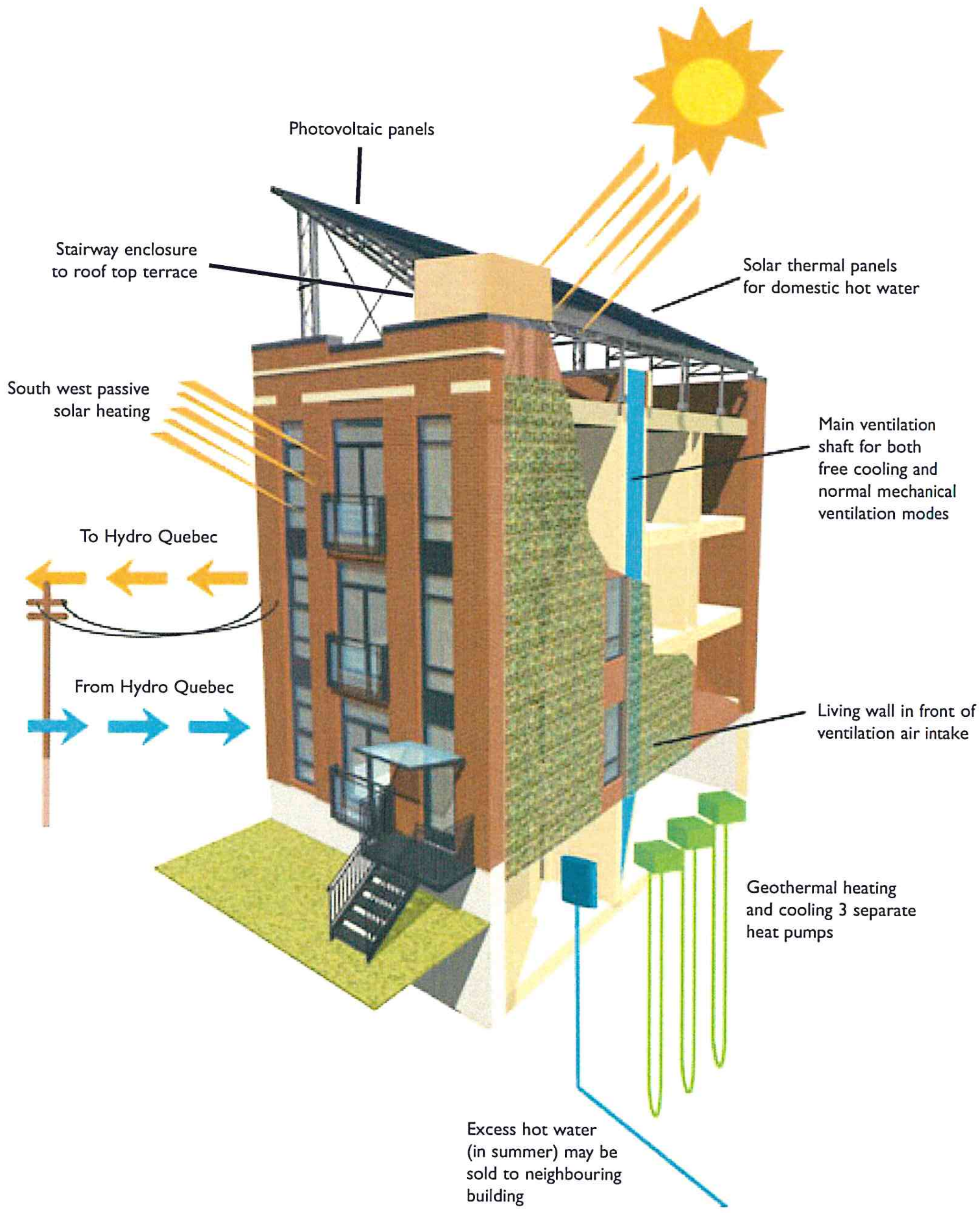


Figure 5—Rendering of Abondance Montréal: le Soleil, showing space and water heating technologies

Technical Summary: Abondance Montréal: le Soleil, Montreal, Quebec[1]

Building Description

Type: New condominium - 3 units, open concept		
Floor space of each apartment	94.4 m²	1016 ft²
Solar Orientation	northeast / southwest	
Building footprint	109.2 m²	1,175 ft²
Heated volume of each apartment	211 m³	7,452 ft³
Heated floor area of each apartment	79.3 m²	854 ft²
Ceiling area of each apartment	79.3 m²	854 ft²
External wall area of each apartment	346.2 m²	3,726 ft²
Window area total in each apartment	19.44 m²	209.3ft²
Southeast	3.19 m²	34.3 ft²
Northwest	0 m²	0 ft²
Southwest	9.38 m²	101 ft²
Northeast	6.87 m²	74 ft²
Ratio of south glazing area to floor area:		n/a

Thermal Characteristics

Roof	RSI 12.3	R-70
Walls — First, 2nd and 3rd floor	RSI 7.92	R-45
Walls — Basement below grade	RSI 6.34	R-36
Windows	RSI 1.23	R-7.0
Basement floor	RSI 2.64	R-15
Measured Airtightness Level	0.4 ACH @ 50 Pa	

Site Characteristics

Location	Montreal (Verdun) Quebec	
Site type	Urban, new development	
Site area	255.5 m²	2,750 ft²
Elevation	29.2 m	96 ft.
Latitude		45°28'N
Longitude		73°45' W

Climate

Average daily horizontal solar irradiation		3.5 kWh/m²
Average daily vertical solar irradiation		2.8 kWh/m²
Average annual precipitation	967 mm	38 in.
Average annual wind speed	14.3 km/h	9 mph
Average outdoor temperatures		
January	-10.4 °C	13.3 °F
April	5.7 °C	42.3 °F
July	20.9 °C	69.6 °F
October	7.9 °C	46.2 °F
Building design temperatures[5]		
January	-24°C	-11.2 °F
July	26.7°C	80.1 °F
Heating Degree Days (base 18°C [64°F])	4,575	[8,234]
Cooling Degree Days (base 18°C [64°F])	235	[423]

Predicted Annual Energy Consumption

Space heating	6.6 kWh/m²
Domestic water heating	26.1 kWh/m²
Appliances/lighting	48.8 kWh/m²
Mechanical ventilation	12.5 kWh/m²
Space cooling	5.4 kWh/m²
Total predicted consumption	**99.5 kWh/m²**

Note: All values are based on heated floor area. The space heating value does not include the contribution from passive solar gains and internal gains (see Space Heating Information, below)

Predicted Annual On-site Renewable Energy Production

Solar (photovoltaic) electricity	60.6 kWh/m²
Active solar domestic water heating	21.7 kWh/m²
Total predicted production	**82.3 kWh/m²**

Note: All values are based on heated floor area.

Predicted Annual Energy Balance -17.2 kWh/m²

EnerGuide for Houses[2] (EGH*) Rating 99.3

Space Heating Information

Space heating requirements for each of the le Soleil apartments will be met as follows (predicted values):

Passive solar gain	35.6%
Internal gains[3]	39.1%
Three-ton ground source heat pump (COP 3.1)[4] for back-up space and water heating	25.3%

Domestic Hot Water Information

Domestic hot water requirements for the le Soleil apartments will be met as follows (predicted values):

Active solar thermal heating system	51%
Three-ton ground source heat pump desuperheater	7.1%
Drainwater heat recovery	31.8%
Electric DHW tank	10.1%

Ventilation

60 cfm heat recovery ventilator (HRV) with 2 ECM motors in each apartment. Maximum efficiency 88% at 0 °C (32 °F). 25 L/s at 125 PA.

Water Consumption (estimated 4 person consumption)

Potable water	Not Estimated	
Rainwater harvesting	36.5 L/day	8 U.K gal/day
	13,333 L/yr	2,935 U.K. gal/yr

1 All size, area, energy use, and system capacity are the average values of the three units
2 Natural Resources Canada's EnerGuide For Houses (EGH) Rating is a standard measure of a home's energy performance, and can range from 0 to 100. The rating is based, in part, on the assumed energy consumption of appliances, assumed hot water draws, and other electricity usages in conventional homes. The EGH* Rating allows reductions in electricity and hot water loads in EQuilibrium™ homes, thereby more accurately reflecting the home's potential energy performance.
3 Internal gains include heat from occupants, lights, appliances, mechanical systems, and consumer electronic items
4 The coefficient of performance (COP) for a heat pump is the ratio of the heat delivered (output) to the electric energy used in operating the pump (input).
5 Building design temperatures are based on historic temperature data for a particular area and are used when designing a building and its heating and cooling systems for that area.

3. 77 GOVERNOR'S ROAD, 6 STOREY CONDOMINIUM, DUNDAS ONTARIO

RESEARCH HIGHLIGHT

December 2002

Technical Series 02-135

Monitored Performance of an Innovative Multi-Unit Residential Building 77 Governor's Road, Dundas, Ontario

INTRODUCTION

In 1998/1999, an innovative, 6-storey, 48-unit condominium was designed and constructed around the four main goals of the Canada Mortgage and Housing Corporation's IDEAS Challenge and Natural Resources Canada's C-2000 programs. These include envelope durability, energy efficiency, indoor air quality (occupant health), and environmental and resource conservation. The building was designed to have energy consumption 35 per cent lower than a similar building designed to meet the Canadian Model National Energy Code for Buildings. The thermal comfort and indoor air quality were also designed to be better than that in typical apartment buildings.

Many advanced, or innovative features were integrated into the design and construction of the building. These included:

- an airtight and well-insulated building envelope using both Exterior Insulating Finish System (EIFS) and brick veneer cladding. Thermal bridging through the building envelope by floor slab brick ledges and balconies was eliminated;
- window features included Low-E, spectrally selective, argon filled, insulating spacers and fiberglass frames;
- individual metering for natural gas and electricity;
- natural gas-fired combination space/water heating in each suite (Figure 1). The in-suite fan-coil units utilize high efficiency electronically commutated motors for low energy consumption;
- individual in-suite and separate common area heat recovery ventilation systems;
- corridor air heat recovery ventilation that used the garbage chute as a return air plenum;

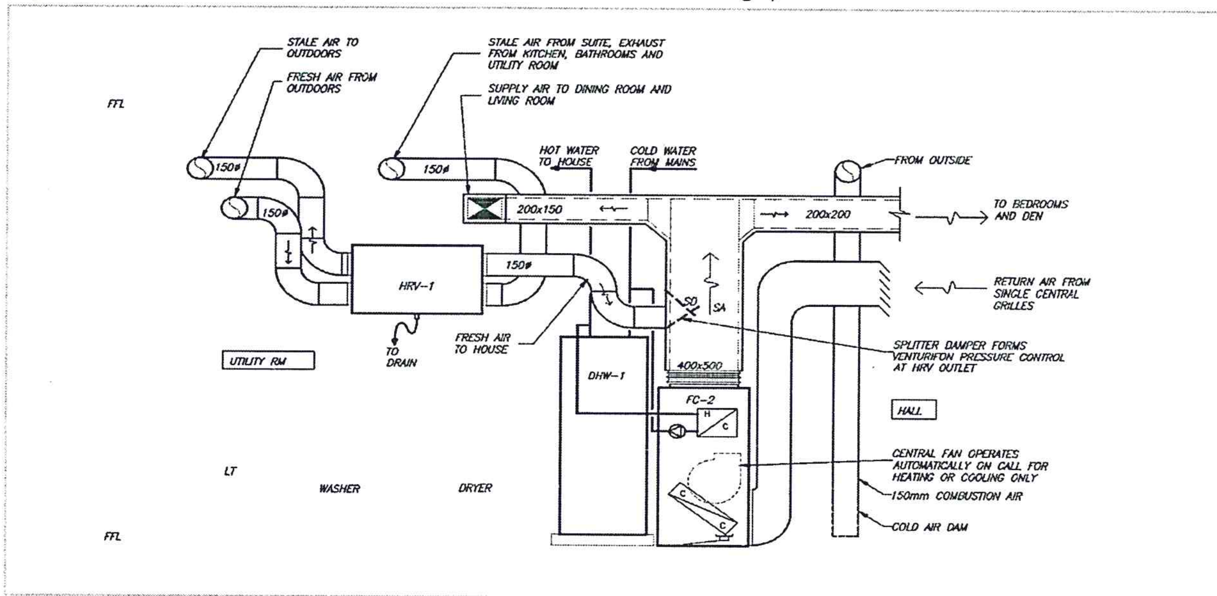
- water efficient appliances and fixtures; and
- energy-efficient appliances and lighting in common areas and parking garage.

While it is one thing to design such features into a building, there has been little follow up work done to determine whether or not buildings that have incorporated advanced technologies actually achieve their goals. Accordingly, Canada Mortgage and Housing Corporation initiated a research project to evaluate the performance of the building in terms of energy and water use, indoor environment, and building envelope durability.

Canada

CMHC SCHL
HOME TO CANADIANS

Figure 1 Combination In-Suite Space, Domestic Hot Water and Ventilating System



RESEARCH PROGRAM

In order to characterize the performance of the building, an extensive monitoring program was developed by the project consultant, Enermodal Engineering Limited. The monitoring program for each performance area was as follows:

1. Building Envelope Air Leakage Control

A program was developed to ensure that the building envelope was designed and constructed to meet a minimum performance criteria of 1.0 L/s/m² @ 75Pa. This criteria was selected as it is roughly 1/3 to 1/4 the air leakage rate of typical multi-unit residential buildings. The project consultants evaluated the building plans and identified areas where air sealing details had to be developed. Once the air leakage details were created, a quality assurance plan involving trades training, site inspection and airtightness testing was instituted. The airtightness testing involved the testing of isolated wall areas, entire apartments and, finally, the complete building envelope.

2. Energy and Water Consumption Monitoring

The natural gas, electricity and water consumption for the common areas and suites were monitored via the utility meters for the first year post occupancy. Detailed energy consumption patterns were monitored continuous in three suites and a common area to characterize the performance of the combination space and water heating systems, high efficiency furnaces and domestic hot water tank (used in one suite) and boilers used in the project.

The energy and water monitoring was used to identify monthly and yearly consumption so that the degree to which the performance targets were met could be assessed. The information was useful to identify the energy performance of combination space and domestic hot water heating systems used in multi-unit residential buildings. The energy data was also used to compare the performance of the building to other multi-unit residential buildings.

3. Ventilation System Performance

The performance of the in-suite heat recovery ventilation systems were assessed via flow measurements and long (PFT tests from Brookhaven National Laboratory) and short term (instantaneous SF6) tracer gas decay tests. The objective of the tests was to determine the ability of the HRV systems to exchange, distribute and circulate ventilation air in the apartments. The performance of the parking garage and corridor ventilation system was also assessed via tracer gas tests to determine whether or not they effectively ventilated these areas and prevented the proliferation of air from these zones to other areas of the building.

4. Indoor Environment

The indoor environment in one suite was monitored for airborne particulates, formaldehyde, and volatile organic compounds. Long term monitoring of temperature, relative humidity and carbon dioxide was also performed in three suites. The objective of these tests was to determine if the measures taken to provide an enhanced quality of indoor air were successful.

5. Heat, Air and Moisture Performance of the Wall Assemblies

The temperature, moisture and pressure regimes through the brick veneer and EIFS wall sections were monitored continuously to determine if conditions in the wall assemblies were conducive to long term durability.

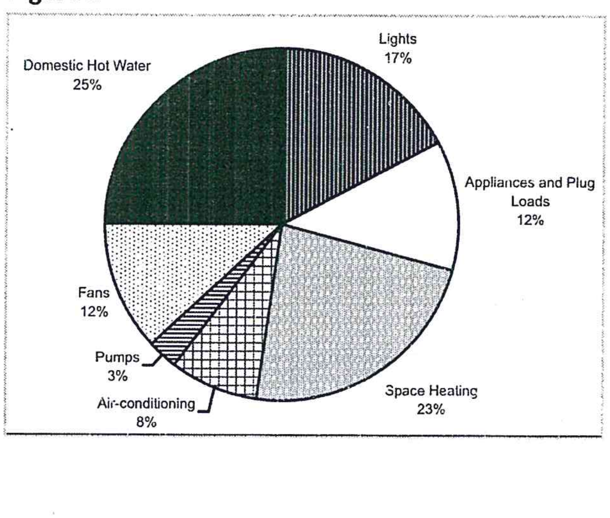
The monitoring program took place once the building was fully occupied for the period of one year. Most of the monitoring was done automatically with on-site instrumentation and data recording equipment.

FINDINGS

In general, the overall performance of the building met with expectations. Some of the major findings of the performance assessment testing and monitoring were as follows:

- The building consumed 137 $ekWh/m^2$ for the year monitored. While this was in excess of the performance target of 125 $ekWh/m^2$, it is still far below the Model National Energy Code for Buildings value of 195 $ekWh/m^2$ and the "typical" annual energy consumption of multi-unit residential buildings that can be in excess of 300 $ekWh/m^2$. Figure 2 shows the distribution of annual energy use in the building.

Figure 2



- The seasonal energy efficiency of the combination space and domestic hot water heating systems was found to range between 43 per cent and 63 per cent. The low efficiency was thought to be a function of inadequate commissioning practices and low space heating and domestic hot water loads.
- The average electrical base load per suite was 11.8 kWh per day. When the space cooling load is included, the average electrical load is 15 kWh per day. The average natural gas use, for space heating and domestic hot water, averaged 2.6 m^3 per day per suite.
- The central cooling system consumed 61,610 kWh during the monitored year or 1,162 kWh per suite.
- Water consumption, metered centrally, indicated a water use of 77m^3 per suite per year or 0.5 m^3/m^2/year. This represents very little water use when compared to other multi-unit residential buildings. The low consumption is likely due to the water saving appliances (toilets and faucet aerators) and the building being populated by affluent seniors who can spend the winter months away.
- The building envelope airtightness target was met despite the challenges of integrating air leakage control procedures across the many stages of design and construction and the many different trades that must be convinced to buy-in to the process. The improved building envelope no doubt contributed to occupant comfort and low space heating energy consumption. The level of airtightness achieved in this project represents a reduction of 75 per cent over conventional buildings.
- The heat, air and moisture monitoring of the wall assemblies found the condensation potential within the walls to be low. This should help to ensure the long term durability of the wall structures.
- The in-suite heat recovery ventilation units were found to operate in an effective manner. The tracer gas tests showed that ventilation air is well distributed and circulated in each apartment—something rarely achieved in conventional apartment buildings. The testing also showed that the HRVs could distribute and circulate ventilation air without the operation of the forced air system fan thereby representing an electricity saving option.
- The corridor ventilation system, that delivered air to the corridors and exhausted air from the garbage chute was found to help contain garbage chute odors, prevent the proliferation of parking garage gases to the apartments and maintain acceptable air quality conditions in the corridors of each floor.

- The indoor air quality monitoring in one apartment found common contaminants to be within Health Canada guidelines. Indoor air temperatures in three apartments were held fairly constant during the space heating and cooling seasons. Indoor relative humidity in the three apartments varied from 15 per cent to 70 per cent but average summertime RH ranged from 40 per cent to 60 per cent while the average winter range was 25 per cent to 40 per cent. Carbon dioxide readings averaged between 516 and 827 ppm but with occasional readings of up to 2,000 ppm. The in-suite HRVs appeared to maintain good IAQ.

IMPLICATIONS FOR THE HOUSING INDUSTRY

The verified performance of this innovative multi-unit residential building indicates that it is possible to include many advanced and environmentally responsible features into a fairly conventional construction project. The integration of an air leakage control procedure into the construction, design and commissioning process is perhaps one of the most important aspects of this project. The in-suite and corridor ventilation strategies represent significant departures from conventional designs but demonstrate significantly improved performance.

The study also shows that the energy use, hence environmental impact, of multi-unit residential buildings can be significantly reduced through thoughtful design and construction techniques without risk to the commercial viability of the project.

Also see:
Research Highlight – Wind-driven Rain Study for the Governor's Road Project on CMHC website.

CMHC Project Manager: Duncan Hill

Research Consultant: Enermodal Engineering Limited
Waterloo, Ontario

Housing Research at CMHC

Under Part IX of the ***National Housing Act,*** the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

To find more ***Research Highlights*** plus a wide variety of information products, visit our website at

www.cmhc.ca

or contact:

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Ottawa, Ontario
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Phone: 1-800-668-2642
Fax: 1-800-245-9274

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3. BELLECHASSE AFFORDABLE HOUSING – REUSE WITH NEW CONSTRUCTION, MONTREAL

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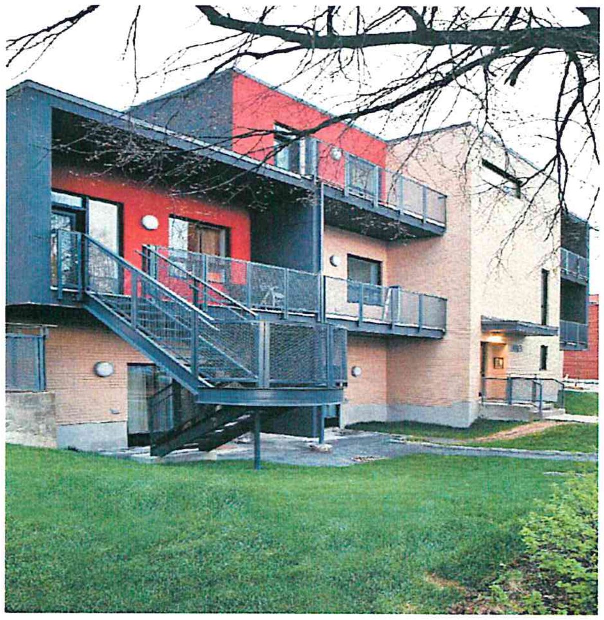
Viewpoint - Disconnects Urbanism and Public Health »

2011 SAB Award Winning Project - Affordable Housing Bellechasse



This is a multi-family social housing development located close to downtown Montreal. It incorporates an abandoned utility building that served previously as a hospital. The overall development included the restoration of this building together with new structures, and totals 9,497m2 in 91 residential units.

The project embraces principles of sustainable design on multiple levels:

• Preservation and rehabilitation of a large existing building had both economic and environmental benefits, but also resulted in the delivery of residential units of higher qualitative standard than might otherwise have been possible within the budget.

• Environmental sustainability is expressed by employing a variety of strategies such as water conserving features, grey water heat recovery, a high-performance building envelope and a variety of

innovative architectural design ideas.

In the existing building, typical units are located along the exterior wall rather than perpendicular to it which allows for generous provision of operable windows, even though it is potentially less energy efficient. This approach was also used in the new building where glazing size exceeds standards by approximately 50%. In both cases, high-efficiency windows and frames were specified.

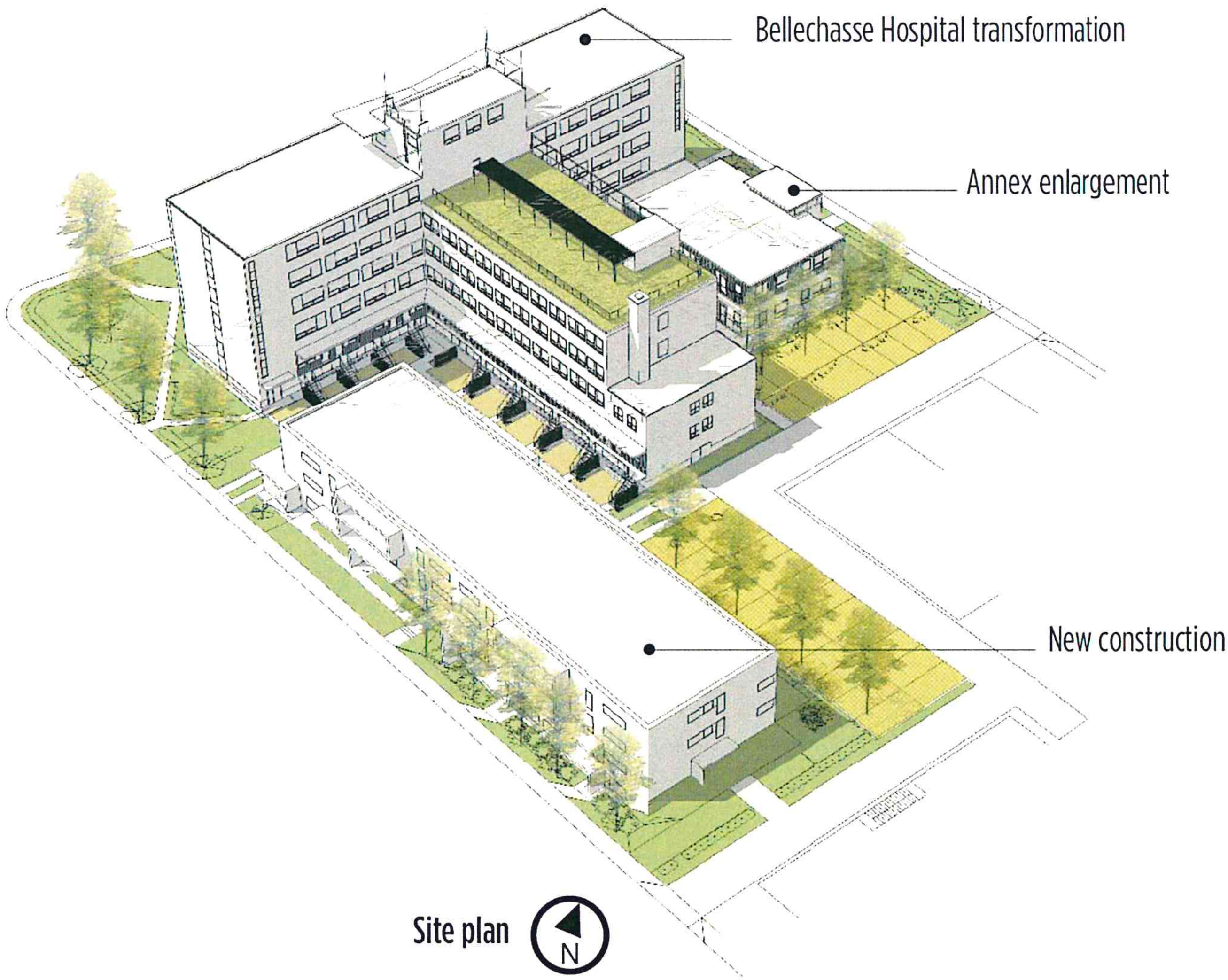
Most of the ground and garden level family units were designed to stretch between the opposite facades of the building allowing for enhanced natural, cross ventilation, a strategy that eliminated the need for any mechanical cooling. Water conservation was accomplished through the use of dual flush, toilets and high-efficiency water fixtures throughout.

Architect Aedifica Inc, Montreal

PROJECT PERFORMANCE

- **Energy intensity:** 442 MJ/m2/year [Includes both base building and process energy]
- **Local materials by value:** 80%
- **Recycled materials content by value:** 50%
- **Water consumption from municipal source:** 43,435 litres/occupant/year [Includes both base building and process energy]

Passive House, the German devised standard for low energy buildings mandates that total energy use must not be more than 432 MJ/m^2/year. There is no solar panel array on this building so its building envelope and other systems are designed and executed to a level which is excellent for conversion to Net Zero.



5. 60 Richmond Street Housing Cooperative

ENERMODAL ENGINEERING

A member of MMM GROUP

Case Study

Toronto Community Housing

60 Richmond St. Housing Co-operative

Where affordable sustainability meets social responsibility

Owner:
Toronto Community Housing Corporation

Architect:
Teeple Architects

Our Services:
- Sustainable Design Facilitation
- Energy Efficiency Consulting
- LEED® Consulting & Certification
- Building Commissioning
- Building Performance Monitoring

The 11-storey cooperative at 60 Richmond St. E in Toronto has been awarded LEED Gold certification from the Canada Green Building Council in recognition of the many sustainability features incorporated into this affordable housing initiative.

The project houses people from the hospitality field, and has a public restaurant and training kitchen on the ground floor, serving to animate Richmond Street. Gardens have been carved out of the building at various levels which will not only provide the restaurant with herbs and vegetables, but will create the principal social spaces of the building. At the same time, these gardens permit additional daylighting to reach further into the dwellings, providing natural light to multiple exposures. An elegant urban farming thesis is incorporated with water and compost harvested and fed to gardens for the propagation of vegetables–which may then be consumed back down at the restaurant level. This is a full-cycle ecosystem, although on a very small scale.

Notable Features

- green surfaces for all roofs
- hose bibs fed by the cistern provide make-up water for the plantings on the sixth floor garden terrace
- low-flow water fixtures
- 7.5 million litres of indoor potable water saved each year
- fibreglass glazing frames act as extended thermal breaks in combination with low-e, argon-filled glazing units with warm edge spacers
- natural ventilation is provided to all principal spaces of the building
- in-suite heat recovery ventilators
- energy recovery ventilators supplying ventilation air for the amenity areas
- low-VOC paints, coatings, sealants, and adhesives
- CRI Green Label certified carpet

LEED® Project Facts

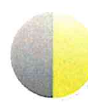
Gross Floor Area: 7865 (m^2)

Energy Density: 196 (kWh/m^2)

Category	% Performance
Water Savings	
Irrigation	50 %
Indoor Use	50 %
Energy Savings	38 %
Waste Diversion	90 %
Recycled Content	16 %
Regional Content	31 %
Daylighting	76 %
Views	91 %
	LEED® Gold

LEED NC Gold Certified
Completed 2010
Toronto, Ontario

38% Energy Savings



50% Indoor Water Savings

16% Raw Materials Savings

www.enermodal.com

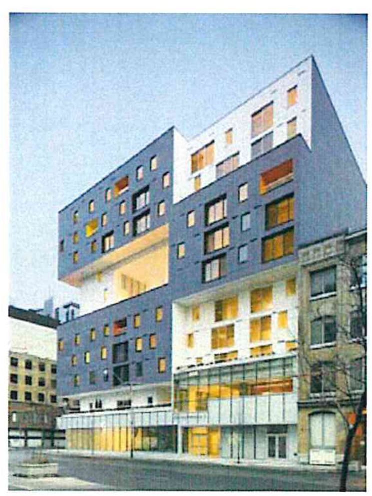
Toronto Community Housing

60 RICHMOND STREET EAST

Sustainable Design

Toronto Community Housing

60 Richmond Street East – Sustainable Design



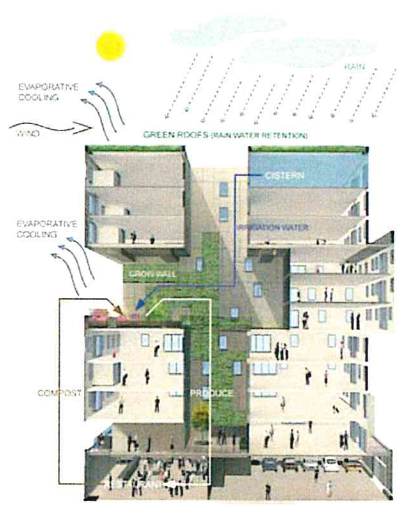
Toronto Community Housing

60 Richmond Street – Sustainable Design

Green Construction and Building Features

- Dedicated on site LEED Co-ordinator
- Demolition/construction waste diversion
- Procurement of local construction materials
- In suite ERVs and heat pumps
- High efficiency boiler
- Building automation system
- Potential for sub metering in units

Toronto Community Housing



Toronto Community Housing

60 Richmond Street – Sustainable Design

Projected Energy Savings

- Lighting – electric - 32%
- Space heating – natural gas – 57%
- Space cooling – electric - 65%
- Pumps – electric - (72%)
- Fans – electric - 51%
- Service water heating – natural gas – 56%

Toronto Community Housing

60 Richmond Street – Sustainable Design

Total Projected Energy Summary

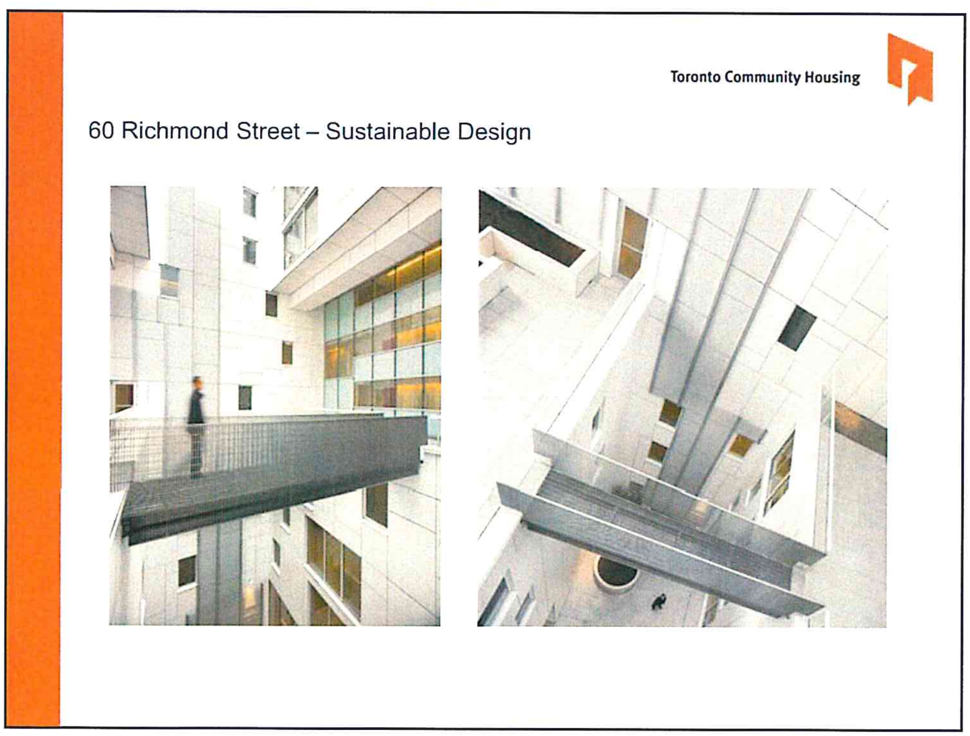
	Proposed	Building	Reference	Building	Percent	Savings
	Energy	Cost	Energy	Cost	Energy	Cost
	(MJ)	($)	(MJ)	($)	(MJ)	($)
Electricity	2,678,940	$66,080	3,470,992	$84,564	23%	22%
Natural Gas	2,875,951	$28,065	6,637,954	$63,648	57%	56%
Total	5,554,891	$94,145	10,108,946	$148,212	45%	36%

PRINCIPLES FOR DESIGN OF A BUILDING FOR EDMONTON

Architecture

In all the above discussion this research has been concerned with the technical knowledge of energy management in the planning and design of a residential building. But the planning of a successful net zero carbon building is no more an excuse for dispensing with architecture than if the building was meant to house fire trucks. The last building considered above, 60 Richmond Street by Teeple Architects, is not a star example of energy efficiency, although the savings are projected to be 45%. It is included because of the high quality of its architectural design, which has benefited the surrounding community and its residents obviously and remarkably. It occupies a corner in a poor and somewhat neglected pocket of Toronto, but by its striking and sophisticated composition of solids, voids, and setback volumes, its various planes and indentations emphasized by colour, and the subtle, lyrical arrangement of windows, it elevates and enlivens the spirit, attitude, and character of its environs. Such an architecturally rich and dynamic presence can be expected to spark and sustain a consequence of change and progress in an area where formerly an inertia of apathy and despondence lay over the neighbourhood.

The design features a cutting away of sections of the building to create an internal open-air courtyard (see section on p. 48 above), which extends from the mezzanine to the sky, with



terraces, bridges, and gardens into which air and light penetrate to the off-street side of all suites. Common areas for relaxation and interaction of the occupants are thereby created. So although the exterior skin is greatly extended, giving rise to added heat loss and the sacrifice of revenue-earning space, the advantages to the enjoyment of the occupants and the appeal of the building more than offset the losses. At the same time the building envelope and heating system have been designed to reduce heat loss to 43% of the standard code level equivalent.

The best of current architecture, like Teeple's building, develops from site, context, and function, and does it with respect for the environment. An approach that first considers the needs the building is meant to fulfill, and the ways this can best be achieved, is one that develops from the specifics of the problem without a preconceived idea around which the rest would need to be force-fit. In starting from the essentials of programme and the constraints and attributes of the site, architecture is the search for and the discovery of what the building should be. As the solutions come into focus, the mind and imagination can begin to stretch the choices of form, space, circulation, materials, and most essentially, light.

We live in a time that has finally realized the essential need for natural light and views of nature to nurture our spirits and energies. What are so loosely termed 'traditional' forms are those that try to recall styles from a time which did not place importance on humans' natural origins, or our love of, and need for, light. The attitude was quite forgivable considering our long history of battling the difficulties posed by the natural world. External form, order, rhythm, repetition, etc., all intellectual concepts, were dominant in architectural styles to the detriment of the experience of being inside a building. Necessarily that experience was enhanced, or not, by decoration. Modernism, since its beginning a century ago, has revolutionized the old order through an embattled trajectory of high and low points that continues to evolve, having survived the sealed and windowless craze, Postmodernism, Deconstructivism, and the endless cheapisms of industry's accounting departments.

Modernism is not a 'style'. It's rules are loose and inclusive of invention and metamorphosis, the basic imperatives perhaps lying in values of beauty, function, simplicity, originality, homage to nature, and the integrity of the design effort. Its flexible essence allows us to design in context with local culture engendering authenticity and meaning for those who experience the building or space whether directly or in passing. Good architecture will consider every facet of the building and endow all decisions with meaning congruent with the overall design. This is an arduous and extensive work, but cut and paste interjections onto a design are the stuff of untrained designers and technicians. As in 60 Richmond Street, the results of the effort reach out to the populace, as well as the users, creating a landmark that can inspire pride and encourage better architecture.

Faced with the current crisis of climate change, we cannot ignore the responsibility to steer our clients towards ever lower carbon emission levels, posing the difficulty of achieving both good architecture and low CO^2 within a single budget. It seems, based on this research, that it should not be an impossible feat. Extensive glazing, a Modernist hallmark, fits well with low CO^2 principles, needing only to be carefully tuned for natural lighting and solar heat gain, but with shading and, in our climate, constrained to no more than 40% of total exterior wall area. The added cost of air-tightness and higher insulative values can be easily justified by the promise of higher comfort and lower operating costs. The success of buildings such as Abondance Montreal indicates that budgets for low-income developments do not eliminate the possibility of low and net zero carbon. Good architecture does not demand expensive and strikingly innovative solutions in every project; careful, comprehensive, informed design applied to the specific problem of a client's programme will produce notable and excellent results.

ARCHITECTURE

- TAKE THE CLIENT'S PROGRAMME AND ATTITUDES AND APPLY THEM TO THE ATTRIBUTES OF THE SITE TO FIND CLUES. AIM TO CREATE A SENSE OF PLACE.

- AVOID THE GRAND SCHEME: WORK ON THE PROBLEMS FROM BASICS THROUGH TO DETAILS TO DISCOVER THE SOLUTIONS.

- BE INSPIRED BY WORLD ARCHITECTURE, BUT THINK IN THE LOCAL CONTEXT.

- CONCIEVE THE SPACES OF THE BUILDING AND WORK OUT FLOOR PLANS WITH A 3D PESPECTIVE. CONSIDER THE EXTERIOR WORLD AS ADDING TO THE RICHNESS OF THE INTERIOR SPACE.

- ALWAYS GIVE THOUGHT TO ALTERNATIVE SOLUTIONS, IMAGINING ALL EXISTING CONDITIONS BEFORE APPLYING THE FIRST TO MIND.

- USE THE BEST MATERIALS FROM THE CLOSEST SOURCES TO BUILD UP A TEXTURAL PALLET UNIQUE TO THE BUILDING.

- INJECT MEANING INTO EVERY GESTURE AND DETAIL SO NO CRITICISM CANNOT BE MET.

- BE PRPARED FOR THE WHIMS OF THE CLIENT AND BEOPEN TO DETOURS WHICH YOU CAN LEAD TO EQUALLY GOOD OR EVEN BETTER ENDINGS.

TECHNOLOGY

1. BUILDING FORM DERIVED FROM SITE ORIENTATION

2. ELIMINATE ALL HEAT BRIDGES AND USE HEAT RECOVERY TECHNOLOGIES IN VENTILATION

3. MAXIMIZE PASSIVE SOLAR HEAT AND DAYLIGHTING WITH MULTI-PANE COATED GLAZING

4. COOL WITH SHADING AND NATURAL VENTILATION

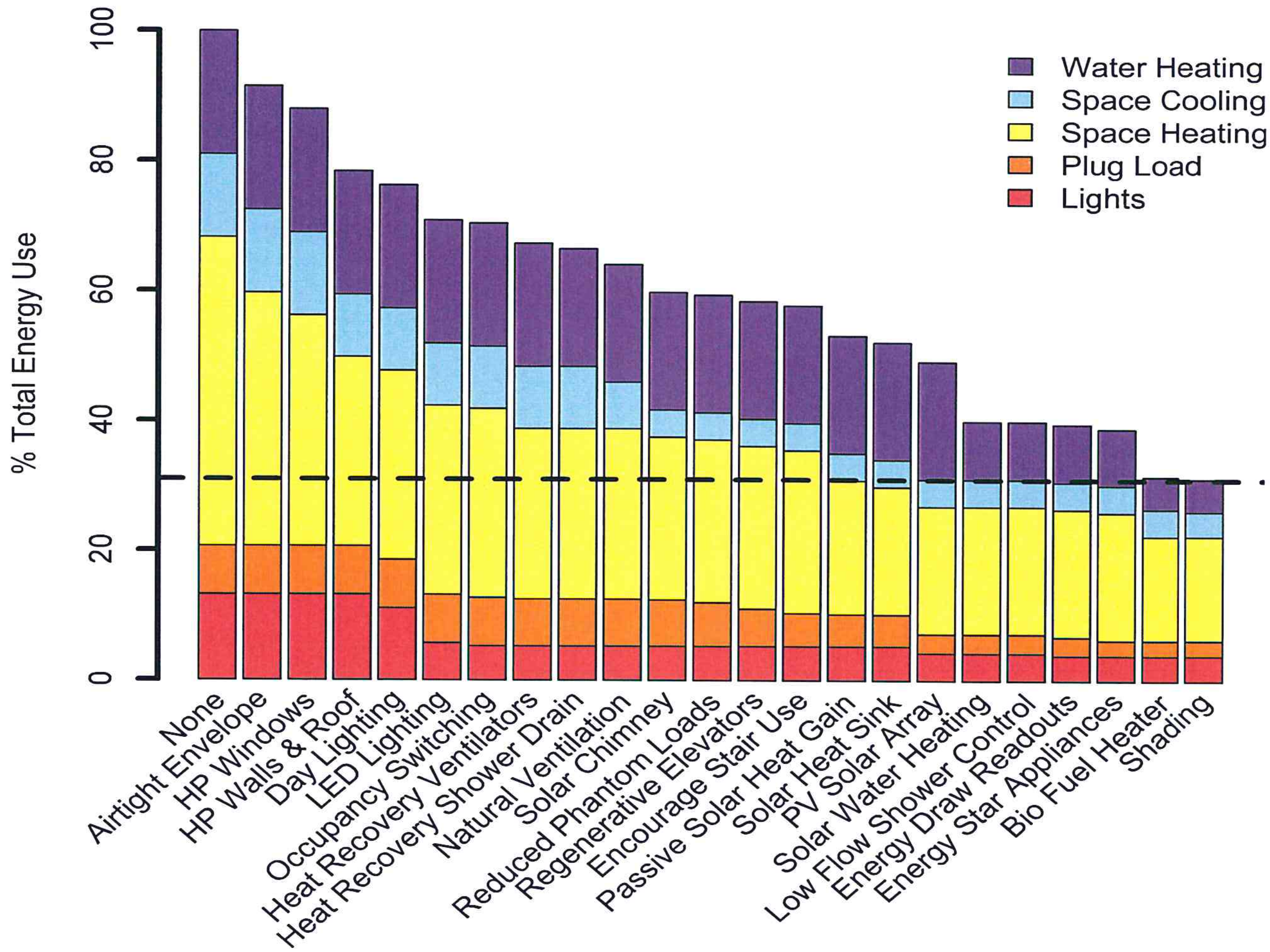
5. REDUCE ELETRICAL LOADS & USE AUTOMATIC CONTROLS

6. USE GRID-TIED SOLAR PV AND HOT WATER PANEL ARRAYS

7. AVOID GEOTHERMAL HEATING AND COOLING WHERE ELECTRICITY IS COAL-GENERATED

8. ENCOURAGE CONSERVATIONIST HABITS AND AMBITIONS

The last page shows a graph illustrating a theoretical reduction of electrical, heating, and cooling loads in a building by percentage and due to the various strategies in the text of this report.



% Total Energy Use
0
20
40
60
80
100
Water Heating
Space Cooling
Space Heating
Plug Load
Lights
None
Airtight Envelope
HP Windows
HP Walls & Roof
Day Lighting
LED Lighting
Occupancy Switching
Heat Recovery Ventilators
Heat Recovery Shower Drain
Natural Ventilation
Solar Chimney
Reduced Phantom Loads
Regenerative Elevators
Encourage Stair Use
Passive Solar Heat Gain
Solar Heat Sink
PV Solar Array
Solar Water Heating
Low Flow Shower Control
Energy Draw Readouts
Energy Star Appliances
Bio Fuel Heater
Shading

- END –

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Jonathan Ouellette
Registrar RAIC Syllabus.

Please find enclosed one bound copy of my Syllabus D9A + B Thesis. Note that, as previously suggested, I have edited the Preamble (pp. 3-5) of the written part.

Thank you.

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