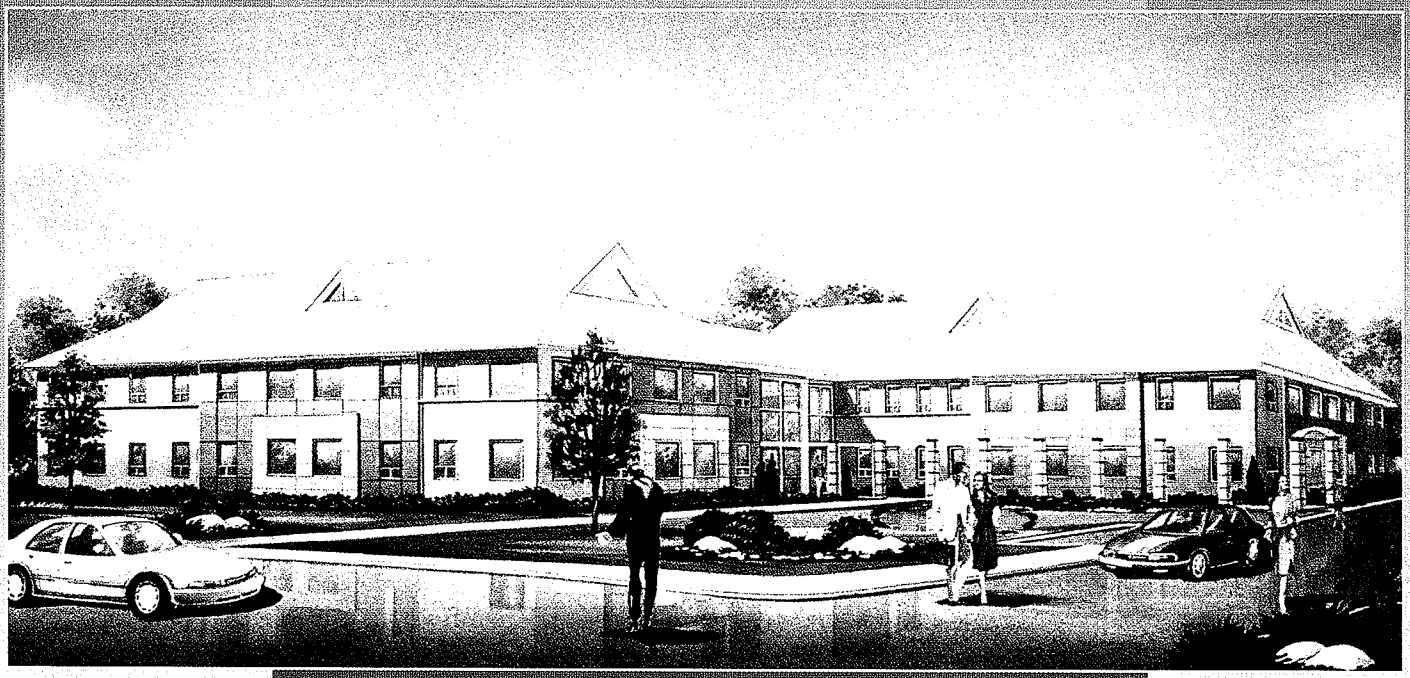
Green on the Grand



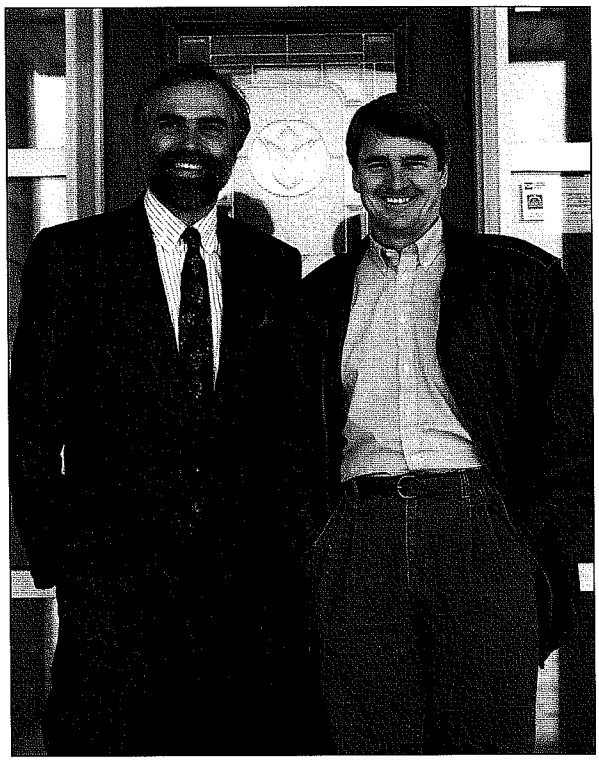
CANADA'S FIRST C-2000 OFFICE BUILDING

Energy Efficiency and Environmental Responsibility in Commercial Construction

Welcome!

Welcome to... Green on the Grand

Green on the Grand is one of Kitchener-Waterloo's newest office buildings and, as Canada's first C-2000 project, it is already setting the standard for environmental responsibility in new construction. During construction and in operation, the building consumes significantly less energy, water, and construction materials than a typical office building, uses almost no ozone-depleting chemicals, and sends minimal waste to landfill. Green on the Grand is a beautiful and comfortable place to work and is inexpensive to operate and maintain. This building is fully leased–thanks to Hybrid Turkeys, MTE Consultants, Enermodal Engineering and Sommerfeld Commercial Realty–which proves that doing the right thing for our common environment is also financially sound.



Green on the Grand is a joint project of Ian Cook Construction and Enermodal Engineering Limited, but it would not be a success without the support of numerous organizations and suppliers who are as committed to environmental stewardship as we are. These members of our team are listed in the last section of this brochure, and we appreciate their contribution. The project partners and suppliers welcome inquiries about Green on the Grand design, components, or operation.

It has been said that it doesn't matter if you are on the right track if all you are doing is just sitting there. We encourage you to investigate how the unique features of Green on the Grand result in a resource and energy efficient building. Consider making these features a part of your next construction project.

Ian Cook
Ian Cook Construction

Stephen Carpenter, P.Eng.
Enermodal Engineering Limited

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Design Objectives

Green on the Grand is a response to the challenges posed by the C-2000 program of CANMET, the research and technology development arm of Natural Resources Canada. CANMET set detailed design and performance guidelines for all the commercial projects supported under the C-2000 program. These guidelines cover energy efficiency, environmental impact, occupant health and comfort, and durability and functionality.

Energy Efficiency

Energy production, transmission, and use result in many environmental problems. These include global warming, acid deposition, smog, radioactive contamination, thermal pollution, and the use of land for dams and power corridors. Energy efficiency in construction means that a building should consume a minimum amount of energy for heating, cooling, and electrical loads, and that construction and finishing materials have low embodied energy.

The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) writes the standards that determine building design practices throughout the continent. Standard 90.1 governs the design of energy-efficient new buildings; buildings designed to ASHRAE 90.1 consume 15% to 20% less energy than buildings designed according to typical practice.

The Green on the Grand project team set a tough objective: a minimum 50% reduction in energy use and a 60% reduction in electricity consumption and peak demand, relative to an ASHRAE 90.1 building.

Environmental Impact

Commercial building construction and operation can have many negative impacts on the natural environment: ozone depletion due to the use of CFCs and HCFCs; depletion of virgin and/or non-renewable resources; air, water, and soil pollution from the manufacture of construction materials; and waste disposal problems at landfill sites.

Many negative impacts can be avoided or minimized through careful specification of building materials and proper building design. Design objectives at Green on the Grand included the use of recycled and re-used materials; the avoidance of products from unique or non-renewable sources; the elimination of materials that involve noxious manufacturing pollution; and the avoidance of CFCs and HCFCs. The waste management objective was to send minimal waste to landfill.

Fresh water is a precious resource. Water can be wisely managed through the use of water-conserving mechanical systems, low water-use plumbing fixtures, and low water-demand landscaping. The objective for Green on the Grand was a 70% reduction in water usage compared to a conventional commercial building.

Occupant Health and Comfort

Many materials used to construct, finish, and furnish offices continue to release contaminants into the building air long after construction is complete. The most common air contaminants are urea formaldehyde and volatile organic compounds; these are found in some particleboard, carpets, fabrics, paints, and adhesives. These contaminants, along with poorly designed ventilation systems, combine to create "sick building syndrome." The objective for Green on the Grand was to supply tenants with air superior in quality to that found in typical offices. This required the use of non-contaminating materials such as natural linoleum flooring; VOC-free paints, sealants and adhesives; and formaldehyde-free wood products. The ventilation system must provide a continuous supply of fresh air at a comfortable temperature without air recirculation.

Durability and Functionality

Effective resource conservation requires that buildings have a long operating life. The Green on the Grand design team chose materials with good durability and longevity, and that in most cases, could be re-used or recycled when the building reaches the end of its useful life. Mechanical systems are to be simple, reliable, and require little maintenance.

Building Form

Building size, lot orientation, and the use of passive solar heating and daylighting all played a role in determining the form of Green on the Grand. The size of the building—two-storeys with a floor area of 2,180 square metres—and the architectural style were chosen to be compatible with neighbouring buildings.

The building lot is long in the north-south direction. This configuration presented a challenge because it limits the southern exposure of the building, the exposure best for daylighting and passive solar heating. In addition, the best views over the Grand River (one of the most desirable features of the site) lie to the east and north, usually the sides of a building least attractive for window placement from an energy viewpoint. The objective was to derive a building design that is energy efficient and provides for natural lighting, but that fits onto the building lot and takes advantage of the river views.

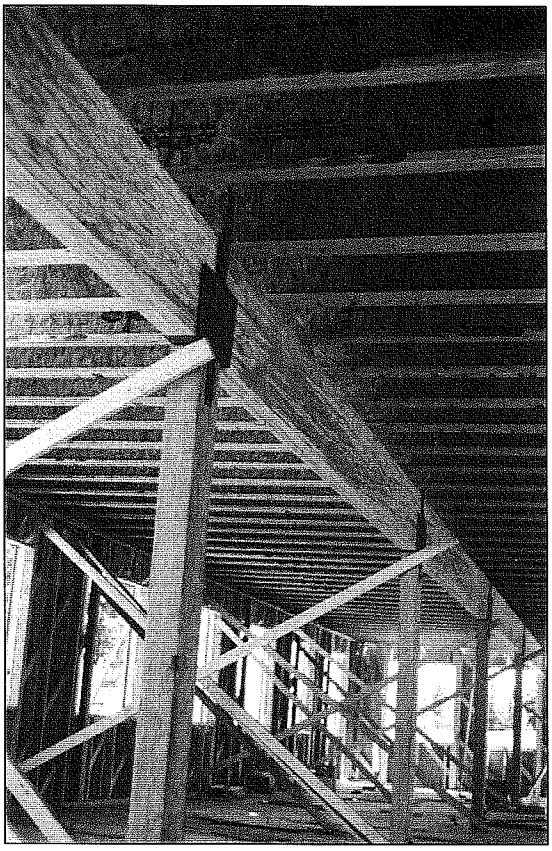
The building form is two offset rectangles; the window-to-wall ratio is 30%.

The building shape is two off-set rectangles. This form increases the building exterior and thus increases the potential for day-lighting and river views. The area where these rectangles "overlap" is kept to a minimum, and houses the central corridor, elevator, stairwell, and washroom area. Eight large dormer windows allow daylighting to serve almost the entire second floor. The steeply-pitched roof has a longer life and lower maintenance than a traditional flat roof.

Green on the Grand is barrier free. The entrances are at grade level and the exterior doors are fitted with automatic door openers [1] (numbers refer to the supplier index at the end of this brochure). An elevator provides access to the second storey.

Building Envelope

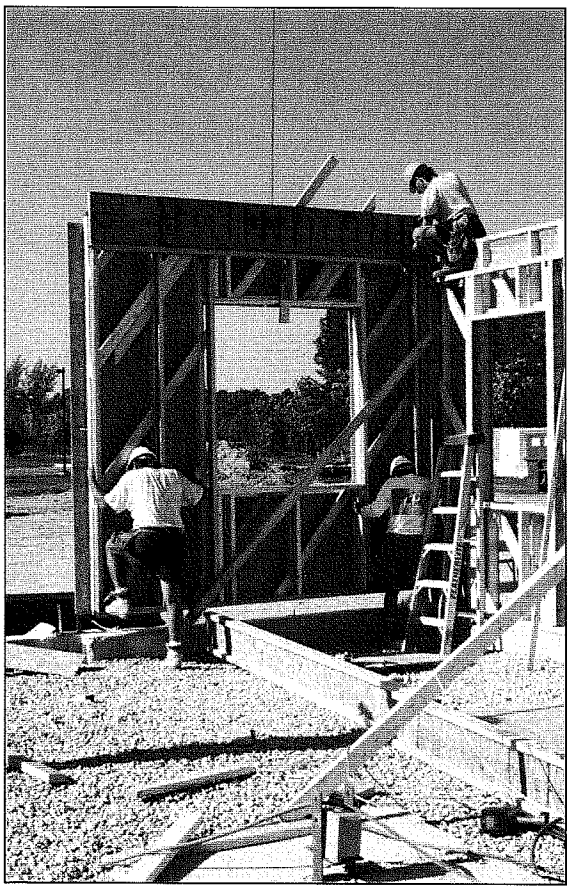
Perhaps no other feature of Green on the Grand exemplifies the commitment to energy and resource efficiency than the construction of the building envelope—structural support, walls, foundation, roof, and windows. Together these components form a building that is well-insulated (close to 3 times normal R-values), airtight, and takes far less energy and materials to construct and operate. In fact, Green on the Grand will require only 40% of the heating energy of a typical commercial building of a similar size built to ASHRAE 90.1 standards.



Beams, columns, and floor joists are made from engineered wood products.

Structural Support System

The concrete and steel support systems of commercial buildings embody large amounts of energy, are made from non-renewable resources, and are difficult to insulate. The structural support for Green on the Grand is as strong as these systems, but is constructed from wood. Wood is a superior building material: it is a plentiful, renewable resource; it is energy efficient; it has low embodied energy; and it is low in cost. One of wood's disadvantages is that it is not dimensionally stable because it is subject to shrinking and twisting. The solution to this is the use of engineered wood products [2], such as laminated strand lumber (LSL) and laminated veneer lumber (LVL), which are made from wood strands and glue. These products are extremely strong, are dimensionally stable, and their glues do not contain urea formaldehyde, an indoor air contaminant.



A crane lowers double-stud wall section into place.

The central support for Green on the Grand are rows of LSL columns; these columns support LSL beams 125mm X 450mm in size, spaced up to 6.7m apart. Structural wall studs for the first-storey exterior walls are made from 38mm X 89mm LVL placed 600mm on centre.

The floor between the first and second storey is constructed of 400mm-deep wood I-joists [2] spaced 600mm on centre; the joists are covered on the underside with 16mm drywall, and on the top side with 22mm oriented-strand board and a layer of 19mm gypcrete for sound dampening. This flooring system has a 3/4 hour fire rating.

Walls

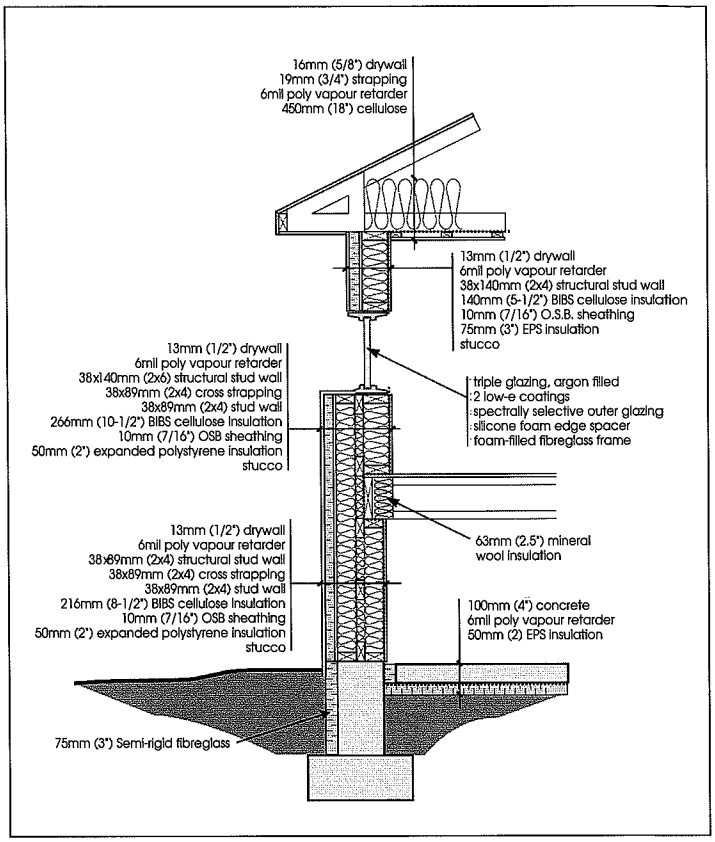
The exterior walls of Green on the Grand are of wooden, double-stud construction. Double-stud walls are energy efficient for two reasons. One, there is plenty of room for insulation. Two, thermal bridging is minimized because wood is less conductive than steel, and because the exterior wall provides an insulated layer over the ring joist at the edge of the floor.

Wall cavities are filled with blown-in cellulose insulation made from 100% recycled newspapers [3], 216mm for the first-storey walls and 140mm for the second-storey walls. A 6mil polyethylene air/vapour barrier is attached to the inner surface of the wall assembly. The seams in the air/vapour barrier are overlapped and sealed with acoustical caulking. This airtight building envelope meets the standard for airtightness for R-2000 houses (NLA of 0.7 cm^2/m^2).

The exterior of the wall is covered with 50mm of expanded polystyrene insulation (EPS) that is coated with stucco to provide a strong, resilient, weather-tight finish. This exterior insulated finishing system (EIFS) [4] provides a layer of insulation over all studs and other thermal bridges.

Foundation

The underside of the slab-on-grade first floor is insulated with 50mm EPS [5] to reduce heat loss and improve thermal comfort. The basement walls are covered with a polyethylene sheet for water-proofing; this eliminates the use of tar, a source of soil contamination. Seventy-five millimetres of rigid fibreglass [6] is both a drainage layer and insulation. Crushed, recycled concrete surrounds the weeping tile [7].



Exterior wall cross-section

Roof

The roof at Green on the Grand has sections that are steeply-pitched and sections that are shallow in pitch. Steeply-pitched sections are constructed from 450mm wood I-joists, while shallow pitch areas are supported by pre-manufactured wood trusses. The trusses are made from small-dimensional lumber, which means that the lumber is from young, fast-growing tree species, and not from old-growth forests. The roof is finished with high-grade, fibreglass-reinforced shingles for a long life expectancy.

The cathedral ceilings on the second storey are insulated with 350mm of mineral-wool batts spun from 50% recycled slag waste [8]. Flat ceiling areas are insulated with 450mm of blown cellulose.

COMPONENT R-Values
(in m^2K/W and in $hr*ft^2F/BTU$)

COMPONENT	GREEN ON THE GRAND	ASHRAE 90.1
Above-Grade Walls	5.6(32)	2.3 (13)
Below-Grade Walls	1.9(11)	1.9 (11)
Windows	1.1(6.2)	0.68 (1.5)
Doors	1.0(5.7)	0.4 (2.3)
Ceiling	10.0(57)	3.6 (20)
Floor	1.6(9)	0.2 (1)

Windows and Doors

Green on the Grand windows [9] exemplify three key features: low heat loss, high daylight transmission, and low solar heat gain. The windows are triple-glazed with two low-e coatings [10], two argon gas-fills and two silicone edge-spacers [11]; the total U-value is under 1.0 W/m²C. An outside lite of spectrally-selective glass [10] maintains high visible light transmission (0.53) and minimizes solar heat gain (solar heat gain coefficient, SHGC, 0.28). The visible transmission-to-SHGC ratio, sometimes called the glazing luminous efficacy, is 1.9, which is close to the highest value possible.

The window frames are assembled from pultruded fibreglass lineals [12] filled with polystyrene insulation. Fibreglass frames are a good choice environmentally, for they have low embodied energy, are excellent insulators, and their manufacture results in few noxious emissions.

Large glazed areas at the front and rear entrances have thermally-broken, structural aluminum frames [13] which provide maximum strength with a minimum of framing. The 50mm thermal break is ten times wider than that found in typical commercial aluminum windows.

The entrance system is triple-glazed, thermally-broken and tightly sealed.

Window sizing is a balance between the need for light and the need to keep warm/cool air inside. Computer simulations show that this balance for Green on the Grand is optimum at a window-to-wall ratio of 30%. The windows are evenly distributed on each side of the building to provide light to all perimeter offices.

For reasons of energy efficiency, most windows are fixed. Ten per cent of window area is in operable windows (awning type) to allow for tenant control of outdoor air. These windows enhance the mechanical displacement ventilation system and can be used to provide ventilation air in the event of a power failure.

The main entrance doors [13] are perhaps the most energy-efficient commercial door system in the world. These newly designed doors, which incorporate a 13mm thermal break, were imported from Europe. The door glazing system is similar to that in the windows.

The rear insulated steel door [14] has a wood (and not a steel) edge and a high-performance glazing unit [15]; these result in reduced heat loss.

Heating and Cooling

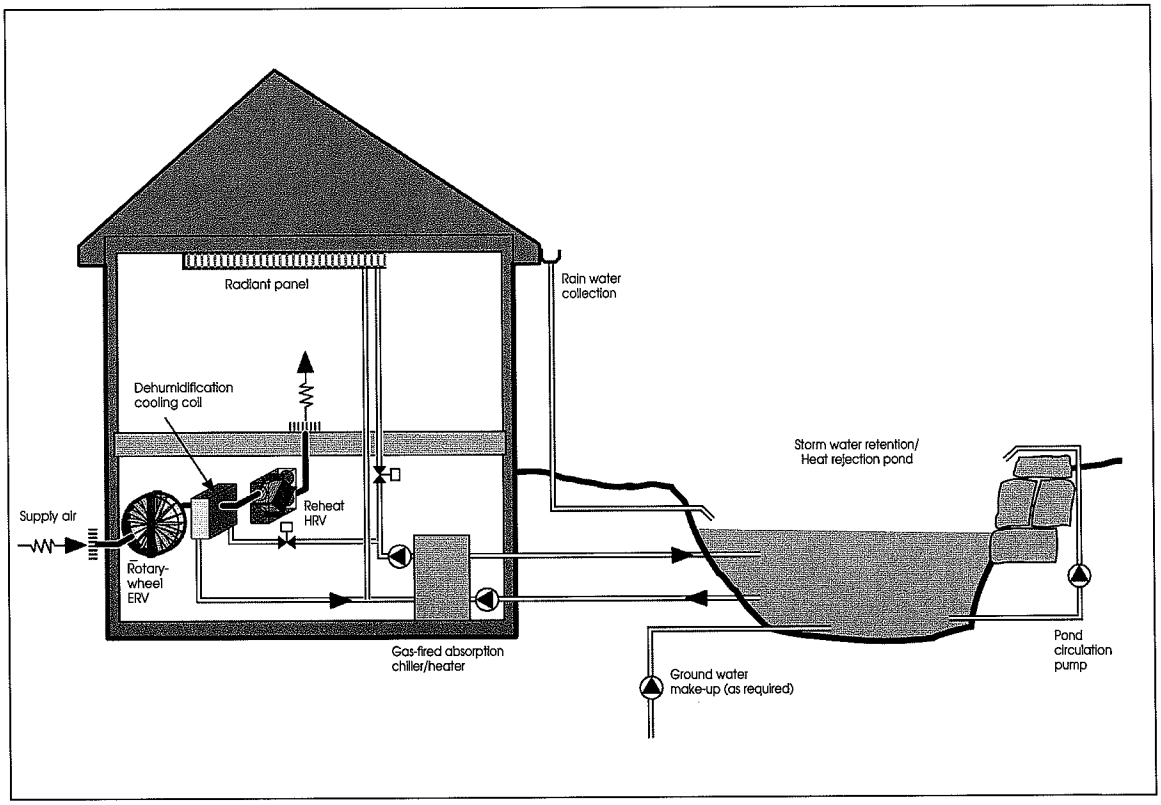
The philosophy underlying Green on the Grand design was to create a building as energy efficient as possible, and then meet the small remaining heating and cooling loads efficiently and with the most environmentally-benign fuel and equipment. This implies the use of CFC/HCFC-free equipment and, in Ontario, natural gas as the fuel.

Radiant Heating and Cooling

Space heating and cooling is provided through water-based radiators [16] located in each tenant area. Radiant heating and cooling offers three main advantages over traditional forced-air heating. Because water is a more efficient heat transfer medium than air, the motor energy required to move heat through water-based radiators is less than that required to move heat through air-based ducts. Radiant heating provides a more even and comfortable warmth to occupants. Finally, more effective zone control of temperature can be achieved with control valves than through the use of air-based registers.

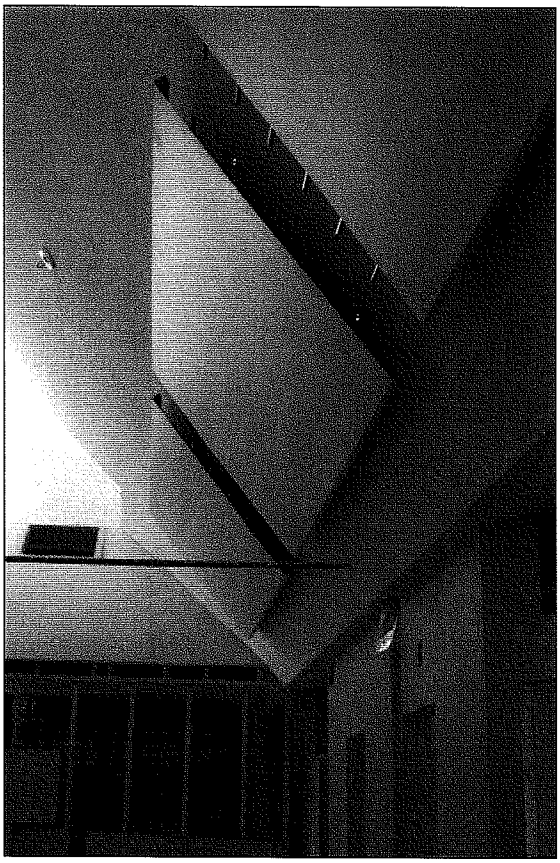
Conventional finned radiators cannot meet the building cooling load, so a new radiant system is used: ceiling panels. Sized to meet the peak cooling load, radiant panels cover 30% of the ceiling area. Tenants selected from one of two panel designs. In some offices, flat steel panels are suspended below a drywall ceiling. The panels are painted the same colour as the ceiling and are thus unobtrusive. In other offices, extruded aluminum panels fit into a T-bar ceiling. Condensation on the radiant panels is prevented by dehumidifying ventilation air. Entrances are heated and cooled by water-based fan coil units because entrance ceiling space is too limited for the radiant panels.

The radiators carry hot water in the winter and cold water in the summer. The water is both heated and cooled by the same efficient appliance: a natural-gas fired boiler/absorption-chiller [17]. The boiler operates at 85% efficiency, the highest level a water-based boiler is able to achieve. This boiler/chiller has many advantages over the use of separate heating and cooling systems. The unit can be installed outdoors to maximize useable interior space; even when located indoors, the unit takes up much less space than typical heating and cooling equipment.



Cooling system

Most of the advantages of the gas-fired boiler/chiller relate to its use as an air cooling system. Because natural gas, and not electricity, is used to supply building cooling, Green on the Grand does not add to the problem of summertime peak electricity demand, and does not contribute to the negative environmental impact of electricity production. The chiller is much less expensive to operate than a conventional air conditioning unit because inexpensive natural gas is the fuel. Although the chiller is not as efficient as an electrical air conditioner (COP 0.95 versus COP 2.5), this is made up for by the lower cost of natural gas, and because its two-stage operation reduces cycling losses. Lastly, because the refrigerant is water and the absorbent is lithium bromide (an environmentally-benign salt), the boiler/chiller does not use any ozone-depleting or toxic substances.



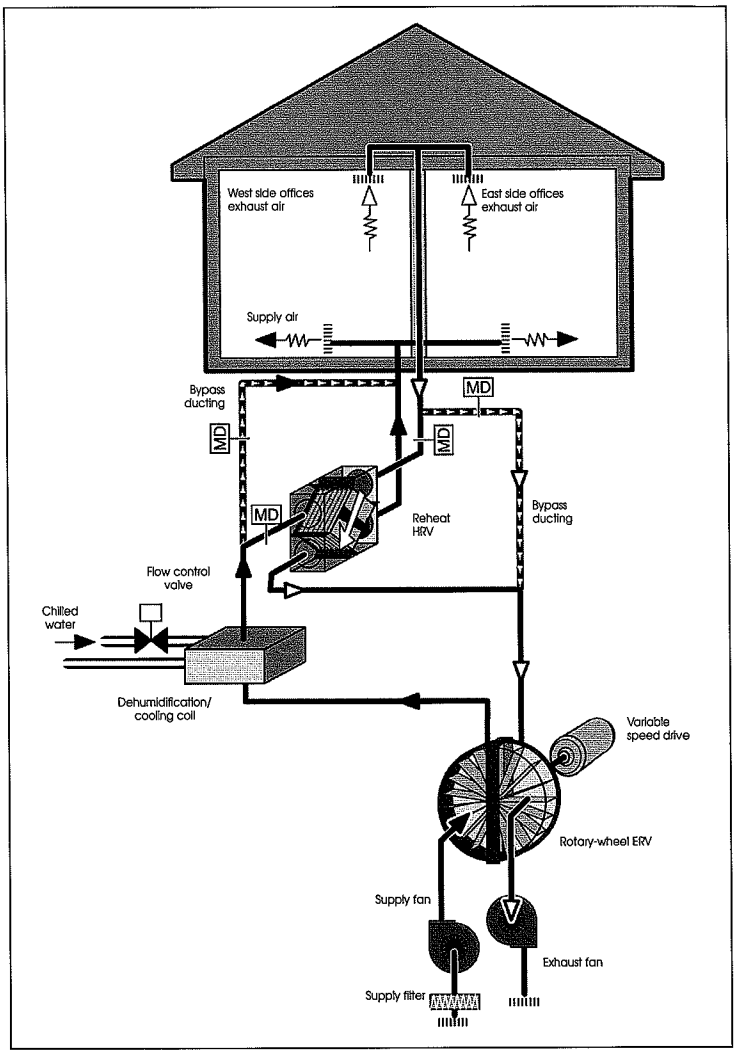
Radiator panels, shown mounted on the cathedral ceiling, provide both heating and cooling.

Any air conditioning system requires a method for rejecting heat to the outside. Normally, large buildings utilize cooling towers for this purpose. Although effective, cooling towers consume large quantities of water and fan energy, and require toxic water treatments. The solution to this problem at Green on the Grand not only solves a mechanical problem, but adds beauty as well: a manmade pond [18] located to the front of the building operates as a cooling tower and enhances the property. The pond is approximately 20m X 10m and is an average of 0.9m deep. When the chiller is operating, untreated pond water circulates through a filter system and the chiller condenser. Heat is lost from the pond by evaporation, which is enhanced through the circulation of pond water over landscaping rocks at the perimeter of the pond. This circulation increases the effective pond surface area (and thus increases evaporation), and adds the beauty of water movement to the landscaping.

Heat Recovery and Ventilation

The ventilation system, independent of the heating and cooling system, supplies outdoor air to all the offices. The main component of the ventilation system is an air handling unit [19] which contains two heat exchangers, two fans, and a heating/cooling coil. This unit provides a continuous flow of air at a comfortable temperature and humidity. Fresh air from the air handling unit is delivered via a displacement ventilation system which operates without air recirculation. The system is energy efficient, cost effective, and provides superior indoor air quality.

When outdoor air enters the air handling unit, it passes through a rotary-wheel heat exchanger, or energy recovery ventilator, ERV [20] which transfers both heat and moisture between the fresh, incoming air and the stale, exhaust air. Because moisture is transferred as well as heat, there is no need for wintertime air humidification. Frosting problems are eliminated because the control system moderates the speed of the heat exchanger wheel. During the summer, the need for dehumidification is greatly reduced through the use of the ERV. A computer-based control system turns off the exchanger when there is no need for air conditioning because outdoor air is at the correct temperature and humidity.



Ventilation system

After outdoor air passes through the ERV, it passes over a hydronic heating/cooling coil. On extremely cold days, the heating coil raises the air temperature to prevent cold drafts from the ventilation grilles. During the summer, the coil cools and dehumidifies the ventilation air.

The air then passes through a plate-type heat exchanger, or heat recovery ventilator (HRV). The HRV operates during normal winter weather to capture additional heat from exhaust air. During the summer, the HRV uses exhaust heat to warm the air cooled by the coil; this prevents cold drafts but maintains comfortable humidity levels.

The ventilation system operates at two flow rates: low flow is 10 l/s/person and high flow is 20 l/s/person. The low flow rate is the norm in building operation and meets the indoor air quality requirements of ASHRAE 62-1989. The high flow rate is used when free cooling is provided by outdoor air, when additional airflow is required to meet the cooling load, or when additional fresh air is needed. Energy-efficient motors [21] and circulation fans [22] move the supply and exhaust air flows. High-efficiency filters remove pollutants from the supply air.

A novel element of the fresh air distribution system at Green on the Grand is the use of displacement ventilation to move air. Displacement ventilation brings air into each room through low-wall grilles and exhausts it through high-wall grilles. This strategy is more effective in supplying fresh air to occupants than ceiling-mounted diffusers because it places fresh air closer to occupants. Odours and air-borne contaminants are carried to the ceiling and then exhausted out of the building. Supply air is ducted through the interior wall to floor level. The wall-mounted diffusers are specifically designed for displacement ventilation.

To meet Ontario Building Code requirements, the washroom exhaust airflow rate must equal 60% of the ventilation supply flow. For the displacement ventilation system to work properly, the office exhaust airflow needs to equal the supply airflow. To meet both requirements, a transfer duct will move 60% of the office exhaust air into the corridors by the washrooms. This air will feed the washrooms to balance the washroom exhaust airflow. This design ensures that the proper volume of ventilation air cascades through the building and provides the best possible air quality to all occupants.

VENTILATION SYSTEM OPERATION

OUTDOOR TEMPERATURE	VENTILATION SYSTEM OPERATION
Very Cold (under -10 C)	ERV + HC + HRV
Cold (-10 to 0 C)	ERV + HRV
Cool (0 to 10 C)	ERV
Moderate (10 to 15 C)	none (free cooling cycle)
Warm (15 to 25 C)	ERV + CC + HRV
Hot (greater than 25 C)	ERV + CC

Water Conservation and Plumbing

The Green on the Grand team set itself a challenging water conservation objective: building operation should consume only 30% of the water that a conventional office building would use. This objective is achieved through the use of rainwater (supplemented by a well) for landscape watering; elimination of a cooling tower; and the use of low water-consumption bathroom fixtures and dishwashers.

The cooling tower for Green on the Grand is a storm-water retention pond located in front of the building. Water from the pond is supplemented from rainfall collected off the building roof. By allowing the pond depth to fluctuate up to 150mm, no additional well water is required for cooling system operation. The use of the pond as the cooling tower for Green on the Grand will conserve approximately 500m^3 of water annually.

Toilets and urinals in all bathrooms are low water-use fixtures. The high-powered flush toilets [23] use 6 litres of water per flush compared to a typical 13 litres per flush. All urinals and faucets have infrared sensors [24] that shut-off the fixture when not in use. Shower valves also have infrared sensors, and have a manual shut-off to reduce water use during showering.

The design of Green on the Grand places all washrooms in the central, common area where the two rectangles of the building overlap. Because the washrooms and kitchen areas are located in close proximity to one another, there is no need for a hot water recirculation loop in the plumbing system. This reduces water heating demand by 20%. Hot water for bathrooms and kitchen areas is heated by a high-efficiency, direct-vent, wall-mounted gas boiler [25] connected to a small tank for hot water storage.

ANNUAL WATER USE
(M^3/PERSON)

FUNCTION	GREEN ON THE GRAND	TYPICAL BUILDING	% SAVINGS
Toilets/Urinals	4.5	10	55
Sinks/Washing	2.5	5	50
Showers	1	2	50
Cooling Tower	0	10	100
Landscaping	0	2	100
Total	8	29	72

Lighting

Commercial buildings consume large amounts of electricity during operation, and much of this electricity is used for lighting office space. One objective of the Green on the Grand project is to demonstrate that offices can be attractively and effectively lit while using only a fraction of normal electrical demand. Three strategies are employed to meet this objective: daylighting, energy-efficient light fixtures, and task lighting.

Natural daylight is the most efficient source of building lighting, however, its full potential has yet to be demonstrated in Canada. Green on the Grand is an important first step in developing expertise in the design of daylit buildings.

Daylighting provides two very different challenges to designers. Perimeter spaces in buildings can suffer from overlighting and glare, while interior spaces without windows are too dark for normal use. Solutions to each of these problems are found at Green on the Grand.

Dormer windows admit natural light into interior spaces.

Window size and placement provide sufficient daylight for office needs without increases in heating and cooling loads. Windows are placed high on the wall in each office, so that the natural light will reach deep into the room. Green on the Grand demonstrates two window shading systems. In some offices, translucent fabric roller-blinds admit diffuse light and reduce glare. In other offices, horizontal blinds have the slats "upside-down," in other words, the concave side facing up, in order to deflect light into the rear areas of perimeter offices.

Daylighting demands that natural light be admitted to interior spaces. Eight large dormer windows permit natural daylight into the interior office space on the second storey, and this is sufficient for ambient lighting. Daylighting through large glazed entrances will service the first and second floor corridors. Another method utilized to admit natural lighting into interior spaces is the use of glass in the walls between the perimeter offices and interior spaces; some of these glazings feature an electro-chromic coating [26] that can be switched from clear to white when privacy is required.

In those areas that are artificially-lit, energy efficient light fixtures [27] are used. Most light fixtures have electronic dimmable ballasts [28] in indirect/direct lighting fixtures [29]. These lights use 35% less electricity than 40W tubes with magnetic ballasts, although they provide the same lighting level. Electric lights are controlled by a modulating dimming system [30], so that desired light levels are maintained; lights will dim on bright days, and brighten on dark days. Motion sensors [30] and timers ensure that lights are on only when required. In addition, the lighting design emphasized task lighting. Task lighting does not illuminate an entire room but simply a small area, for example a desk top, where illumination is required. Compact fluorescents are used for task and accent lighting; halogen lights spot lights with parabolic reflectors light very small task-lit areas.

Parking lot lighting is provided by energy-efficient, high-pressure sodium lights. Exterior security lighting is controlled by motion sensors. Exit lights are be solid-state LEDs that consume less than 1.5 Watts [31]. Lighting of the exterior signage is powered by photovoltaics [32].

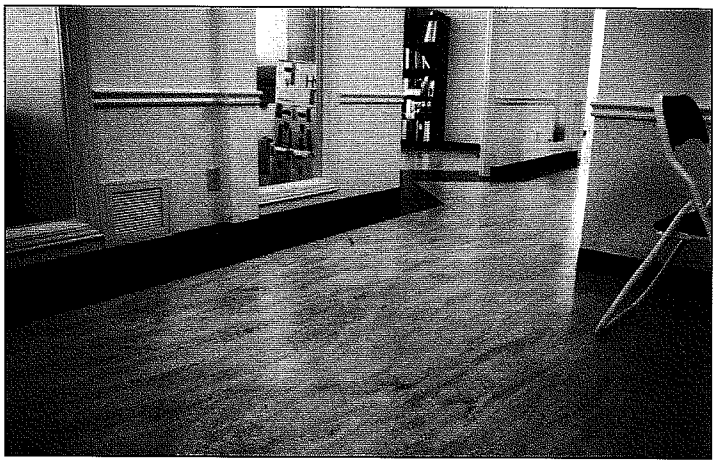
The combination of daylighting, task lighting, and energy-efficient fixtures reduces the use of electricity for lighting to only 50% of that typically required for offices.

Finishes, Furnishings, and Office Equipment

Choices made in office interior design, and the selection of furniture and equipment have significant environmental and indoor air quality impacts. In addition, computers, printers, and photocopiers can have a major effect on electricity consumption and demand.

Many traditional interior decorating materials pose health and comfort hazards to building occupants because they "off-gas" toxic or annoying fumes. The most common of these are volatile organic compounds (VOCs) and urea formaldehyde. The build-up of these fumes, along with carbon dioxide, mould, bacteria, fibres, and dust can lead to "sick building syndrome" common in modern office buildings. Green on the Grand has very healthy air quality for its tenants and visitors because care was taken to choose construction and decorating materials that do not contribute to indoor air pollution. In addition, the building ventilation system is designed to effectively exhaust pollutants because it does not recirculate indoor air.

Each tenant in the building furnishes their offices according to their own requirements and tastes. Following are some of the environmentally-appropriate choices featured in Green on the Grand.



Natural linoleum floors and baseboards are long-lasting and beautiful.

Finishes

Interior walls are covered with 100% recycled gypsum board [33]; 80% of the board is a by-product of flue-gas desulphurization at coal-fired thermal generation stations, and 20% is from reclaimed, recycled drywall. All walls are painted with VOC-free paints. Some offices are decorated with a cellulose-based, textured wall covering [34] that is an attractive alternative to wallpaper. This covering does not contain the toxic glues or fungicides commonly found in wallpaper.

Wood trim is made from finger-jointed woods; this makes the best use of lumber. Some of the in-suite doors are re-used, taken from an older, renovated office building .

Much of the flooring and baseboarding are natural linoleum [35]. Linoleum is a superior material because it is made from natural products (linseed oil, flax, jute, and wood fibres); is low in embodied energy; does not off-gas; is highly durable; and is not maintained with toxic products. All flooring adhesives are VOC-free [36].

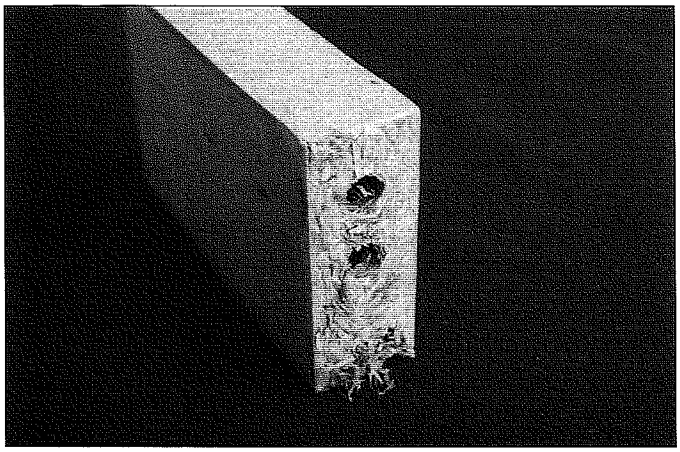
In one tenant space, interior walls and office dividers are made from straw-filled building panels [37]. These panels, 75mm-thick straw covered on each side with paper, meet the fire code and come in standard board sizes. The panels provide a two-sided wall without the need for framing

Furnishings

Modern office furniture and cabinetwork is commonly manufactured from particleboard (or medium density fibreboard) that off-gasses formaldehyde. Formaldehyde-free particleboard [38] is available and is used for much of the cabinetwork in the building. Most of the furniture is reused, refinished, or made from steel finished with powder-coat paint; this paint is solvent-free.

Office Equipment and Appliances

Modern offices can have high electricity demand due to the use of equipment such as computers, photocopiers, and printers. This "plug load" power consumption can be dramatically reduced. Purchase priority is given to lap-top computers and laser printers with low idling-power requirements and that automatically switch to standby mode, and to fax machines that use plain paper and have low-idling powers. The photocopier contains the latest in environmentally appropriate technology: low power consumption (only 200 Watts on standby), automatic switching to standby, reduced ozone generation, and reduced paper consumption through automatic double-sided printing.



Some interior walls are made from straw panels

Many offices contain appliances such as refrigerators, microwave ovens, and dishwashers in their kitchen/lunchrooms. Green on the Grand features the most energy and water efficient dishwasher [39] available in Canada. It is appropriately sized for the smaller washing loads. The refrigerator [40] contains the winning technology from the U.S. Super Efficient Refrigerator Program. It is the first North American-made CFC-free refrigerator.

Landscaping

Green on the Grand's site was chosen in part because of its beauty: it sits high on a bluff overlooking the Grand River, a heritage waterway. The steep slope down to the river is in natural woodlot, and the Grand River walking trail follows the bluff-top between the building and the slope. The landscape design enhances this existing beauty and wildlife habitat, minimizes energy and waste from landscape maintenance, and reduces the impact of the building on the environment.

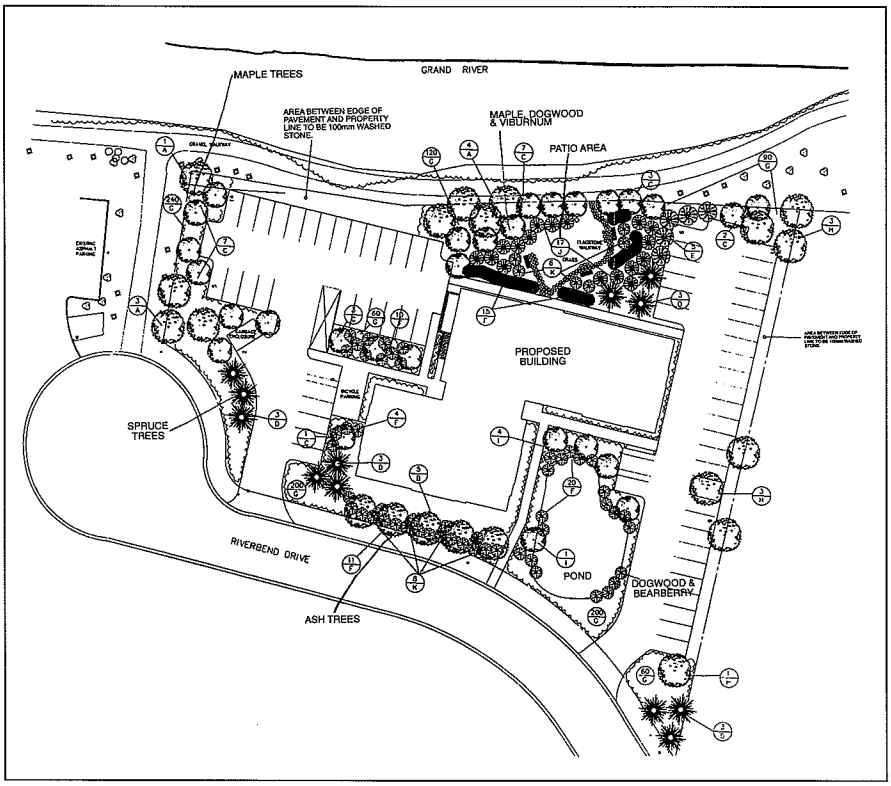
The negative visual and environmental impact of asphalt surfaces is reduced through the use of a grass paving system [41] for light-use areas such as the bike parking area. This system comprises a plastic support structure seeded with grass. The surface does not require asphalt and permits rainwater to sink into the ground and recharge the groundwater aquifer—an important feature in a region dependent on groundwater.

In order to encourage tenants to bike to work, bike racks are provided. Those who walk or bike to work may use the office shower facilities to freshen up before work.

The landscape plan emphasizes the use of native species of shrubs, trees, and ground cover. Native plant species provide shelter and food for wildlife, and reduce maintenance costs and the use of pesticides because they are hardy and disease resistant. Native plants also reduce water demand because they have evolved to cope with Ontario's summer dry periods. Building privacy is provided by large sugar maple trees; white ash provide shade, especially along the western side of the property; white spruce serve as a wind break from cold northern winds. Ground cover is provided by bearberry, and on the small lawn area, a mixture of rye grasses and fescues. The water for the lawn is supplied from the storm water retention pond.

Two prominent features of Green on the Grand's landscaping are the pond and the patio area. The pond, the cooling tower for the chiller, also stores rooftop rainwater. The pond serves as wildlife habitat: its perimeter is planted in red-osier dogwood, bearberry, and flowering dogwood, all plants rated excellent for attracting wildlife. It is a visual focal point, and benches located near the pond encourage visitors to stop and enjoy its refreshing atmosphere.

The second noteworthy component of the landscape plan is the secluded patio area between the building and the Grand River Trail. This quiet area, planted with many types of native shrubs and trees, can be used by tenants during lunch breaks or informal business meetings. The patio furniture is made from recycled plastic [42], and there is a compost container provided for food scraps. There is a bird-feeding station provided to supplement the existing habitat along the Grand River Trail.



Landscaping plan

Waste Management

Green on the Grand has a comprehensive waste management plan that applies the principles of reduce, reuse, and recycle to both building construction and operation.

Construction Waste

Construction waste was minimized through the use of factory-built components such as engineered wood products; these eliminate the need for on-site cutting and waste generation. In addition, building design was determined in part by the decision to order standard dimension supplies.

Many waste materials were re-used on the construction site. For example, scrap wood was used for blocking or chipped for use as mulch. Waste from off-site sources was turned into useful products at Green on the Grand: 100 tonnes of crushed concrete were used as drainage materials [8], and used office furnishings were refurbished.

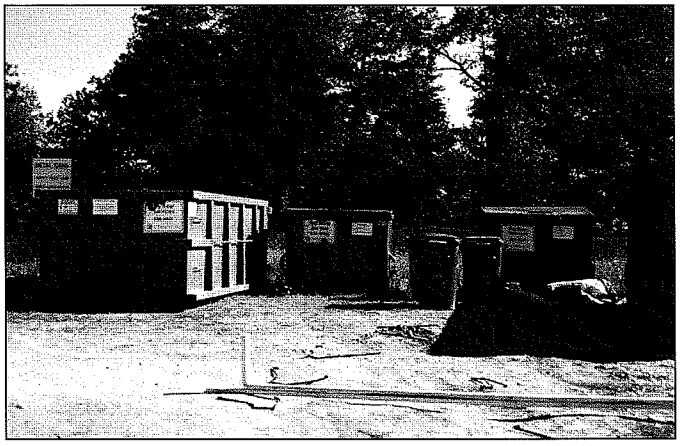
A variety of construction materials were sent to public [43] and private recycling centres [44, 45, 46, 47]. Cardboard, paper, glass, and metal were recycled at municipal centres, while waste drywall was sent to a private recycling facility. The construction site held several large bins [44] for each of these materials, and workers were responsible for placing the sorted materials in the bins.

These strategies combined to reduce the waste generated by Green on the Grand construction by about 70% when compared to conventional construction practices.

The Green on the Grand team decided to reduce construction waste to a minimum, but also to opt for construction materials with a high recycled content. These materials include the following:
- cellulose insulation made from old newspapers;
- rock wool insulation from slag;
- engineered wood products made from wood chips;
- 100% recycled drywall; and
- outdoor furniture of recycled plastic.

Operation Waste

Each tenant is responsible for implementing a program of in-office recycling of paper, metal, cardboard, and glass. The Green on the Grand waste disposal area contains more than just a garbage dumpster. Separate bins for fine paper, newspaper, glass, cardboard, and metal are provided. The waste hauler delivers these materials to the public recycling facility.



Ten recycling bins contained sorted construction waste

The landscaping plan at Green on the Grand results in a yard area that is virtually waste-free because of the minimal use of lawn area.

The Finished Product

Computer simulations and detailed calculations compared the energy consumption of Green on the Grand with that of a similar office building built to contemporary energy-efficiency standards (ASHRAE 90.1). The building will be monitored during 1996 and 1997 to determine actual energy performance.

The simulated performance of Green on the Grand is impressive: it will require only 50% of the operating energy of a building designed to ASHRAE 90.1, and only 40% when compared to a typical new building. Green on the Grand will have only 28% of the water demand of a conventional building. The building is expected to have an annual utility bill (gas, electricity, water and sewer) of only $8400, or $3.85/m^2 of floor area, 42% that of an ASHRAE 90.1 building. Savings to owners and tenants are only a part of the story, for society as a whole benefits from reduced greenhouse warming and less acid rain.

No CFCs, and minimal amounts of HCFCs (when no alternative was available), were used to construct or operate Green on the Grand.

Indoor air quality will be markedly superior to that of a typical office building due to an effective ventilation system and wise choices in construction materials, interior finishes, and furniture.

Construction waste was reduced by 70% from normal practice, and the construction of Green on the Grand is a useful example for other construction projects. The building's construction has consumed far fewer raw materials than conventional construction because of the reliance on re-used and recycled-content building and finishing materials.

All these advantages are in a building that offers a superior indoor environment, is attractive, enhances natural habitat, and has a long lifetime.

PREDICTED ANNUAL UTILITY COSTS

COMPONENT	GREEN ON THE GRAND	TYPICAL NEW OFFICE	% SAVINGS
Space Heating	$1,105	$2715	59
Space Cooling	$863	$1874	54
Water Heating	$86	$132	35
Receptacle Loads	$2,796	$3855	27
Lighting	$1,978	$6534	70
Pumps/Fans	$855	$2099	59
Water/Sewer	$720	$2610	72
TOTAL COST	$8,403	$19,819	58

Economics

An economic analysis of any office construction project must consider three factors: construction costs, lease rates, and market acceptance of the office space. Green on the Grand compares favourably to conventional buildings with respect to each of these factors.

Construction Costs

Total construction cost for Green on the Grand, including land, leasehold improvements, and design fees, is $1100 per square metre of floor area. To determine the incremental construction cost–the added cost of environmental features—Green on the Grand is compared to two other buildings. The first is a slightly smaller office building designed to the local building code without any special environmental features. The second building is an office building approximately twice as large as Green on the Grand costed in the 1996 MEANS Cost Guide adjusted for Canada. There are some anomalies in the comparison, likely due to differences in cost allocation.

Not surprisingly, the cost of Green on the Grand's mechanical system is higher than for a rooftop mechanical system used in the typical office building. This cost, however, compares favourably the mechanical system cost for a building that uses a chiller, such as the MEANS example building. The increase in mechanical systems cost are offset by savings in the building shell, primarily due to the low cost of the engineered wood structure. The net result is that the total construction cost for Green on the Grand is on par with other similar-sized office buildings.

Lease Rates and Market Acceptance

The building space is being leased at rates comparable to other commercial properties in the region. The operating cost of Green on the Grand, however, will be 58% (or $5.30/m^2) below that of similar buildings. This cost, which becomes part of the tenant common cost, makes Green on the Grand financially attractive to potential tenants.

Leasing success is a good indicator of market acceptance, and it is important to note that Green on the Grand is fully leased at the time of construction completion. Two of the tenants selected Green on the Grand for office space because environmental responsibility is part of their corporate philosophy.

COMPARISON OF CONSTRUCTION COSTS[1]
(in dollars per square metre of floor area)

COMPONENT	GREEN ON THE GRAND	TYPICAL OFFICE	MEANS 1996
General Conditions	39	50	62
Excavation	9	13	11
Foundation	54	49	23
Building Shell	105	192	99
Windows & Doors	44	76	12
Roofing	16	24	15
Insulation	17	27	
Exterior Walls	40	38	179
Miscellaneous Steel	7	1	
Finishes	16	90	
Mechanical	209	90	179
Electrical	93	78	115
Elevator	25	32	37
Contingency	49	28	-
TOTAL ($/m^2)	722	718	773

[1]- *values do not include land, tenant leasehold improvements, design fees, landscaping and site services*

Sponsors

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Project Supporters

City of Kitchener/Kitchener Utilities

Ontario Ministry of Environment and Energy

Ontario Hydro

Union Gas Limited

Regional Municipality of Waterloo

Management and Design

Project developer and construction management	Ian Cook Construction: 169 Lexington Court, Waterloo, ON N2J 4R4 TEL 519-746-6244 FAX 519-746-4027
Energy efficiency and environmental design	Enermodal Engineering Limited: 650 Riverbend Drive, Kitchener, ON N2K 3S2 TEL 519-743-8777 FAX 519-743-8778
Structural and site plan services	MTE Consultants: 650 Riverbend Drive, Kitchener, ON N2K 3S2 TEL 519-743-6500 FAX 519-743-6513
Architectural design	Snider Reichard & March Architects: 145 Columbia Street West, Waterloo, ON N2L 3L2 TEL 519-885-5600 FAX 519-885-5653
Mechanical design	JNE Mechanical: 35 Goderich Road, Unit 1, Hamilton, ON L8E 4P2 TEL 905-578-7987 FAX 905-578-3240
Electrical engineering	Davis Design Engineering Services: 385 Fairway Road South, Suite 6, Kitchener, ON N2C 2N9 TEL 519-744-0192 FAX 519-894-5082

Green on the Grand owes its success to the contributions of many firms and individuals. Thank you for your commitment to environmentally-responsible construction.

Building Form and Building Envelope

1	automatic door openers	Horton Automatics: 8600 Boyd Avenue, Ottawa, ON K2B 2E1 TEL 613-798-4848 FAX 613-798-9528
2	engineered wood products	Trus Joist MacMillian: 86 Guided Court, Suite 10, Rexdale, ON M9V 4K6 TEL 800-263-2325 FAX 416-740-0714
3	cellulose insulation	Climatizer Wall Insulation System Ltd: 120 Claireville Drive, Etobicoke, ON M9W 5Y3 TEL 416-798-1235 FAX 416-798-1311
4	exterior insulated finishing system	Sto Industries Canada: 3495 Laird Road, Units 16-18, Mississauga, ON L5L 5S5 TEL 905-569-3900 FAX 905-569-2090
5	underslab polystyrene insulation	Plasti-Fab Ltd: 1214 Union Street, Kitchener, ON N2G 4G1 TEL 519-579-1650 FAX 519-579-8921
6	below-grade fibreglass insulation	Owens-Corning Canada: 5140 Yonge Street, Suite 700, North York, ON M2N 6T9 TEL 416-733-1600 FAX 416-221-3369
7	recycled aggregate	Kieswetter Cartage and Excavating Company: PO Box 231, Heidelberg, ON N0B 1Y0 TEL 519-699-4445 FAX 519-669-4577
8	mineral-wool batt insulation	Roxul: 551 Harrop Drive, Milton, ON L9T 3H3 TEL 905-878-8474 FAX 800-991-0110
9	high-performance windows	Accurate Dorwin Company: 60 Nairn Avenue, Winnipeg, MB R2L 0X5 TEL 204-982-4640 FAX 204-663-0020
10	low-e glass and spectrally-selective glass	PPG: 834 Caledonia Avenue, Toronto, ON M6B 3X9 TEL 416-789-3331 FAX 416-783-7966
11	insulating edge spacer for windows	Edgetech I.G. Ltd: 39 Vaughan Street, Ottawa, ON K1M 1W9 TEL 613-749-0624 FAX 613-749-0754
12	fibreglass lineals for windows	Omniglass Ltd: Suite 13, 9-1329A Niakwa Road East, Winnipeg, MB R2J 3T5 TEL 204-256-3767 FAX 204-256-3767
13	high-performance entry door and window systems	Kawneer Company Canada Ltd: 1051 Ellesmere Road, Scarborough, ON M1P 2X1 TEL 416-755-7751 FAX 416-755-1829
14	utility door	Steelwood: 155 Regalcrest Court, Woodbridge, ON L4L 8P9 TEL 905-851-4665 FAX 905-851-7340
15	high-performance door lite	Baylite Division of Bay Mills Ltd: 7299 David Hunting Drive, Mississauga, ON L5S 1W6 TEL 905-672-2255 FAX 905-672-2256

Heating and Cooling

16	radiant ceiling panels	Manufacturer: Twa Panel Systems Inc: 10410-172nd Street, Edmonton, AB T5S 1H1 TEL 403-489-3338 FAX 403-484-4490 Sales Agent: R & D Energy Savers Ltd: 2861 Sherwood Heights Drive, Unit 21, Oakville, ON L6J 7K1 TEL 905-829-4941 FAX 905-829-4942
17	gas-fired absorption chiller	Trane Canada: 38 McBrine Place, #7, Kitchener, ON N2R 1G8 TEL 519-895-0950 FAX 519-895-0952
18	pond liner	Manufacturer: Carlisle: 5940 Shawson Drive, Mississauga, ON L4W 2W5 TEL 800-387-4990 FAX 905-564-5556 Sales Agent: A & T Industries: 64 Tudor Glen Crescent, Scarborough, ON M1C 2S2 TEL 800-665-4320 FAX 800-665-4320

Suppliers

Heat Recovery and Ventilation

19	air handler unit	Manufacturer: Haakon Industries (Canada) Ltd: 11100 River Road, Richmond, BC V6X 1Z5 TEL 604-273-0161 FAX 604-273-8397 Sales Agent: HTS Engineering Ltd: 211 Paisley Street, Guelph ON, N1H 2P5 TEL 519-570-1800 FAX 519-741-9380
20	energy recovery wheel	Semco: 1800 East Pointe Drive, Columbia, MO 65201 TEL 573-443-1481 FAX 573-443-6921
21	high-efficiency electric motors	US Motors: 1955 Cote de Liesse, Suite 210, Montreal, PQ H4N 3A8 TEL 514-332-1880 FAX 514-332-5912
22	high-efficiency blowers	Chicago Blower Corporation: 56 Abbey Close, Ancaster, ON L9G 4K8 TEL 905-648-7030 FAX 905-648-9220

Water Conservation and Plumbing

23	ultra low-flush toilets	Kohler Ltd: 110 Woodbine Downs Boulevard, Unit 3, Etobicoke, ON M9W 5S6 TEL 416-798-9311 FAX 416-798-9181
24	infra-red sensors for faucets, urinals and showers	Nepitek Ltd: PO Box 5581, Station F, Nepean, ON K2C 3M1 TEL 613-723-8090 FAX 613-723-5766
25	high-efficiency water heater	Delta-Temp Corporation: 6140 Main Street, Stouffville, ON L4A 1A5 TEL 905-642-4677 FAX 905-642-6207

Lighting

26	switchable (electro-chromic) window	Marvin Windows: 1455 Courtneypark Drive East, Mississauga, ON L5T 2E3 TEL 800-263-6161 FAX 905-670-0364
27	lighting system	Rutenberg Sales: 500 Hensall Circle, Unit 1, Mississauga, ON L5A 1Y1 TEL 905-848-2255 FAX 905-848-9737
28	dimmable ballasts	Advance Transformer Co: 10275 West Higgins Road, Rosemont, IL 60018 TEL 847-390-5000 FAX 847-390-5109
29	direct/indirect lighting fixture	Ledalite Architectural Products: 7103 South 216th Street, Kent, WA 90832 TEL 206-872-6061 FAX 206-872-6062
30	motion and light dimming sensors	Pass and Seymour Canada Inc: 448 North Rivermede Road, Concord, ON L4K 3M9 TEL 905-738-9195 FAX 905-738-9721
31	1.5 W exit lights	Prescolite: 1251 Doolittle Drive, San Leandro, CA 94577 TEL 510-562-3500 FAX 510-577-5016
32	PV system	Prometheus Energy: 33-400 Creditstone, Concord, ON L4K 3Z3 TEL 416-660-7868 FAX 416-660-7868

Finishes, Furnishings, and Office Equipment

33	100% recycled gypsum board	WESTROC Industries: 2424 Lakeshore Road West, Mississauga, ON L5J 1K4 TEL 905-823-9881 FAX 905-822-9832
34	cellulose textured wall covering	Fibrewall Canada Ltd: 6808-78th Avenue, Edmonton, AB T6B 2J5 TEL 403-469-8368 FAX 403-469-8371
35	linoleum	Forbo Industries: 8300 Keele Street, Concord, ON L4K 4T1 TEL 416-661-2351 FAX 416-661-5362
36	VOC-free adhesive	Roberts Company Canada Limited: 2070 Steeles Avenue, Bramalea, ON L6T 1A7 TEL 416-791-4444 FAX 416-791-1998
37	straw-filled interior wall panels	Stramit U.S.A: Loop Road 143 East, Box 885, Perryton, TX 79070 TEL 806-435-9303 FAX 806-435-4311

38	formaldehyde-free medium-density fibreboard	Medite Corporation: PO Box 4040, Medford, OR 97501 TEL 503-773-2522 FAX 503-779-9921
39	compact dishwasher	WCI (Frigidaire) Canada: 866 Langs Drive, Cambridge, ON N3H 2N7 TEL 519-653-8880 FAX 519-653-4515
40	CFC-free refrigerator	Inglis Limited: 1901 Minnesota Court, Mississauga, ON L5N 3A7 TEL 800-461-5681 FAX 800-363-3888

Landscaping

41	grass paving system	Invisible Structures Inc: 14704-D East 33rd Place, Aurora, CO 80011 TEL 800-233-1510 FAX 303-373-1223
42	recycled plastic lumber	Lackie & Associates: 1177 Franklin Boulevard, Unit 1, Cambridge, ON N1R 7W4 TEL 519-621-7569 FAX 519-6216227

Waste Management

43	recycling facility	Region of Waterloo Waste Management Centre: 925 Erb Street West, Waterloo, ON TEL 519-883-5150 FAX 519-747-4944
44	recycling bins and materials hauling	Big Bear Services: 645 Conrad Place, Waterloo, ON N2V 1C4 TEL 519-886-4400 FAX 519-886-3559
45	wood recycling	SEL Recycling: PO Box 36, R.R.#1, Elmira, ON N3B 2Z5 TEL 519-669-2456 FAX 519-669-5710
46	metal recycling	Heynen's Metals: 111 Cedarhill Crescent, Kitchener, ON N2E 1R3 TEL 519-742-0696
47	drywall recycling	New West Gypsum Ontario Inc: 2182 Wycroft Road, Oakville, ON L6L 5X6 TEL 905-847-0520 FAX 905-847-0522

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