

Evaluation of High Performance Residential Housing Technology

by

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Authors Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

The energy consumption of residential buildings in Canada accounts for 17% of national energy use (Trudeau, 2005). Production homes represent a considerable portion of new housing. In an effort to reduce the national energy demand, the energy consumption of these homes must be addressed. Techniques, methods and materials to achieve reductions in residential energy use are readily available.

The goal of this thesis is to show that it is possible to build a low-energy home for less total carrying cost than a home built to the 2006 Ontario Building Code. To show how this is possible, a range of cost-effective and practical-to-implement upgrades are identified, and quantitative projections of cost-savings and benefits gained by the homeowner are generated.

The interest in, and demand for, greener less energy consumptive homes is increasing. As oil prices rise, climate changes, landfills become overburdened and water restrictions become more frequent, the public pushes harder for change. The residential housing sector has seen increased demand for energy efficient homes that incorporate green features, high efficiency appliances and mechanical systems. Increased environmental concern has put 'Green' in demand.

This thesis reviews a variety of North American green rating systems and contrasts their energy performance requirements with those of the Ontario Building Code. The Ontario Building Code was considered the baseline. Although the R2000 program was originally developed nearly 30 years ago it has managed to maintain a standard of performance that has always exceeded the OBC. It has a wider range of requirements than either the building code or ENERGY STAR, but falls short of the LEED for homes program in terms of breadth of environmental concerns.

The literature review shows that homes that use 75% less heating energy than a standard house could be built in the 1980s for a mere 5% construction cost premium. When care is taken to produce quality designs and specifications, and to ensure that details are properly finished, these types of homes can be built almost anywhere. Some of the most successful technology and strategies of the 80's have found their way into mainstream Canadian houses.

As a result, the average new Canadian home consumes less energy than its predecessors. The Ontario building code has some of the most stringent thermal insulation and energy performance requirements of all provincial codes in Canada. However, significantly more can be done to economically reduce house energy consumption.

A parametric analysis of a representative urban house was performed. This analysis suggests that there is significant room for improvement in the minimum Ontario Building Code requirements, especially with regard to the insulation and air tightness specifications. In 2006 the OBC requirements for above grade wall insulation were increased from R17 to R19 whereas this investigation found that R34 could be justified financially. The fenestration requirements in the 2006 OBC require windows to attain at least R2.8, while this investigation shows that a further 25% increase to R3.5 will soon be financially sensible.

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1.0 Introduction

The energy consumption of the residential housing industry accounts for 17% of national energy use (Trudeau, 2005). Production homes account for a considerable portion of the new housing industry. In an effort to reduce the national energy demand, the energy consumption of these homes must be addressed. A technology review shows that techniques, methods and materials to create reductions in residential energy use are readily available.

The Ontario building code compliant levels of insulation and air tightness are built on previous versions of the building code dating back to the 1970s. Modern financial and environmental decisions require rigorous investigation to determine the optimal recommendations for long term viability. A parametric financial feasibility study with computer based energy modelling is presented in this thesis to determine the optimal levels of insulation for a relatively simple single detached home in Toronto, Ontario. It is a common misconception that building highly energy efficient, green homes is expensive and restricted only to special 'green' home builders with limitless budgets.

Through a literature review, building code and green rating program comparison, the construction of a demonstration production home and a parametric financial feasibility study with computer based energy modelling this thesis shows that building energy efficient, green homes can be accomplished with little to no increase in monthly cash flow required by the consumer.

1.1 Scope

The scope of this thesis is new low-rise residential production homes in Ontario. Monarch Corporation, the industrial partner for this research, offers considerable experience with the development, design, construction, and marketing of homes. They are currently involved in the design and development of several properties that will include energy efficient and green design features. A test home located within the Topper Woods subdivision in Kitchener, Ontario will be used as a prototype for efforts towards attainment of the chosen green rating program certification.

1.2 Objective

The goal of this thesis is to show that it is possible to build a low-energy home for less total carrying cost (monthly mortgage and utility costs) than a home built to 2006 Ontario Building Code levels. To show how this is possible, a range of cost-effective and practical-to-implement upgrades are identified, and quantitative projections of cost-savings and benefits gained by the homeowner are generated. To investigate the economic potential for energy-saving, a relatively simple single detached home on a standard 7.6m wide lot in Toronto, Ontario was chosen for the parametric modelling study.

This thesis compares varying green rating programs to the Ontario Building Code and presents a comprehensive evaluation of the available rating systems. Based on this review, the LEED program is chosen and a prescriptive implementation is developed and monitored as a case study. Monarch Corporation as the partner of an Industrial Partnership Scholarship (IPS) through the Natural Sciences and Engineering Research Council of Canada (NSERC) provided the site, building knowledge and funding to implement the prescriptive changes developed.

1.3 Approach

The approach will be to review past examples, methods, research, building codes and programs. A current program will be chosen based on its fulfillment of what this thesis considers 'Green' construction and it will be compared in depth to the current Ontario building code of 2006. The chosen program was scrutinized and implemented through the construction of a prototype home. The construction from site preparation to final trim was meticulously monitored. A review of the applied changes will be conducted and possible options for future green buildings will be reviewed through a parametric financial feasibility study with computer based energy modelling.

1.4 Why Green? Why Now?

'Green' has become a household, everyday word. As oil prices rise, climate changes, landfills become overburdened and lawn watering restrictions more frequent, the public is

pushing harder than ever for change. The residential housing sector has seen societal and customer demand for energy efficient homes incorporating green features and high efficiency appliances and mechanical systems. The increased environmental concern has put 'Green' in demand. More and more buyers are becoming aware and asking the necessary questions such as *how much energy will this use? which one of these uses less energy? how can I reduce the volatile organic compounds in my home? and what are my renewable energy options?* Whether it is rooted in the consumer's need to reduce pollution from energy production, trim down their energy bills or to minimize their effects on landfills, homeowners want more from their homes.

1.5 The Dilution and Delusions of Green

There are no well-accepted or legal definitions of 'Green'. Most people seem to think they have an idea of what 'Green' is, and yet no one seems to be able to produce a tangible, all encompassing, legal definition. The National Association of Home Builders (NAHB) states that:

The process of green building incorporates environmental considerations into every phase of the home building process. That means that during the design, construction, and operation of a home, energy and water efficiency, lot development, resource efficient building design and materials, indoor environmental quality, homeowner maintenance, and the home's overall impact on the environment are all taken into account. (NAHB, 2006)

The definition above is not shared by everyone everywhere. Some parties believe Green building is simply good building practices, incorporating recycled building products into the home, or installing photovoltaics on the roof. Because there is widespread misunderstanding about what Green construction is or what Green buildings are there are many buildings that are labeled Green that definitely would not meet the NAHB definition. There is a dilution of the term Green without a legal definition, codes to meet or tests to pass. There are numerous technical options that not only the public, but also architects, engineers and construction firms perceive as 'Green' upgrades. These upgrades include green roofs, radiant flooring,

various green building products, photovoltaics, heat pumps, ‘geothermal’ systems, pre-fabricated homes and alternate insulation options such as straw-bale, insulating concrete forms, structural insulated panels and spray foams. The only aspect that seems unanimous is the belief that ‘Green’ buildings cost more. The general public is under the impression that ‘Green’ building costs are much higher than standard practices.

Even a cursory review will show that there are many confusing and misleading concepts surrounding the grey-zones of green building. Various ‘Green’ rating programs attempt to streamline and set boundaries to the industry, a selection of which will be discussed later. There are buildings today that are being advertised as ‘Green’ that are using more energy, more materials, more resources, imported materials from the other side of the planet and costing many times more than their code-built equivalents. All of these facets defy the NAHB definition of green building.

It is also becoming clear that new home construction should not be the only focus of green building practices. The existing housing stock should also be considered and cost effective renovation options need to be implemented to repair the old, drafty, poorly insulated, energy in-efficient buildings. The list of suggestions and options for this sector would be a study unto itself and will not be covered in this thesis.

1.6 The Real Green

1.6.1 Resource Use

To attain the goal of reducing the amount of resources a home consumes, a full spectrum view of the project must be taken. From the initial stages of design, including site planning and interior design to the final paint brush stroke there are a wide array of strategies and subsequent tactics that can be implemented. Following construction, the operations and maintenance of the building should be carefully planned. Once the facility has served its useful lifetime, the demolition and reuse of the space as well as building products should also be considered.

A properly designed site plan reduces the amount of soil displaced, and removes the necessity to bring in backfill. A low embodied energy home design incorporates various material reduction techniques such as advanced framing, knock down plans showing the placement of each piece of lumber, stacked plumbing to reduce materials, proper selection of low embodied energy building products and interior design that removes the necessity for large steel beams and oversized headers. The design should also incorporate durability measures to ensure the home lasts for a long time without significant wear or necessity for repair. A carefully thought out design reduces complicated intersections of exterior walls which can cause air sealing and insulating nightmares.

Durable designs ensure that the minimum resources need to be expended during the life of the building for maintenance and repair, and low flow plumbing fixtures reduce the use of water and the generation of waste water.

Reducing energy demand can be accomplished by providing an airtight, well-insulated enclosure with glazing chosen based on its thermal and orientation-specific solar performance.

To meet the remaining energy demand, energy consumption can be minimized by using properly-sized high-efficiency space heating, cooling and water heating equipment, along with low-energy use lighting, energy efficient appliances, and smart controls.

The above is a list of technical design and process-related actions that can be taken. It will be shown that the resource consumption of a typical home can be reduced significantly with little or no increase in life-cycle costs. However, it must be emphasized that the occupants and their behaviour are also very important. Studies have shown large variations in energy and water use for the exact same house design occupied by different people. As building industry professionals only so much can be done before the product is handed to the homeowner.

1.6.2 Environmental Impact

Assessing the environmental impact of a new home is complex and imprecise. However, it is widely accepted that the impacts of energy, resource use, waste generation, habitat

destruction, and hydrology interruption are some of the most important factors that generate pollution and cause environmental damage.

Proper home design taking advantage of passive solar heating reduces dependency on pollution producing energy sources such as natural gas and electricity. Energy is used during the operation of a home as well as during the construction and manufacture of the home's materials. Many of the operational energy reduction techniques can be justified on the basis of reducing pollution. Energy consumption reduction and pollution reduction are directly related to one another. The energy supplied to a home is typically in the form of electricity, natural gas, propane, oil or wood. The production of electricity can come from a variety of sources including coal and natural gas burning plants to more environmentally-friendly renewable sources such as hydro electric and wind power. Typically electricity in Ontario would come from a combination of these sources. The burning of coal and natural gas whether in the hot water heater within the home or at the power plant produces emissions of various pollutants and greenhouse gases. A reduction of site used electricity directly reduces the amount of greenhouse gases and sulphur dioxide produced at the power plant.

The environmental impacts of using materials that consume large amounts of energy to extract, process, manufacture or transport are devastating. Using materials that are locally sourced, contain high contents of recycled materials, or are in fact completely re-used are strategies employed to reduce the environmental impact and pollution produced in supplying materials for a home.

Major centers such as Toronto have many problems with the amount of waste produced by the people and industries. Home construction produces on average over 20 kilograms of waste per meter squared (4.1 lb/ft²) of finished living space built (NAHB, 1997). Waste reduction can be accomplished with proper design, construction process management, recycling and re-use. Reducing the amount of waste a home produces directly reduces its environmental impact.

Other environmental impacts such as excessive rain water run-off causes flooding and transport of pesticides into water that could be used downstream for consumption. Proper

site design using swales, infiltration galleries and the selection of permeable hard-surfaces can reduce if not eliminate the run-off.

1.6.3 Occupant Health, Comfort and Use

Although not related to environmental damage and sustainability, occupant health and comfort are often rolled into the 'Green' label. Of course, health and safety should be considered at many phases throughout the design and construction of all buildings. Health as a primary concern can be safeguarded in many ways. During the late 1980s and into the mid 1990s problems associated with mould and decay within the building assembly caused the demise of many buildings across Canada. Proper design of the rain control and thermal control layers as well as provision of a functional air barrier can greatly reduce the chances of mould being a concern. Once the design has been completed, careful construction methods must be followed to ensure all penetrations in the air barrier are properly sealed, including everything from wiring to windows.

Indoor air quality can be adversely affected by many choices. Selection of the proper combustion appliances, air filters and humidity control as well as air flow testing and the verification of the supply and return of adequate air volumes to each area of the home can help ensure air quality is maintained. Interior finishes can be a source of harmful volatile organic compounds many of which are carcinogens. Considerations for indoor air quality must be taken throughout the life of the building.

Buildings that are properly designed require little maintenance and can last hundreds of years. Reducing the required maintenance as well as employing tactics and materials to extend the life of the home will result in pleased homeowners, a reduction in greenhouse gas emissions and decreased resource use.

2.0 Literature Review

2.1 Introduction – Low-energy housing examples and research

Canadians have had a long-standing interest in well insulated homes. This is likely due to the fact that many of us live in relatively cold environments typically heating our homes for a large portion of the year. This chapter explores low-energy use housing examples and research that date back almost 40 years to the fallout of the oil crisis of 1973. Other energy efficiency and green buildings programs from Europe as well as North America are studied.

2.2 Harold Orr – Saskatchewan House

The birthplace of super-insulated buildings is often considered the 6100 Celsius (11,000 Fahrenheit) heating degree day city of Saskatoon, Saskatchewan. In the post fuel crisis, late 1970s and early 1980s, a small development of 14 super-insulated houses was constructed (Orr, 1982). The government of Canada, the province of Saskatchewan, a local branch of the Housing and Urban Development Association and the City of Saskatoon started the Saskatoon Energy Showcase. The Showcase called upon 13 builders to construct 14 chosen designs. Two primary criteria for the homes were mandatory: they had to be less than 2150 square feet and they had to appear as normal homes. The builders were given \$6,000, approximately 5% of costs, to offset the additional constructions costs (Orr, 1982). What resulted from this challenge was what came to be called the super-insulated home. Figure 1 is a typical super-insulated home in the Saskatoon Energy Efficient Showcase.



Figure 1 - Saskatchewan House (Orr, 1982)

Superinsulation is not solely the addition of large amounts of insulation. Many other construction details must be properly accomplished. The Saskatoon superinsulated homes all share the following features:

- The air barrier is a continuous 6 mil polyethylene (also acting as a vapour diffusion barrier), meticulously overlapped and joined with acoustical sealant. The barrier is continuous in the walls, ceilings and basement creating an air-tight enclosure.
- An air-to-air heat exchanger, known today as a heat recovery ventilator (HRV), was included in the heating, ventilation and air conditioning (HVAC) system to remove odours, pollutants, moisture by ventilation and to reclaim the heat in the exhaust air.
- The glazing ratio was between 5% and 10% (window area/finished floor area) with windows primarily on the south-facing side of the home to allow solar gains to aid in the heating of the home. The windows were all triple or quadruple glazed units. Figure 2 shows a triple glazed unit employed in the superinsulated homes.
- The walls were double framed and filled with insulation. The typical wall varied from R30 to R60. Figure 3 contains a typical wall construction specification.
- The ceilings were R60 with exterior attic hatches to maintain the integrity of the air barrier.

- Basements were insulated to at least R20.



Figure 2 - Saskatchewan House Window (Orr, 1982)

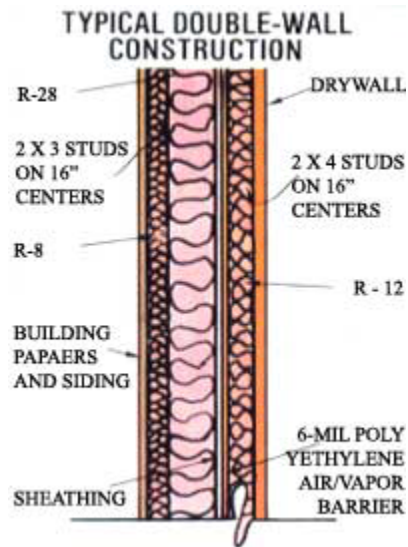


Figure 3 - Saskatchewan House Wall Section (Orr, 1982)

Over a 13 month test it was found that the homes performed very well. They used approximately 75% less heating energy than homes that were already considered energy-

efficient models. The energy monitoring was completed by the Energy Research Group of the Department of Mechanical Engineering at the University of Saskatoon (Orr, 1982).

Over the past few decades several hundred homes have been built similar to the Energy Efficient Showcase homes. The provincial government aided in the construction by providing interest free loans to those who build low-energy homes. The showcase shows that homes that use 75% less heating energy could be built in the 1980s for a mere 5% construction cost premium. With thorough design and specification, as well as diligent care taken to ensure details are properly constructed these homes can be built almost anywhere.

2.3 Shurcliff – Passive Solar House

This house is an example of a second movement that began in the late 1970s: passive solar houses. The primary goal of the Shurcliff house was to achieve 100% solar heating. The architect was to have minimal restrictions, necessitating innovative methods for air movement, storage and control. All of the floor space within the home was to be useable, liveable space with a maximum temperature of 26°C (80°F). The basic premise of the system was to utilize solar radiation to heat a medium within living space and use the buoyancy of heated air to transport the captured energy to a storage system. The use of buoyancy properties removed a large portion of the energy required to move the heated air.

Figure 4 and Figure 5 show the large amount of south facing glazing utilized to help capture the necessary solar radiation.

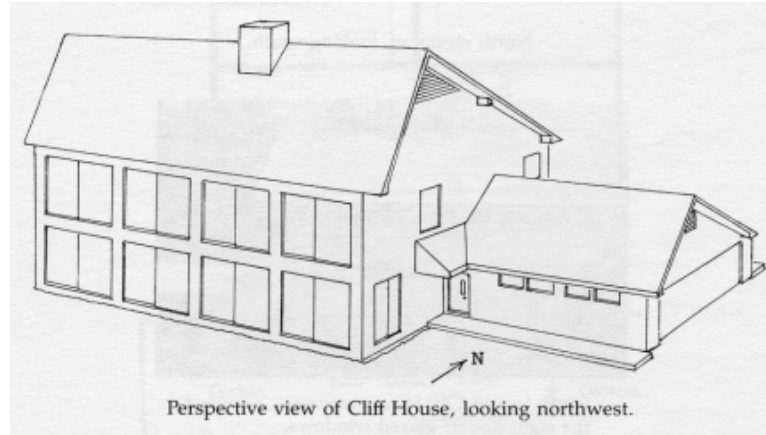


Figure 4 - Shurcliff House Perspective View (Shurcliff, 1983)



Figure 5 - Shurcliff Solar Home (Shurcliff, 1983)

Both an upper and lower energy storage system were installed. Each system had high thermal capacity and large surface areas. The upper storage system had approximately 40-50% of the thermal capacity of the lower system and the lower system had over 15 times the surface area. Two air handling systems were utilized for a variety of functions including transfer of heat between storage systems, heat delivery to the rooms from either storage system, and simple air circulation throughout the living space. The two storage systems are quite different in function. The upper system must always be prepared to provide heating

while the lower system must maintain the capability to be either a source or sink of heat depending on the needs of the interior living space. This was accomplished with a calculated combination of surface area, mass and thermal capacity. The lower storage system's capability to be both a source and a sink is the primary difference between this home and most other solar heated homes. The typical system involves storage of heat only and is capable of heating but not moderating the living space. The system combination utilized in the Shurcliff home does not require auxiliary heating as would normally be included in a solar system to accommodate varying heating or cooling load requirements in the spring and fall.

The diagram in Figure 6 shows a vertical cross section of the sunspace and upper storage system.

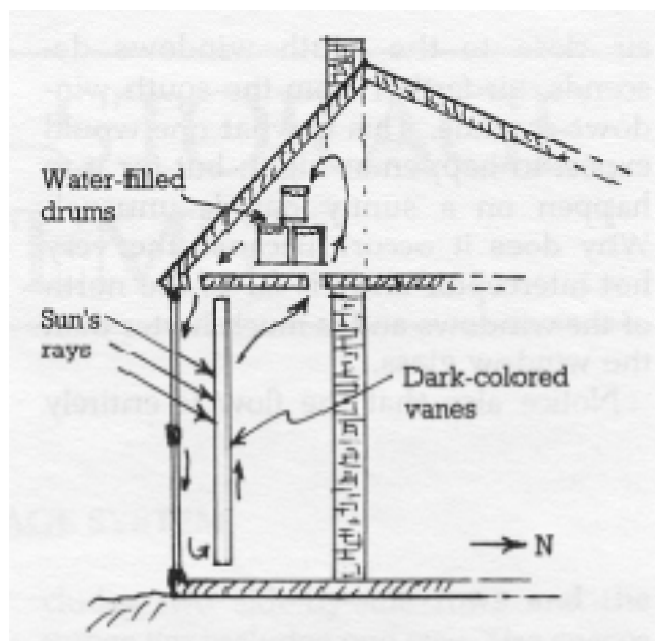


Figure 6 - Shurcliff Sunspace and Upper Storage System (Shurcliff, 1983)

The sun's rays enter the space through the south facing windows and are intercepted by the dark-coloured two-storey-high hanging vanes. The heated air rises and enters the upper storage area through a slot in the ceiling, heats the barreled water and falls back through a separate slot, past the windows and is ready to be re-heated. The lower habitable portion of

the sunspace must remain below 26°C (80°F) as the area would be uncomfortable and hence relatively unusable above this temperature.

The interceptor vanes are made of a low weight, high area material that is coated with a chrome green pigment. The chrome green pigment allows a high percentage of absorption while permitting some light to penetrate the space, reducing the necessity for interior lighting and energy use. The vanes are also adjustable allowing up to 95% light through when less heating or more lighting is desired.

To attain 100% solar heating the building must have low energy demand and adequate storage. The upper storage system is encapsulated in R19 insulation and sits on a floor also insulated to R19. The attic roof above the storage system as well as the end walls are insulated to R30. The lower storage system consists of R10 insulated foundation situated on bedrock, filled with over 90 tonnes of small stones and covered with a 100mm thick concrete floor. The mass of the lower system along with its large surface area creates an ideal storage and buffer system. The walls of the home are insulated to R30 by fiberglass cavity insulation within 2"x4" studs at 16 inches on centre and 2 inches of exterior polyisocyanurate foam. The insulation, although quoted as R30 would likely be closer to R20 to R22 due to the curing and degradation of the insulating value of the polyisocyanurate insulation over time. The window area on walls that do not face south is kept to a minimum and are multi-pane glazing units attaining an estimated insulating value of R5. The air tightness of the home was an estimated 0.25 to 0.5 air changes per hour at normal operating pressures. This is equivalent to approximately 10 to 12 air changes per hour at 50 pascals imposed pressure differential (ACH50). This was considered relatively air tight construction at the time (modern homes can achieve 1.5 to 3 ACH50). To minimize the auxiliary heating required for domestic hot water the water heater is placed within the attic space. The sustained high temperatures surrounding the water heater reduce losses and heating, if any is required. The windows are situated to allow maximized daylighting and reduce energy required for lighting.

The cost of the house is about the same as that of a conventional house of comparable size at the time. The savings from not installing a furnace, oil tank or radiators and associated

plumbing makes affording the insulation, thermal storage, and fans relatively easy. The annual operating cost will be merely the cost of running the fans, which at the time was estimated at \$100.

2.4 The German Passivhaus

Dr. Wolfgang Feist is the primary developer of the German Passivhaus program. The concepts for the program were derived from research by Bo Adamson, conducted in areas of China where resources are scarce and low energy buildings are required because fuel is not available (EDU, 2008). Similar buildings such as the Shurcliff and Orr houses, previously discussed, were also inspirations.

The word “Passiv” implies that the homes are passive in that they do not require an active heating system. The suggestion that the homes do not require a heating system is, in most cases, incorrect. Most homes are not fitted with a conventional heating system, but are fitted with a liquid or electrical resistance heating coil within the buildings air ventilation distribution system. The system is typically installed with a heat recovery ventilator (HRV) in Europe. Although they are fitted with these heating coils, the buildings do not require significant heating. In Germany and Austria, where over 9000 Passivhaus dwellings have been built, the winter heating design temperature ranges from -8°C (16°F) to -12°C (9°F) which is slightly warmer than southern Ontario. Munich has approximately 3500 Celsius HDD, Berlin has 3100 Celsius HDD and Toronto has 4200 Celsius HDD. Unlike North American low-energy design standards and building codes, which specify insulation quantities, the Passivhaus program mandates energy use specifications. The site heating requirements for the home are recommended not to exceed $15\text{kWhr}/\text{m}^2/\text{yr}$ and the total consumption for the home, including all appliances, plug loads, water heating and lighting cannot exceed a source energy total of $120\text{kWhr}/\text{m}^2/\text{yr}$ (EDU, 2008). Source electricity is valued at three times more than site electricity (to account for generation and transmission losses), which makes the total allowable site consumption equivalent to $40\text{kWhr}/\text{m}^2/\text{yr}$ for an all electric house. The ratio of natural gas source to site is 1:1. In Canada, in 2004, the average single detached home site energy demand for heating only was over $160\text{kWhr}/\text{m}^2/\text{yr}$ and the average total use was over $270\text{kWhr}/\text{m}^2/\text{yr}$ (Trudeau, 2005).

Maintaining the low energy demand in a Passivhaus is done primarily through (PHI, 2008):

- Simply designed building shape;
- South-facing primary glazed wall;
- Minimal glazing on East, North and West walls;
- Minimize and account for thermal bridging;
- Standard R-38 Enclosure (Desired R-56 Enclosure);
- Minimum R7 windows, or specific window design;
- Air-tightness maximum of 0.6 ACH50;
- HRV with minimum 75% efficiency;
- High efficiency water fixtures;
- High efficiency appliances.

The air tightness requirement for the Passivhaus standard is four times as stringent as the Canadian ENERGY STAR program, and the insulation standard is twice that required by the Ontario Building Code. When compared to the Passivhaus standard, there is a very large gap in performance between the average Canadian home and what is possible. Dr. Feist summarizes the approach by saying “Don’t be afraid of insulation.” (EDU, 2008)

2.5 Illinois Passivhaus - 2003

German native Katrin Klingenberg came to the US in 1994 to continue her post-graduate studies in Architecture. In her professional career she has focused on energy efficiency and sustainable building. In 2002 she built herself an all-electric home that complies with the Passivhaus standard. The building is super-insulated, simple in design and incorporates most of its windows on the south face. Using computer simulations Klingenberg was able to determine the optimal enclosure specifications. Figure 7 shows an exterior photo of the home.



Figure 7 - Illinois Passivhaus (EDU, 2004)

All sides of the home are insulated to R-56. The foundation is exterior insulated with 6" of expanded polystyrene (EPS) insulation and below the slab there is 14" of EPS. In lieu of standard framing with a thick layer of exterior insulation the Illinois house uses 12" I-joists filled with blown in fiberglass, ½" structural fiberboard and 4" of exterior EPS sheathing. Careful attention to design and detail allows a continuous air barrier with minimal penetrations. All of the exterior panels are glued or taped together, the electrical boxes are mounted into the concrete floor and the light switches are remote, surface mounted and battery powered. The roof consists of 16" I-joists with blown in fiberglass. The roof overhang is designed to shade the windows during the summer months. The windows are fiberglass framed, triple glazed, argon filled with low-e coatings resulting in a U-value of 0.17 BTU/ft² F (R-5.9). Although the windows do not meet the required European R-7 the standard methods of testing vary between Europe and North America. According to Steven Thwaites, the owner of Thermotech Windows in Ottawa, the European methods provide results that are 10% lower than the same window tested in North America (EDU, 2004). The

windows have specific solar heat gain coefficients (SHGC) depending on their orientation. The west windows have an intentionally lower SHGC rating to minimize overheating from the setting sun. It was found that the south facing windows could overheat the space in sunny conditions in the winter and spring and shading of the windows may be necessary. An instantaneous electric water heater is used for domestic hot water heating. The mechanical ventilation is provided by a sophisticated HRV connected to an earth tube and a built-in 1000 watt heater, which due to the construction of the Illinois house, provides ample heat. In January 2004, the electricity bill for the home, which includes all appliances and heat was a mere \$35 or 340kWhr (EDU, 2004). If the entire year consisted of weather similar to January 2004 the home would only consume 36 kWhr/m²/yr which is well below the Passivhaus standard of 40kWhr/m²/yr.

2.6 Lovins – Rocky Mountain Institute

Amory Lovins director of research at the Rocky Mountain Institute (RMI), holder of an Oxford M.A. and six U.S. honorary Doctorate degrees has provided the motivation to many working on the super-efficient building frontier. His own RMI headquarters was built to be super-efficient in a cold mountain climate.

As a first major step he suggests that integrated whole-building design can develop a building that uses 3 to 30 times less energy with a lower capital cost (Lovins, 1995). The following house, built in Davis, California, was cited as an example.

- Production or tract built home
- 1672 square feet
- 105°F (41 °C) design temperature

During preliminary design the team removed 7 meters (23 feet) of unnecessary wall and improved the floor plan. They increased the walls to R-27, improved air tightness, durability, stability, speed of construction and saved \$2000. The envelope improvements saved 15% of the energy costs and another 45% savings was found in selecting energy efficient lights, appliances and hot water heating system. The traditional heating system was removed and the water heater was used to heat a radiant floor. The cooling system requirements were also

dropped to 1/3 of their original. Including the capital savings from reducing or eliminating HVAC equipment and the slight increases in construction costs in other areas, construction cost would be about \$1800 below normal. This project along with others, such as RMI's passive solar banana farm in an 8700 heating degree day Fahrenheit climate, show that big savings can be cheaper than small savings if you combine the right ingredients in the right way (Lovins, 1995).

Amory Lovins also suggests that these forms of savings can be seen in many other residential and commercial applications. The proper selection of envelope materials, most importantly glazing in commercial applications, can show paybacks that are from minus 5 to plus 9 months (Lovins, 1995).

This suggests that if we properly count multiple benefits and take credit for those that are real and measurable in rigorous engineering economic terms, we will very often find that the way to make a building inexpensive to construct is to make the windows expensive. This is not the usual value engineering approach of squeezing pennies out of each component separately, but it is investing our money in a highly integrated fashion to put more in some places so we can put a lot less in others. (Lovins, 1995)

2.7 CMHC Best Practice Guide for Wood Frame Envelopes

The Canada Mortgage and Housing Corporation (CMHC) developed the best practice guide for wood frame envelopes in 1999. The guide shows many ways to build an energy efficient wood framed building. It is an informative and concise presentation of many fundamental ideas behind energy efficient, durable buildings. The primary chapter of interest to this thesis is Chapter 3 - Heat Transfer.

Within Chapter 3, three modes of heat loss are discussed: conduction, convection and air leakage. Thermal bridging is discussed and various reduction methods are presented.

In conduction heat is transferred at the molecular level through the material itself. Convection is the transfer of heat through air movement within the assembly carrying energy

from one side to the other. The third method, air leakage, is the passage of air either from the interior through the assembly to the exterior or vice-versa.

Thermal bridging is when energy travels through the higher conductivity wood framing and effectively bypasses the lower conductivity insulation. Three methods to reduce thermal bridging and increase thermal performance are shown in Figure 8.

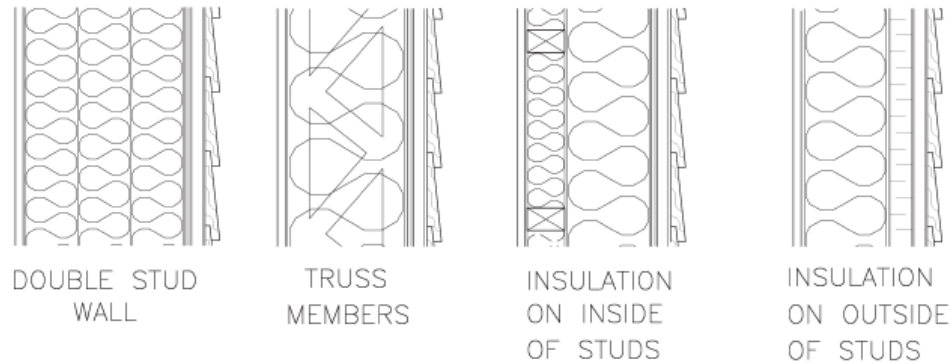


Figure 8 - CMHC Wood Framed Vertical Wall Sections (CMHC, 1999)

The double stud wall increases the thermal insulation value of the wall, and if the studs in the first wall are offset from the studs in the second wall it will reduce thermal bridging and increase the space available for insulation. The major limitation of this approach is that the sheathing is kept very cold, and has little drying potential if the sheathing is wetted by air leakage or rain leakage. The truss member also increases the thermal performance and shows a reduction in thermal bridging because of the decrease in cross sectional area.

Adding rigid insulation on the inside of the studs increases the thermal performance as well as decreases the thermal bridging due to the reduction in area of possible heat transfer. However, this approach does not solve thermal bridging at the floor joists, and also decreases the winter temperature, increasing the risk of moisture damage.

The final method of providing exterior insulation has proven to be the most cost-effective means of increasing thermal performance and decreasing thermal bridging (CMHC, 1999). Exterior insulation covers all of the wood structural thermal bridges, and increases the

temperature of the sheathing substantially, thereby dramatically reducing the risk of air leakage condensation and increasing the potential for inward drying.

Externally insulated wood framed walls eliminate thermal bridging by providing a continuous layer of insulation at the chosen thickness. In Figure 9 the exterior wall board would be replaced with an insulated sheathing board product. A diagonal metal strap would typically be added to the assembly to ensure there is sufficient lateral shear strength. The thickness of the exterior insulated sheathing layer is typically 1" but could just as easily be up to 4" and, with consecutive layers, be almost any thickness.

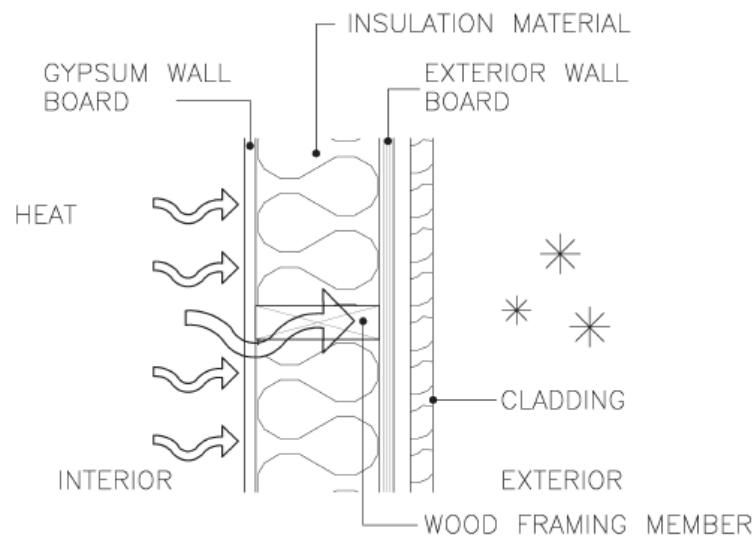


Figure 9 - CMHC Thermal Bridge Horizontal Section Diagram (CMHC, 1999)

Convection is the transfer of heat through air movement within the assembly carrying energy from one side to the other. This occurs in places where the stud space insulation does not fill the entire stud space. Gaps typically occur due to improper installation. When installing the stud space insulation if the edges or centre are pressed too far into the cavity or areas are missed completely air can effectively circulate within the stud space, bypassing the insulation, and transport energy from one surface to another. This can greatly reduce the effectiveness of the insulation. Proper installation of stud space insulation, ensuring the entire cavity is full, is vital for maintaining the thermal resistance value of the insulation.

Air leakage can be a significant source of energy loss in cold climates. Air leakage during the heating season is in effect the loss of warm air from inside the building envelope to the outside and typically the gain of cold exterior air into the envelope. The reverse of this will also occur during the cooling season. Proper air sealing can greatly reduce energy loss, increase comfort by reducing drafts and increase durability. Air barriers are discussed further in Section 3.2.7.

3.0 The Ontario Building Code, Energy and Environmental Rating Programs in Ontario

3.1 Introduction

The Ontario Building Code, the R2000 program, ENERGY STAR for Canada and LEED for Homes sections provide a framework for reducing energy and environmental impact of new housing. This code and these programs were chosen for investigation due to the fact that they are currently in effect or available in Ontario. The code and programs are presented in chronological order based on the date of first introduction.

3.2 The Ontario Building Code - 1975 to 2006

3.2.1 Introduction

The first building code in Canada was the National Building Code of Canada developed in 1941. The first residential building code was developed from the National Building Code in 1965 as the Residential Standards. The discussion here will start 1975 with the National Building Code Sixth Edition and the Residential Standards Third-Edition.

The basic layout, sections and formatting of the 1975 code has remained essentially unchanged to this day. The 357 page National Code and 190 page Residential Standards rapidly multiplied in size over the years. The residential standards is the focus of this discussion as they apply to housing.

There are 40 sections in the 1975 residential standards code. For the purposes of 'Green' building the most relevant sections are:

- Section 3 – Materials, Systems and Equipment
- Section 6 – Doors
- Section 7 – Windows

- Section 13 – Waterproofing and Damproofing
- Section 20 – Above Grade Masonry
- Section 26 – Thermal Insulation and Vapour Barriers

3.2.2 Section 3 – Materials, Systems and Equipment

Section 3 has remained virtually unchanged over the decades. In 1975 many of the mandates were written into the code. By 1986 the code referenced Canadian Standards Association (CSA) testing methods in most areas and these standards were carried on through the 1997 and 2006 building codes. The wood moisture content limit of 19% at installation seen in the 1975 building code (RS 1975, 3.C.4) remains unchanged to this day. The moisture content was originally derived from the equilibrium moisture content of the softwood lumbers used for framing in North America. Using wood that is already at its equilibrium moisture content reduces dimensional changes in the lumber and hence in the structure itself. Although in construction, wood that is delivered to the site at 19% moisture content rarely stays at that level due to exposure to the weather.

3.2.3 Section 6 – Doors

Section 6 relating to doors has had only a few changes throughout its history. The minimum sizes, location requirements and materials have changed marginally. The 1975 building code did not specify thermal insulation requirements for doors. In 1986 the building code required doors to be insulated to R4 (RSI 0.7) (OBC 1986, 9.6.4.4) and pass an air infiltration test (OBC 1986, 9.6.4.7). The insulation specifications were changed in 1997 and 2006 where doors must conform to varying standards dependant on their construction and use. In 1997 a specification was introduced for thermal breaks, which requires a thermal break within the metal frames of doors, glazing for doors and sidelights for doors (OBC 1997, 9.6.7.2). The weather stripping specifications for doors have remained essentially unchanged.

3.2.4 Section 7 – Windows

The specifications listed in Section 7 for windows have changed significantly in terms of thermal insulation properties since 1975. In 1975 windows were required to provide

adequate daylighting (RS 1975, 7.A.1) and that was nearly the extent of their specifications. There was a stipulation that if the January design temperature was +5°F on a 2.5% basis a storm sash or double glazing was required (RS 1975, 7.A.5). Many Canadian cities required storm windows or double glazing. The minimum glass area for rooms of residential occupancy has changed very little. Table 1 shows Table 7A from the 1975 residential code.

Table 1 - 1975 Residential Building Standard Table 7A (NRCC, 1975)

Minimum Glass Areas for Rooms of Residential Occupancy		
Location	Unobstructed Glass Area	
	With No Electric Lighting	With Electric Lighting
Laundry, Basement Recreation Room, Unfinished Basement or Cellar	4 per cent of area served	Windows Not Required
Water-Closet Room	4 sq ft	Windows Not Required
Kitchen Kitchen Space, Kitchen Alcove	10 per cent of area served	Windows Not Required
Living Rooms, Dining Rooms, Bedrooms and other finished rooms not mentioned above	10 per cent of area served	10 per cent of area served
Column 1	Column 2	Column 3

The code for 1986 changed the window area specifications with the addition of another table row which allowed bedrooms to have less window area. Table 2 shows the 1986 table 9.7.1.A.

Table 2 - 1986 Ontario Building Code Table 9.7.1.A (MMAH, 1986)

Minimum Glass Areas for Rooms of Residential Occupancy		
Location	Unobstructed Glass Area	
	With No Electric Lighting	With Electric Lighting
Laundry, Basement Recreation Room, Unfinished Basement	4 per cent of area served	Windows Not Required
Water-Closet Room	0.37 m ²	Windows Not Required
Kitchen Kitchen Space, Kitchen Alcove	10 per cent of area served	Windows Not Required
Living Rooms and Dining Rooms	10 per cent of area served	10 per cent of area served
Bedrooms and other finished rooms not mentioned above	5 per cent of area served	5 per cent of area served
Column 1	Column 2	Column 3

The additional row allows a reduction of window area in bedrooms to 5 percent of the floor area. Because this was reduced an additional article was added stipulating a minimum height from the floor, minimum area as well as a minimum dimension of 380mm (OBC 1986, 9.7.1.3) to allow for egress in the event the window must be used for such. The glass area table remains unchanged in the 1997 and 2006 building code.

1986 also saw the addition of a minimum thermal performance of windows at RSI 0.30m²C/W (OBC 1986, 9.7.1.7) and an air infiltration standard (OBC 1986, 9.7.1.9). The air infiltration standards have not changed since 1986 but the thermal performance standards were upgraded only in 2006 to U=2.0 W/m²C (RSI 0.5 m²C/W) (OBC2006, 12.3.2.6), a 67% increase in thermal performance requirements.

3.2.5 Section 13 – Waterproofing and Damproofing

Section 13 has had slight but significant changes from 1975 to 2006. In 1975 article 9.13.1.1 stated:

Where hydrostatic pressure occurs, floors on ground and exterior surfaces of walls below ground level shall be waterproofed. (NRCC, 1975)

And article 9.13.1.2 stated:

Where hydrostatic pressure does not occur and the exterior finished ground level is at a higher elevation than the ground level inside the foundation walls, exterior surfaces of foundation walls below ground shall be damp-proofed (NRCC, 1975)

By 1997 the articles had been reversed, seemingly putting more emphasis on damp-proofing than waterproofing. In 1986 the code also added article 9.13.1.1 (3) stating:

Floors in garages, floors in unenclosed portions and floors over granular fill in conformance to 9.16.2.1 need not be damp-proofed. (MMAH, 1997)

Due to sentence (3) most basement floor slabs no longer required any dampproofing, contractors could simply pour their concrete over 4in of gravel and meet code requirements. The dampproofing previously required acted as a capillary break for the slab reducing the water-uptake of the slab which is then evaporated into the basement. Capillary breaks are recommended by today's building science specialists (Lstiburek, J., 2006). Section 13 remained relatively unchanged from 1997 to 2006.

3.2.6 Section 20 – Above Grade Masonry

Section 20 has remained relatively unchanged since the 1975 code. Section 9.20.13 is most pertinent to building durability because it deals with flashings. This section stated that flashings must be metal, 45lb roofing roll or 6 mil polyethylene. In the 1986 code it appears that polyethylene and roofing paper were removed and were no longer allowed. A stipulation was also added that the flashing can be omitted if the sill is a non-jointed masonry coping. By 1997 the code allowed polyethylene and roofing paper as unexposed flashing membranes. Section 9.20.13 was unchanged from 1997 for 2006.

3.2.7 Section 26 – Thermal Insulation and Vapour Barriers

The title of this section has changed over the decades.

- 1975 and 1986 – 9.26 – Thermal Insulation and Vapour Barriers

- 1997 and 2006 – 9.25 – Heat Transfer, Air Leakage and Condensation Control

The focus of this section has also shifted over the span of codes discussed in this chapter.

In 1975 the primary concern was as stated in 9.26.2.1.

Buildings of residential occupancy shall be provided with sufficient thermal insulation to prevent moisture condensation on the interior surfaces of walls, ceilings and floors during the winter and to ensure comfortable conditions for the occupants.
(NRCC, 1975)

By 2006, 9.25.2.1 stated:

All walls, ceilings and floors separating heated space from unheated space, the exterior air or the exterior soil shall be provided with thermal insulation in conformance with Sections 12.2. and 12.3. to prevent moisture condensation on their room side during the winter and to ensure comfortable conditions for the occupants.
(MMAH, 2006)

The 2006 code is much more specific than any of its predecessors with respect to thermal insulation levels. In 1975 table 26A contained the minimum thermal resistance (R Value) for wood frame, plank frame and steel stud elements. Table 3 contains table 26A.

Table 3 - Minimum Thermal Resistances (NRCC, 1975)

Maximum number of heating degree days. F (C)	Type of Heating			
	Other than Electrical		Electrical	
	Walls R (RSI)	Ceilings, Roofs, Floors R (RSI)	Walls R (RSI)	Ceilings, Roofs, Floors R (RSI)
6000 (3334)	9.8 (1.73)	9.8 (1.73)	11.8 (2.08)	11.8 (2.08)
8000 (4445)	11.8 (2.08)	11.8 (2.08)	14 (2.47)	14.1 (2.48)
10000 (5556)	13.5 (2.38)	13.5 (2.38)	14 (2.47)	16 (2.82)
12000 (6667)	14 (2.47)	15 (2.64)	14 (2.47)	17.9 (3.15)
14000 (7778)	14 (2.47)	16.4 (2.89)	14 (2.47)	19.6 (3.45)
Column 1	Column 2	Column 3	Column 4	Column 5

The content of Table 3 has been altered from its original version with the addition of the RSI insulation converted values for comparison to the more current codes. Within table 26A it is important to note that account was taken for different heating sources as well as heating degree days. Table 9.26.2.A. from the 1986 building code is shown in Table 4.

Table 4 - Minimum Thermal Resistances (MMAH, 1986)

Building Element Exposed to the Exterior or to Unheated Space	R (RSI) Value Required
Ceiling Below Attic or Roof Space	30.7 (5.40)
Roof Assembly Without Attic or Roof Space	20.0 (3.52)
Wall other than foundation wall	12.0 (2.11)
Masonry or Concrete Foundation Wall	8.0 (1.41)
Frame Foundation Wall	12.0 (2.11)
Floor, Other than slab-on-ground	25.0 (4.40)
Slab-on-ground containing pipes or heating ducts	10 (1.76)
Slab-on-ground not containing pipes or heating ducts	8.0 (1.41)
Column 1	2

The thermal insulation breakdown changed in 1986. The division of heating degree days was no longer used and the different heating sources were also removed. The thermal resistance requirements were increased significantly across the board and further divisions within the categories were developed to differentiate between the various wall, floor and ceiling types. The 1986 code also contained Section 9.39, which was a thermal design section intended to be a design alternative to Section 9.26. Table 9.39.3.A. is shown in Table 5.

Table 5 - Minimum Thermal Resistances (MMAH, 1986)

Building Element Exposed to the Exterior or to Unheated Space	R (RSI) Value Required
Ceiling Below Attic or Roof Space	30.7 (5.40)
Roof Assembly Without Attic or Roof Space	20.0 (3.52)
Wall other than foundation wall	12.0 (2.11)
Masonry or Concrete Foundation Wall	8.0 (1.41)
Frame Foundation Wall	12.0 (2.11)
Floor, Other than slab-on-ground	25.0 (4.40)
Slab-on-ground containing pipes or heating ducts	10 (1.76)
Slab-on-ground not containing pipes or heating ducts	8.0 (1.41)
Column 1	2

The thermal resistances shown in Table 5 were for the total assemblies where framing or furring does not exist and had allowances for different heating degree days while inserting the new breakdown for various wall types. The assembly thermal resistance values allowed the summation of all building products constructing the wall to be considered in the thermal resistance. By 1997 the code had changed again and listed in Section 9.25.2.1 the table of installed insulation values shown in Table 6

Table 6 - Minimum Insulation Resistances to be Installed (MMAH, 1997)

Building Element Exposed to the Exterior or to Unheated Space	R (RSI) Value Required		
	Zone 1 Less Than 5000	Zone 2 Greater than 5000	Electric Space Heating Zone 1 and 2
Ceiling Below Roof or Attic Space	31 (5.40)	38 (6.70)	40 (7.00)
Roof Assembly without Roof or Attic Space	20 (3.52)	20 (3.52)	22 (3.87)
Walls other than Foundation wall	17 (3.00)	22 (3.87)	27 (4.70)
Foundation Walls Enclosing Heated Space	8 (1.41)	12 (2.11)	19 (3.25)
Floor, other than slab on ground	25 (4.40)	25 (4.40)	25 (4.40)
Slab on ground containing pipes or heating ducts	10 (1.76)	10 (1.76)	10 (1.76)
Slab on ground not containing pipes or heating ducts	8 (1.41)	8 (1.41)	8 (1.41)
Column 1	2	3	4

The division of degree day zones was once again in the main thermal design section of the code as were provisions for electric space heating. The thermal insulation to be installed was approximately the same as what the assembly was expected to perform as in the 1986 code. Depending on the wall construction this could be considered, on average, a slight increase in the thermal performance requirements for the 1997 code. In 2006 another building code was introduced which significantly changed the performance requirements. Table 7 shows the 2006 installed insulation requirements.

Table 7 - Minimum Insulation Resistances to be Installed (MMAH, 2006)

Building Element Exposed to the Exterior or to Unheated Space	R (RSI) Value Required		
	Zone 1 Less Than 5000	Zone 2 Greater than 5000	Electric Space
Ceiling Below Roof or Attic Space	40.0	40.0	50.0
Roof Assembly without Roof or Attic Space	28.0	28.0	28.0
Walls other than Foundation wall	19.0	24.0	29.0
Foundation Walls Enclosing Heated Space	12.0	12.0	19.0
Floor, other than slab on ground	25.0	25.0	25.0
Slab on ground containing pipes or heating ducts	10.0	10.0	10.0
Slab on ground not containing pipes or heating ducts	8.0	8.0	8.0
Column 1	2	3	4

The insulation changes in the 2006 Ontario building code (OBC) were well overdue as they had not changed significantly since 1986 whereas energy costs had. Figure 10 contains a summary of the installed insulation requirements from 1975 to 2006.

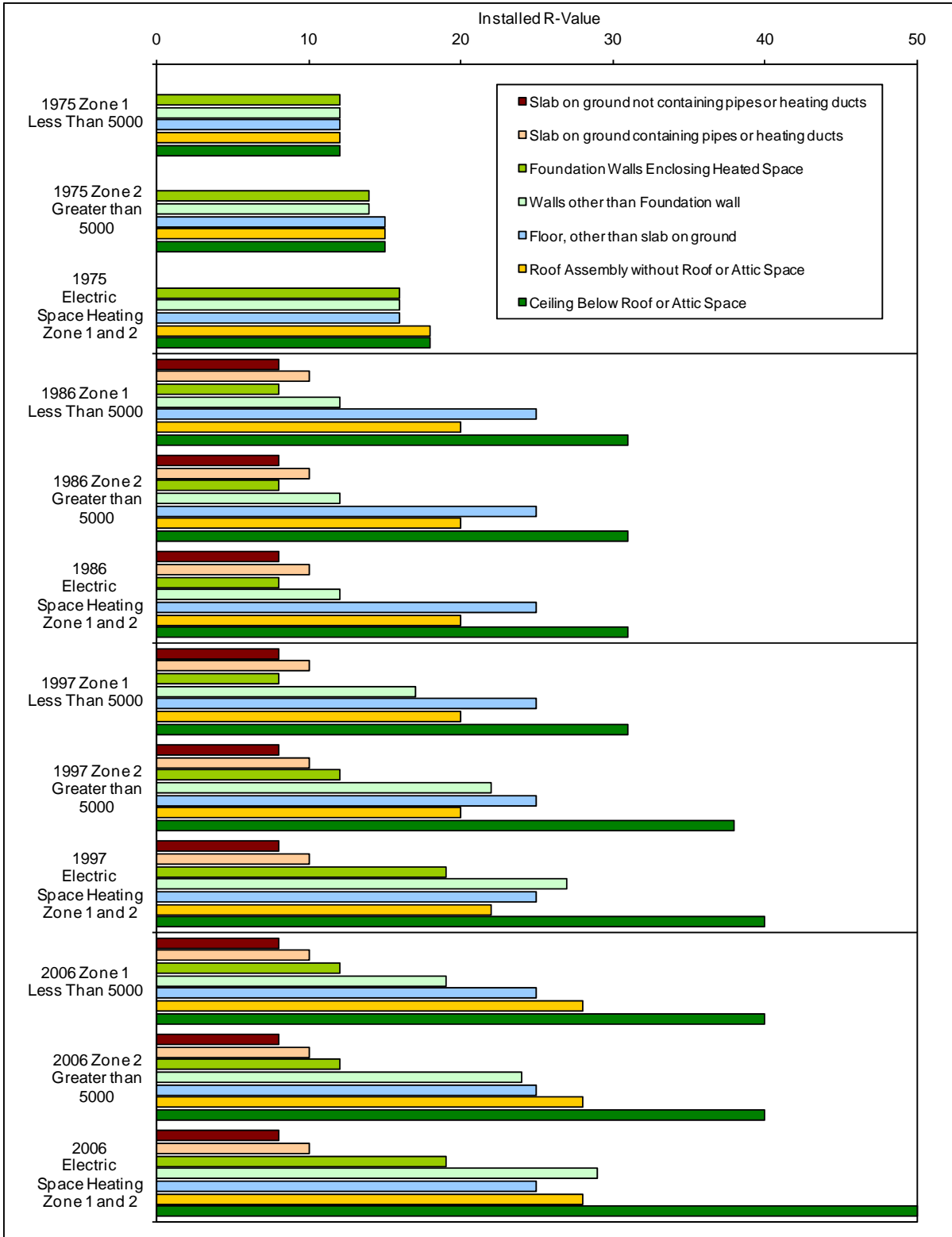


Figure 10 - Ontario Building Code Installed Insulation Values Comparison

In Figure 10 a few important items should be noted. The ceiling and wall insulation values have always increased while the floor and slab on ground values have remained relatively unchanged since 1986. To determine what is financially sensible a simple payback calculation can be completed. For the simple payback calculation the following are assumed:

- Natural gas heating
- 20°C interior temperature
- 4.1 cents/kWhr (Natural gas heating with 90% efficient furnace in Ontario with gas delivered at \$0.40 per m³)
- 85m² (900 ft²) footprint of slab

yields the following simple payback scenarios:

- R8 – 6.8 Years (the same as the OBC slab-on-grade specification)
- R12 – 10.0 Years
- R16 – 13.4 Years
- R20 – 16.7 Years

Most home buyers would not ask for R8 insulation beneath their basement slabs where code does not mandate any insulation at all, but it would provide a 6.8 year payback, added comfort and energy savings. If the building is expected to be used for more than 16 years it would make economic sense to increase slab insulation to R20, without accounting for added comfort and greatly reduced emissions from fuel use. Chapter 5.0 Next Generation: An Economic Case for Better Homes examines insulation quantities and net present value calculations for residential low-rise homes.

Section 9.25, which replaced Section 9.26, recognizes after 1997 the necessity of an air barrier system within the home. Air tightness is very crucial in determining the energy consumption of a home. The air entering the living space from outdoors during the winter creates an uncomfortable space and requires a large amount of energy to heat. The air

leaving the home takes a large amount of energy with it and carries moisture into the building structure which can cause major problems. Increased levels of standard insulation such as fiberglass and blown cellulose do not stop air infiltration, they merely filter the air. The air barrier system (ABS) must have the following (Straube & Burnett, 2005):

- **Continuity.** This is the most important and most difficult criterion. Enclosures are 3-D systems. Ensure ABS continuity through doors, windows, penetrations, around corners, etc.
- **Strength.** If the ABS is in fact much less air permeable than the remainder of the enclosure assembly, then it must be designed to transfer the full design wind load (e.g., the 1-in-30 year gust) to the structural system. Fastenings are often critical, especially for flexible, non-adhered membrane systems.
- **Durability.** The ABS must continue to perform for its service life. Consider the ease of repair and replacement, the stresses due to movement, fatigue, temperature, etc.
- **Stiffness.** The ABS must be stiff enough so that deformations do not change the air permeance and/or distribute loads through unintentional load paths.
- **Impermeability.** Naturally, the ABS must be impermeable to air. Typical values are $K < 1.3 \times 10^{-6} \text{ m}^3/\text{m}^2/\text{Pa}$ or $Q < 0.1 \text{ lps}/\text{m}^2 @ 75\text{Pa}$. Although this is an easy property to measure, it is not as important as might be thought. In practice, the ability to achieve other requirements (especially continuity) are more important to performance, and the air “permeance” of joints, cracks, and penetrations outweighs the air permeance of the solid materials that make up most of the area of the ABS.

The inclusion of air barrier requirements has caused a large amount of confusion in the construction industry as to the difference between an air barrier and a vapor barrier and their purposes. The following excerpts provide a description of vapor barriers and air barrier systems:

The function of a vapor barrier is simply the control of water vapor diffusion to reduce the occurrence or intensity of condensation. As such, it has one performance

requirement: it must have the specified level of vapor permeance and be installed to cover most of the area of an enclosure. If a small crack or perforation occurs in a vapor barrier, its performance (i.e., its vapor permeance) is not substantially reduced and such imperfections can usually be accepted in practice.

Air barrier systems control air flow and thereby control convective vapor transport. The control of air flow provides other important benefits such as increased comfort (by reducing drafts), reduced energy consumption, control of odor, pollutants, smoke, and sound transmission. Air barrier systems must meet all of the five performance criteria listed earlier. (Straube & Burnett, 2005)

The recognition of the requirement of an air barrier within the 1997 Ontario building code has the potential to greatly reduce the energy consumption of the residential buildings in Ontario. The confusion about the systems and the lack of testing and verification of the proper installation of the ABS leaves room for improvement within this area of the building code.

3.2.8 Conclusions

The Ontario building code is currently one of the most stringent provincial codes in Canada in terms of thermal and energy performance. The most recent revision has increased its demands significantly for windows and shown steady improvement in all other categories. Although the system has shown gradual improvements society and customers are increasingly demanding better environmental performance (i.e., less environmental impact and energy use). As suggested by the simple slab insulation calculation there is also a financial justification for requiring that buildings use less energy. Chapter 5.0 discusses financial rationalization for high performance building measures normally found only in special low-energy and some green houses.

3.3 R-2000

3.3.1 The History of R-2000

The R-2000 program began as a response to a 1970's desire to build homes that were more comfortable to live in throughout the bitter cold winters of the Canadian prairies while being more energy efficient (CHBA, 2007). Hence the focus of R-2000 is low energy use homes. The original homes were thick walled and had minimal fenestration to reduce losses. The demands of society have changed and small windows are not generally accepted, making the attainment of R-2000 more demanding on window manufacturers. The house-as-a-system approach was a major step developed from the R-2000 research. All of the homes systems and construction elements had to work together and alterations to one system can effect decisions and design of another. System sizing, air tightness and insulation levels are an example of the systems thought process. As the level of insulation and air tightness increases the size of the system required to heat the home is greatly reduced. The program was officially created in 1981 in partnership with the Canadian Home Builder's Association (CHBA) and has carried on through partnerships with the Office of Energy Efficiency (OEE) of Natural Resources Canada (NRCan). Thousands of homes have been built under the program and as the codes, materials, consumers and energy demands change R-2000 has been developed to reflect those changes. R-2000 homes have been built around the world in places such as Germany, Japan and the United States. The program focuses on the involvement of all members of the home building process from the designers to the final testing parties.

3.3.2 The R-2000 Standard

R-2000 is a performance-based standards program. Because the standard is based on performance the builder is allowed a wide range of options for construction, materials and systems to attain the goals set out in the program. R-2000 focuses on three primary areas: energy performance, indoor air quality and environmental responsibility.

3.3.3 R-2000 Energy Performance

Energy performance is a significant focus of R-2000. Specified insulation levels are also mandated. Previous to 1995 the insulation levels prescribed in the program exceeded the local requirements. Within the 1995 R-2000 standard it states that the local requirements (i.e., the OBC) have become sufficient and the standard only requires what the local building codes require.

The window requirements of the standard are based on energy ratings (ER). ERs include provisions for solar gains, heat loss, and energy exchange through air leakage. An ER is basically a summation of the energy losses and gains represented in watts per square meter. A negative ER means that the losses through the window exceed the solar gains while a zero suggests the window will gain as much energy as it releases from the indoors during the heating season in an assumed orientation. Table 8 contains the window ER minimums.

Table 8 - Minimum Energy Rating for Windows within R-2000 (CHBA, 2007)

Degree Day Zone (Celsius Heating Degree Days)	Minimum Energy Rating	
	Operable windows or fixed glazing with a sash	Fixed glazing without a sash
Up to 3500	-18	-10
3501 to 6800	-13	-3
6801 and over	-10	0

For conversion, a window that meets the 2006 building code requirements could have an ER from approximately -15 to 0 depending on what construction is used to attain the code U-value requirements. An energy-efficient operable double glazed window with an insulating spacer, argon gas fill and low-e coating could attain an ER of 0 while some triple glazed units can provide positive ER figures (NRC, 2008). ENERGY STAR windows must have ER values ranging from -16 to -5 depending on the zone in which they are utilized (NRC, 2007).

Air sealing the home is a vital part of building a low-energy home. Although the Ontario building code does not mandate a specific level of air-tightness, many Green rating programs have targets which must be reached. Air-tightness can be measured in many ways from overall air leakage to flow rates to flow rates per area and flow rates per length of exterior

enclosure all at given pressure differences between the interior and exterior of the home. R-2000 states the following:

The building envelope shall be constructed sufficiently airtight such that either the air change rate at 50 Pascals is no greater than 1.5 air changes per hour, or the Normalized Leakage Area at 10 Pascals does not exceed 0.7 cm²/m² (1.0 in²/100 ft²), when measured in accordance with CAN/CGSB-149.10-M8. (CHBA, 2007)

Mechanical equipment must also be efficient for a low-energy home. In R-2000 the mechanical equipment must meet the following criteria:

All natural gas-, propane- and oil-fired space and water heating appliances shall have either sealed direct-vent, induced-draft or forced-draft venting systems with electronic ignition and shall be independently vented. Induced-draft and forced-draft vented appliances shall be capable of positive shutdown in the case of venting system blockage. (CHBA, 2007)

Fireplaces, if installed, must also have similar provisions to the other mechanical equipment. The water heating appliance must attain a minimum energy factor of 0.58 for natural gas or propane and 0.57 for oil units while electric water heaters must have standby losses less than 65 watts for 175L models and 80 watts for 270L models or an R-10 insulating blanket (CHBA, 2007).

Overall the goal of an R-2000 home is to reduce the home's requirement for energy through air sealing, mechanical equipment choices, and added insulation. Typically R-2000 homes will use approximately 30% less energy than a comparable non-R-2000 home (CHBA, 2007). The energy target is determined through modelling with HOT2000, an energy modelling program developed by Natural Resources Canada. The modelling is site, house and orientation specific.

3.3.4 R-2000 Indoor Air Quality

The ventilation system design and installation play a critical role in the quality of the indoor air. The system is to be designed by a Heating, Refrigeration and Air Conditioning Institute

of Canada (HRAI) certified designer. The exhaust and heat recovery ventilator equipment that is installed must be certified by the Home Ventilating Institute (HVI). All of the equipment and ducting is to be inspected by an R-2000 specialist. Each home must have a system in place to introduce fresh air into the home and exhaust stale indoor air. The standard calls for a carbon monoxide detector to be installed which is also part of the Ontario building code. In addition, the standard calls for interior finishes that are low emitting and are generally friendlier to the environment. Within the R-2000 guidelines there is a list of interior finishes, of which three must be chosen, ranging from Green Label carpet to formaldehyde free cabinetry.

3.3.5 R-2000 Environmental Responsibility

Similar to the list of choices for indoor air quality there is a 13 point list for environmentally responsible choices. Two of the items must be chosen. The list contains options such as insulation with increased recycled content, energy efficient appliances and decreased energy use targets to reduce greenhouse gas emissions. Within R-2000 there are also the following requirements for water conservation efforts:

- Toilets - 6.0 lpf or less
- Showers - 9.8 lpm or less at 551 kPa (80 psi)
- Faucets - 8.3 lpm or less at 413 kPa (60 psi)

The environmental responsibility section of R2000 is not very in-depth and attainment of these requirements should be relatively easy for most homebuilders if it is not within their standard construction practices already.

3.3.6 Conclusions

Although the R-2000 program was originally developed in the early 1980s it has managed to maintain a standard of performance that has always exceeded the OBC. It has a wider range of requirements than either the building code or ENERGY STAR (see section 3.4), but falls short of the LEED for homes program (see section 3.5) in terms of environmental concerns. The main shortfall of the R-2000 program is its lack of ability to gain traction in the home

building industry. Early adopters found the program difficult because the public was not yet pushing for green building, and hence builders did not pursue the program.

3.4 ENERGY STAR

3.4.1 *The History of ENERGY STAR*

ENERGY STAR was developed as a program to protect the environment and to save money by saving energy. The program was introduced in 1992 by the United States Environmental Protection Agency (EPA) and the United States Department of Energy (DOE). Computer electronics were the first items to receive labeling. Office equipment, residential heating and cooling equipment, major appliances, lighting, residential and commercial buildings were later added. The program has been able to gain an enormous amount of public acceptance and awareness in the building industry specifically and for energy efficiency in general. Figure 11 shows the internationally recognized ENERGY STAR symbols.



Figure 11 - International ENERGY STAR Symbols (EnerQuality, 2007)

The symbols are an easy way for people anywhere to identify products that lead their class in energy efficiency. This is saving the purchaser significant amounts of money per year and reducing the environmental impact through emissions reductions.

The ENERGY STAR for New Home promotes methods, materials and equipment that aim to produce a home that is up to 30% more efficient than similar code built homes (EnerQuality, 2007).

3.4.2 The ENERGY STAR Technical Specifications

Many ENERGY STAR homes are built using the core building package. The core building package is a set of prescriptive requirements that will, without further testing or analysis, meet the requirements of the ENERGY STAR program. The core package is designed so that almost any certified builder can build an ENERGY STAR home. If there are issues meeting any of the items within the core package there are alternative building packages that are intended to accommodate different building methods with a trade-off mechanism for a range of issues. Figure 12 lists the core building packages for ENERGY STAR qualified new homes in Ontario.

Element	Minimum Requirement (South <5000 DDC)	Minimum Requirement (North >5000 DDC)
Windows, Sliding Glass Doors and Skylights	ENERGY STAR qualified windows Canada Zone B	ENERGY STAR qualified windows Canada Zone C
Window Area	<13% of above grade boundary wall area	
Exterior Doors	Insulated slab door	
Heated Ceiling w/ attic	R40	R50
Heated Ceiling w/o attic	R31	
Exterior Walls	R19+5	R19+7.5
Exposed Floors	R31	
Basement Walls	full height, R12	full height, R+15 / R19
Slab w/o in-floor heating		
> 4 ft below grade:	un-insulated	un-insulated
< 4 ft below grade:	R+10 frost wall	R+15 frost wall
Slab w/ in-floor heating	R+10, full slab	
House Air Leakage	Detached Homes: Air Leakage test: Less than 0.2 cfm50/ft2 Attached Homes: Air Leakage test: Less than 0.286 cfm50/ft2	
Ventilation	Detached homes: HRV with min. sensible efficiency of 60% at 0C Attached Homes: Exhaust Fan without heat recovery Plus: Forced air distribution is required to be interconnected with the operation of the principal exhaust fan or HRV.	
Space Heating	Fuel: ENERGY STAR qualified equipment Electrical: special requirements	
Ducts	All ducts are to be located within the heated boundary. All supply trunks, supply branch take-offs, return trunks, and lined joists are to be sealed.	
Water Heating	Fuel: Canadian Minimum Efficiency requirements Electrical: Minimum EF 0.92	
Electrical Savings	A minimum savings of 600, 800, 1000 or 1200 kWh/yr depending upon the finished floor area of the home.	
ENERGY STAR Branding	Unless otherwise noted elsewhere in this document, all windows and all space heating equipment are required to be ENERGY STAR qualified. All products selected for the Electricity Savings credits in Section 3.11 that are installed in an ENERGY STAR qualified new home at time of sale, are required to be ENERGY STAR qualified, whenever a Canadian ENERGY STAR specification applies.	

Figure 12 - Ontario ENERGY STAR Core Building Package (EnerQuality, 2007)

As an example of a trade-off, if a builder could not install an HRV, they would have the option to install a higher efficiency water heater along with either installing northern zone basement insulation or a very high efficiency furnace.

Most of the insulation stipulations in the ENERGY STAR for new homes specifications are now included in the 2006 Ontario building code. The HRV requirement, electrical savings, duct sealing and house air leakage specifications are not included in the building code.

Along with the building package options there is also independent testing required to attain ENERGY STAR qualification. The house air leakage testing mandates a Normalized Leakage Rate (NLR) of 0.2 cfm50/ft² which correlates to approximately an ACH50 of 2.2 for

detached homes. The NLR for attached homes is 0.286 cfm50/ft² which is approximately an ACH50 of 3.0. The R-2000 requirement of 1.5 ACH50 is almost twice as stringent as ENERGY STAR. From experience with production built homes, 2.5 ACH50 can be achieved by using reasonable care and understanding of ABS. Airtightness of 1.5 ACH50 requires careful attention to details and a thorough knowledge of ABS.

3.4.3 Conclusions

In terms of energy performance the ENERGY STAR rating system is not very different than the OBC 2006. Because the OBC has recently been updated, the Canadian ENERGY STAR system surpasses it in only a few categories. The main difference is the house air leakage testing, which at 2.5 ACH50, is achievable by many home builders, and can be a significant low-cost energy-saving strategy.

3.5 LEED for Homes Canada

3.5.1 The History of LEED

Leadership in Energy and Environmental Design (LEED) began development in 1994 as a project by the Natural Resources Defense Council (NRDC). Today the voluntary green rating system is developed and administered by the United States Green Building Council (USGBC). The Canada Green Building Council (CaGBC) licenses and administers LEED green rating systems within Canada. The LEED program originally focused on new construction but today has nine rating systems.

- LEED for New Construction and Major Renovations
- LEED for Existing Buildings
- LEED for Commercial Interiors
- LEED for Core & Shell
- LEED for Schools
- LEED for Retail
- LEED for Healthcare
- LEED for Homes

- LEED for Neighborhood Development (USGBC, 2008)

LEED is the most well known, and hence most significant, green rating program in commercial buildings. It is hoping to achieve the same status in green homes. This thesis only addresses LEED for Homes.

3.5.2 LEED for Homes

LEED for Homes came into effect in the US in 2008. LEED for Homes in Canada is still in the pilot phase. The program has developed a national consensus-based Green rating standard. The standard is constantly being refined by national experts and green builders. The standard aims to steer homebuilding towards a more sustainable future. The LEED for Homes standard has eight categories of concern. These are:

- Innovation and Design Process (ID)–Special design methods, unique regional credits, measures not currently addressed in the rating system, and exemplary performance levels.
- Locations and Linkages (LL) – The placement of homes in socially and environmentally responsible ways in relation to the larger community.
- Sustainable Sites (SS) – The use of the entire property so as to minimize the project’s impact on the site.
- Water Efficiency (WE) – Water-efficient practices, both indoor and outdoor.
- Energy and Atmosphere – Energy efficiency, particularly in the building envelope and heating and cooling design.
- Materials and Resources (MR) – Efficient utilization of materials, selection of environmentally preferable materials, and minimization of waste during construction.
- Indoor Environmental Quality (IEQ) – Improvement of indoor air quality by reducing the creation of and exposure to pollutants.
- Awareness and Education (AE) – The education of homeowner, tenant, and/or building manager about the operation and maintenance of the green features of a LEED home. (USGBC, 2007)

Within each of the eight categories there are prerequisites and optional credits available. In total there are 18 mandatory prerequisites and 136 optional credits. In each section there a minimum number of credits that must be obtained within that section. Table 9 contains the prerequisites, minimums and maximum credits available in each section.

Table 9 - Prerequisite and Minimum Credit Requirements (USGBC, 2007)

	Prerequisites	Minimum Required	Maximum Available
ID	3	0	11
LL	0	0	10
SS	2	5	22
WE	0	3	15
EA	2	0	38
MR	3	2	16
IEQ	7	6	21
AE	1	0	3

The level of certification depends on the total number of credits: the more credits, the higher the level.

- Certified – 45 Points
- Silver – 60 Points
- Gold – 75 Points
- Platinum – 90 Points

The ID section contains points that are primarily based around good management practices. The ID section has prerequisites of a preliminary rating and durability planning and management. Credits include having an integrated project team of professionals ranging from architects to engineers and green building specialists as well as a design charrette.

The LL section has two possible paths. The neighborhood development (ND) path requires the attainment of the LEED ND certification. The alternate prescriptive path does not have prerequisites. The credits within the prescriptive path include, but are not limited to, the following:

- Site Selection – Protection of land which is farmland, parkland, near wetlands, or made up of prime soils.

- Preferred Location – Encourages the use of lands which are edge development, infill or previously developed.
- Infrastructure – Encourages the use of areas which are close to existing water and sewer lines.
- Community Resources and Transit – Awards points for having the home in an area which allows easy access to community amenities via walking, biking or public transit.
- Access to Open Space – One point can be gained in this section for having the home near publicly accessibly open spaces such as parks.

Sustainable sites attempts to mitigate the long term effects of construction on the land. The SS section has prerequisites that must be planned well in advance.

- Erosion Controls During Construction – Properly designed and planned erosion controls for the duration of construction from initial excavation to final landscaping.
- No Invasive Plants – Ensures that invasive or foreign plants that may require additional irrigation or chemical fertilizers are not planted.

The credits available in SS section include: increasing housing density, minimizing the disturbed area of the site, landscaping plans, minimization of heat island effects, managing surface water runoff, and non-toxic pest controls.

The Water Resources (WR) section does not have any prerequisites. The credits focus on the minimization of potable water and reuse of water from sources such as rain. There are credits for installation of a rainwater harvesting system, grey water reuse system, reduced irrigation demand, high efficiency irrigation systems, and reduced indoor water use through installation of high efficiency fixtures.

The step in the Energy & Atmosphere (EA) section, as a prerequisite, is achievement of an ENERGY STAR certification. The EA section has two possible paths: the prescriptive path and the performance-based path. The prescriptive path assigns points by selection from a list of energy efficient options. Although this path is simpler to follow and mimics other ‘shopping list’ green rating programs, this route can cause problems. For example, to receive

the points for EA 4.2 – Enhanced or Exceptional Windows, all fenestration except for a small percentage must pass the requirements. If it is difficult or expensive to find the window for a specific purpose that meets the requirements, all the points will be lost. The performance based path makes allowances for these minor changes through modelling of the home. All of the components, as well as some testing results are input into a computer model and a Home Energy Rating System (HERS) rating is developed. From this rating a specific number of points can be applied for the energy and atmosphere section. From experience it seems that the performance path is less costly and involved per point than the prescriptive path.

The EA section encourages the use of high efficiency windows (exceeding ENERGY STAR), increased levels of insulation (beyond code requirements and ENERGY STAR), high efficiency mechanical equipment, ventilation equipment as well as hot water heating and appliances. Three levels of air tightness are credited, each progressively adding achieved points. In south-western Ontario (IECC climate zone 6) the three levels are 5.0, 3.5 and 2.0 ACH50. The most stringent, 2.0 ACH50, falls between the requirements of ENERGY STAR and R-2000. Within the EA section there are also credits available for the use of renewable energy from photovoltaics.

The Materials and Resources section (MR) has a prerequisite for each of its three sub-sections. The first prerequisite is framing waste factor. This allots one point for achieving a waste factor of less than 10%. It is calculated as follows in Table 10.

Table 10 - LEED-H Framing Waste Factor (USGBC, 2008)

Framing Component	Total Cost	Waste Factor	Waste Cost
Random Lengths	\$ 1,000	15%	\$ 150
Studs	\$ 2,000	5%	\$ 100
Beams and Headers	\$ 500	20%	\$ 100
Roof Deck	\$ 2,000	0%	\$ -
Wall Sheathing	\$ -	0%	\$ -
Rafters	\$ 2,000	0%	\$ -
Ceiling Joists	\$ 1,500	10%	\$ 150
Cornice Work	\$ 3,000	10%	\$ 300
Total	\$ 12,000		\$ 800
Overall waste factor (waste \$/cost \$)			6.7%

Beyond the waste factor there are optional credits available for detailed framing documents, detailed cut list and framing order, material efficient framing and off-site fabrication. The second prerequisite is that any tropical wood used in the home must be Forestry Stewardship Council (FSC) certified. FSC certification promotes the use of products that are harvested and manufactured in an environmentally and socially responsible manner. There are eight optional credits available for the use of environmentally preferable products (EPP). This section encourages the use of components (cement, lumber, insulation, drywall, paints and finishes etc.) with recycled content and low emissions that are locally produced. The final prerequisite in the MR section is construction waste management planning. This mandates that waste diversion options must be investigated for all waste types and documentation must be developed for all waste that is diverted from landfill. There are up to three credits available for maximizing the amount of waste diverted from landfill or minimizing the amount of waste produced.

The indoor environmental quality section (IEQ) has two possible paths. The first path contains the ENERGY STAR indoor air quality package at 13 credits plus 8 optional credits. Optional credits include enhanced ventilation and exhaust as well as improved air filtering and control of contaminants during construction. The second path contains 6 prerequisites and 21 optional credits. The prerequisites include mandates for combustion exhaust venting, outdoor air ventilation and distribution as well as air filtering and vehicle emission protection.

The final section (AE) deals with education and awareness of both the owner and the public. The only prerequisite is to educate the homeowner or tenant through the development and discussion of a homeowner's manual. The homeowner's manual is to contain the completed LEED-H checklists and plans, accountability forms, manufacturer's manuals for appliances and equipment as well as operations and maintenance guidelines for their new 'Green' home. Optional credits include enhanced training, public awareness and training of the building manager for multifamily buildings.

3.5.3 Conclusions

Although the LEED program is very in-depth in terms of credits available for environmental concerns (Sections LL, SS, WE and MR total 63 credits) and energy consumption (Section EA totals 38 Credits), it is quite possible to avoid building an energy efficient home at the lower levels of certification by choosing different optional credits. Achieving the Certified level can be done relatively easily with little concern for energy conservation or the environment because the prerequisites and minimums are not overly demanding. Proper selection of suitable points in an effort to attain an energy efficient, environmentally sustainable, durable home with better indoor air quality can meet the requirements of the Certified level. Selections can also be made to build up the number of points without creating a truly 'Green' home. Of the 136 available points only 45 are required for a standard-sized home to attain the Certified level. The minimum levels of points are not adequately distributed between the sections of the program. There is no minimum number of points required in the Energy and Atmosphere section and there are only two mandatory measures. This allows a home to be LEED certified but have very similar performance to the ENERGY STAR level of energy consumption. Many of the minimum requirements are also included in the 2006 Ontario building code. If the program aims to create a building that consumes less energy than an ENERGY STAR home in Ontario the EA section would require increased prerequisites. Achieving the Silver and Gold certifications requires more total credits and to attain these credits all of the sections must be used to a greater depth. Attaining Platinum in most cases requires credits from renewable energy sources (often the most expensive credits) and numerous optional credits from each section. All levels of LEED-H can attain low energy consumption, but the Silver, Gold and Platinum houses will typically attain the lowest levels of energy use.

4.0 LEED for Homes–Monarch Case Study

The previous chapter showed that the proposed LEED for Homes program was more demanding than the Ontario Building Code in terms of the requirements for energy savings. The ENERGY STAR program is the foundation of the LEED for Homes energy package, but does little for other environmental concerns such as landfill waste, site planning, house size, water use, etc. Hence, the LEED for Homes program appears to be one of the best potential programs for rating and thus improving new Ontario homes. However, it is currently in the pilot phase in Canada and has never been applied to a production building setting (even in the United States), the area of new home construction that has the potential for the largest total impact.

This chapter documents a case study in which a large production home builder built a prototype home, rated under the LEED for Homes pilot program, in preparation for the construction of a whole sub-division of over 200 homes (begun during April 2008).

4.1 Introduction

In early 2006 Monarch Corporation made the formal decision to create an entire development devoted to being ‘Green’. The following mission statement describes the intent of the project from Monarch’s perspective.

Create at Evergreen a community that serves as a model for urban infill, redevelopment and green housing that is economically viable, desired by buyers and produced without subsidy from government. (O’Shea & Carr, 2007)

LEED was chosen over ENERGY STAR because ENERGY STAR primarily focuses on the implementation of products that reduce the need for energy resources. LEED examines a bigger picture, incorporating and blending current socio-environmental concerns such as waste, water and resource management. LEED also uses ENERGY STAR as a baseline requirement, but directs green building with a more holistic approach.

At the time of conception, if the project were already complete, it would have been the single largest LEED-H project in North America, nearly tripling the number of LEED-H single family houses in North America, and quadrupling the number of LEED buildings in Canada. Figure 13 depicts the quantities of LEED homes in North America.

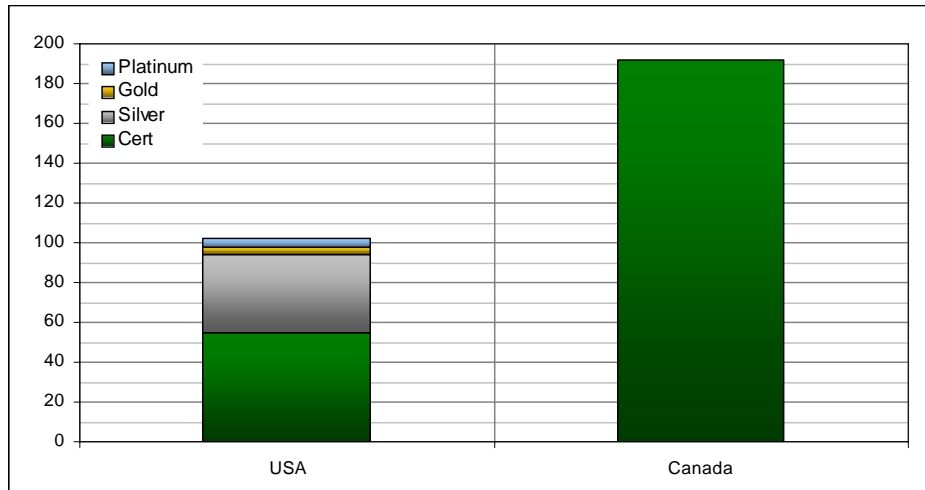


Figure 13 - LEED H in North America (USGBC, 2007)

Before the management of Monarch Corporation felt comfortable advancing with a full development of LEED-H homes they required that a prototype be built. The construction of a single home would allow them to test their suppliers, construction crews, management, organization and site supervisors. The financial risk involved with a single prototype was of course much less than that of a development of 202 homes.

4.2 Credit Selection Process

The LEED-H technical manual was reviewed multiple times with Monarch management, civil engineers, planners, architects and building science consultants. A point-by-point chart was developed, costs per item were quoted, and then a preliminary set of attainable points were chosen. The chart allowed the consultants and Monarch to determine which points and prerequisites are standard practice, building code enforced, locally enforced, included in Canadian ENERGY STAR and which ones would require changes to their current construction practices.

To ensure that each applicable point was attained at Evergreen the list was reviewed numerous times by each member of the integrated project team. Preliminary selections of points to attempt were chosen based on four criteria; cost, difficulty to implement, marketability and risk. Each of the last three criteria was assigned a numerical value between 1 and 5. The list was sorted primarily by the total of these points and secondarily by cost. The minimums and prerequisites were not involved in this sorting process due to the fact that they must be implemented regardless of cost, difficulty or risk. The list was reviewed again by the Building Science Consulting (BSC) team, selecting points for durability and sustainability based on extensive knowledge of testing and residential building within the US and Canada. The Monarch management decided during reviews that the level of Certified was to be obtained for all homes of the Evergreen development. After several iterations the final points to attempt were chosen and the LEED-H checklist in Figure 14 and Figure 15 was developed. The points being attempted surpass the requirement for Certified to build an area of cushion. This cushion allows all homes regardless of orientation, location and interior finishes the ability to attain the Certified level.

A prototype house location was determined and the point checklist for Evergreen had to be modified to suit this new location. The LL section of the Evergreen list contains many points due to its location on a brownfield redevelopment within an existing community. Certain points within the LL and SS sections were not available to the prototype house and other points had to be selected. The prototype house was built on lot 4027 of Topper Woods, an existing Monarch development in the south-west corner of Kitchener, Ontario.



for Homes

LEED for Homes Simplified Project Checklist

Builder Name:	Monarch Corporation
Project Team Leader (if different):	Kevin O'Shea, Monarch Corporation
Home Address (Street/City/State):	Evergreen, Toronto, Ontario

Project Description:

Building Type: **Single, detached**

Project type: **Production**

Certified: **43.5** Gold: **73.5**

of Bedrooms: **4**

Floor Area: **2,467**

Silver: **58.5** Platinum: **88.5**

Adjusted Certification Thresholds

Project Point Total: 57	ID: 4	SS: 6.5	EA: 14	EQ: 10
Certification Level: Not Certified	LL: 10	WE: 5	MR: 7	AE: 1

Notes:

- Detailed information on measures below are provided in the LEED for Homes Rating System
- ⊗ Indicates measures that must be documented using the Accountability Form

Innovation and Design Process (ID)		(No Minimum Points Required)		OR	Max Points Available	Project Points	Y / Pts	No	Maybe
1. Integrated Project Planning	1.1	Preliminary Rating		Prerequisite		Y			
	1.2	Integrated Project Team		1	1	1			
	1.3	Professional Credentialed with Respect to LEED for Homes		1	1	No			
	1.4	Design Charrette		1	1	No			
	1.5	Building Orientation for Solar Design		1	1	No			
2. Durability Management Process	2.1	Durability Planning		Prerequisite		Y			
	2.2	Durability Management		Prerequisite		Y			
	2.3	Third-Party Durability Management Verification		3	3				
3. Innovative or Regional Design	⊗ 3.1	Innovation #1		1	1	No			
	⊗ 3.2	Innovation #2		1	1	No			
	⊗ 3.3	Innovation #3		1	1	No			
	⊗ 3.4	Innovation #4		1	1	No			
<i>Sub-Total for ID Category:</i>					11		4		
Location and Linkages (LL)		(No Minimum Points Required)		OR		Y / Pts	No	Maybe	
1. LEED ND	1	LEED for Neighborhood Development	LL2-6	10	10		No		
2. Site Selection	⊗ 2	Site Selection		2	2				
3. Preferred Locations	3.1	Edge Development		1	1		No		
	3.2	Infill	LL 3.1	2	2				
	3.3	Previously Developed		1	1				
4. Infrastructure	4	Existing Infrastructure		1	1				
5. Community Resources/ Transit	5.1	Basic Community Resources / Transit		1	1		No		
	5.2	Extensive Community Resources / Transit	LL 5.1, 5.3	2	2		No		
	5.3	Outstanding Community Resources / Transit	LL 5.1, 5.2	3	3				
6. Access to Open Space	6	Access to Open Space		1	1				
<i>Sub-Total for LL Category:</i>					10		10		
Sustainable Sites (SS)		(Minimum of 5 SS Points Required)		OR		Y / Pts	No	Maybe	
1. Site Stewardship	1.1	Erosion Controls During Construction		Prerequisite		Y			
	1.2	Minimize Disturbed Area of Site		1	1	No			
2. Landscaping	⊗ 2.1	No Invasive Plants		Prerequisite		Y			
	⊗ 2.2	Basic Landscape Design	SS 2.5	2	2	No			
	⊗ 2.3	Limit Conventional Turf	SS 2.5	3	3	No			
	⊗ 2.4	Drought Tolerant Plants	SS 2.5	2	2	No			
	⊗ 2.5	Reduce Overall Irrigation Demand by at Least 20%		6	6	No			
3. Local Heat Island Effects	⊗ 3	Reduce Local Heat Island Effects		1	1		No		
4. Surface Water Management	⊗ 4.1	Permeable Lot		4	4	1			
	4.2	Permanent Erosion Controls		1	1		No		
	4.3	Management of Run-off from Roof		2	2	1			
5. Nontoxic Pest Control	5	Pest Control Alternatives		2	1.5				
6. Compact Development	6.1	Moderate Density		2	2		No		
	6.2	High Density	SS 6.1, 6.3	3	3				
	6.3	Very High Density	SS 6.1, 6.2	4	4	No			
<i>Sub-Total for SS Category:</i>					22		6.5		

Figure 14 - LEED-H Checklist Page 1

LEED for Homes Project Checklist (continued)

						Max Points Available	Project Points		
						Y / Pts	No	Maybe	
Water Efficiency (WE) (Minimum of 3 WE Points Required) OR									
1. Water Reuse	1.1	Rainwater Harvesting System	WE 1.3	4		No			
	1.2	Graywater Reuse System	WE 1.3	1		No			
	1.3	Use of Municipal Recycled Water System		3		No			
2. Irrigation System	✓ 2.1	High Efficiency Irrigation System	WE 2.3	3		No			
	2.2	Third Party Inspection	WE 2.3	1		No			
	✓ 2.3	Reduce Overall Irrigation Demand by at Least 45%		4		No			
3. Indoor Water Use	3.1	High-Efficiency Fixtures and Fittings		3	1				
	3.2	Very High Efficiency Fixtures and Fittings		6	4				
<i>Sub-Total for WE Category:</i>						15	5		
Energy and Atmosphere (EA) (Minimum of 0 EA Points Required) OR									
1. Optimize Energy Performance	1.1	Performance of ENERGY STAR for Homes		Prerequisite	Y				
	1.2	Exceptional Energy Performance		34	13				
7. Water Heating	✓ 7.1	Efficient Hot Water Distribution		2		No			
	7.2	Pipe Insulation		1		No			
11. Residential Refrigerant Management	11.1	Refrigerant Charge Test		Prerequisite	Y				
	11.2	Appropriate HVAC Refrigerants		1	1				
<i>Sub-Total for EA Category:</i>						38	13.5		
Materials and Resources (MR) (Minimum of 2 MR Points Required) OR									
1. Material-Efficient Framing	1.1	Framing Order Waste Factor Limit		Prerequisite	Y				
	1.2	Detailed Framing Documents	MR 1.5	1		No			
	1.3	Detailed Cut List and Lumber Order	MR 1.5	1		No			
	1.4	Framing Efficiencies	MR 1.5	3	0.5				
	1.5	Off-site Fabrication		4		No			
2. Environmentally Preferable Products	✓ 2.1	FSC Certified Tropical Wood		Prerequisite	Y				
	✓ 2.2	Environmentally Preferable Products		8	5				
3. Waste Management	3.1	Construction Waste Management Planning		Prerequisite					
	3.2	Construction Waste Reduction		3	1.5				
<i>Sub-Total for MR Category:</i>						16	7		
Indoor Environmental Quality (EQ) (Minimum of 6 EQ Points Required) OR									
1. ENERGY STAR with IAP	1	ENERGY STAR with Indoor Air Package		13		No			
2. Combustion Venting	2.1	Basic Combustion Venting Measures	EQ 1	Prerequisite	Y				
	2.2	Enhanced Combustion Venting Measures	EQ 1	2	2				
3. Moisture Control	3	Moisture Load Control	EQ 1	1		No			
4. Outdoor Air Ventilation	✓ 4.1	Basic Outdoor Air Ventilation	EQ 1	Prerequisite	Y				
	4.2	Enhanced Outdoor Air Ventilation		2	2				
	4.3	Third-Party Performance Testing	EQ 1	1		No			
5. Local Exhaust	✓ 5.1	Basic Local Exhaust	EQ 1	Prerequisite	Y				
	5.2	Enhanced Local Exhaust		1		No			
	5.3	Third-Party Performance Testing		1		No			
6. Distribution of Space Heating and Cooling	✓ 6.1	Room-by-Room Load Calculations	EQ 1	Prerequisite	Y				
	6.2	Return Air Flow / Room by Room Controls	EQ 1	1		No			
	6.3	Third-Party Performance Test / Multiple Zones	EQ 1	2		No			
7. Air Filtering	7.1	Good Filters	EQ 1	Prerequisite	Y				
	7.2	Better Filters		1	1				
	7.3	Best Filters	EQ 7.2	2		No			
8. Contaminant Control	✓ 8.1	Indoor Contaminant Control during Construction	EQ 1	1	1				
	8.2	Indoor Contaminant Control		2		No			
	✓ 8.3	Preoccupancy Flush	EQ 1	1		No			
9. Radon Protection	✓ 9.1	Radon-Resistant Construction in High-Risk Areas	EQ 1	Prerequisite	Y				
	✓ 9.2	Radon-Resistant Construction in Moderate-Risk Areas	EQ 1	1	1				
10. Garage Pollutant Protection	10.1	No HVAC in Garage	EQ 1	Prerequisite	Y				
	10.2	Minimize Pollutants from Garage	EQ 1	2	2	No			
	10.3	Exhaust Fan in Garage	EQ 1	1	1				
	10.4	Detached Garage or No Garage	EQ 1, 10.2, 10.3	3		No			
<i>Sub-Total for EQ Category:</i>						21	10		
Awareness and Education (AE) (Minimum of 0 AE Points Required)									
1. Education of the Homeowner or Tenant	✓ 1.1	Basic Operations Training		Prerequisite	Y				
	✓ 1.2	Enhanced Training		1		No			
	1.3	Public Awareness		1	1				
2. Education of Building Manager	✓ 2	Education of Building Manager		1		No			
<i>Sub-Total for AE Category:</i>						3	1		
LEED for Homes Point Totals: (Certification level)						136	57 Certified		

Figure 15 - LEED-H Checklist Page 2

4.3 Credit Attainment Process

This section discusses a selection of the points used to attain LEED Gold by Monarch Corporation at their prototype home. Lot 4027 in the second phase of Topper Woods in Kitchener, Ontario was chosen as a prototype site. The option to complete a prototype was pursued to ensure all steps required to attain LEED for Homes Certified level could be easily completed. The prototype would highlight areas of concern, possible stumbling blocks and act as a training centre for trades, site supervisors, as well as the engineering and management teams that will be involved when Monarch advances towards a full development of LEED-H homes. Lot 4027 is within a current development surrounded by existing homes, located close to green spaces and existing infrastructure. The home was planned as a part of the original development and hence there were limitations to the amount of changes that could be made to the building envelope, site, grading and planning. Overall the trades, site supervisors, engineering team and management team were eager and excited to be involved with the prototype home and to see the birth of a new generation of homes.

4.3.1 Innovation and Design Process

ID Prerequisite 2.1: Quality Management for Durability – Durability Planning

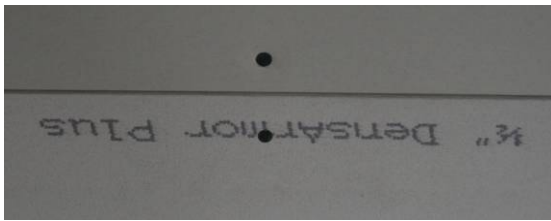
Durability measures that affect each particular facet of construction and long term durability were critically analyzed. Careful selections were made to ensure a long lasting, healthy, comfortable, dry, and quiet living environment was created. Strategies for durability can vary greatly depending on the project, building type and locale; therefore each project must have a specific set of customized requirements. The durability plan in Appendix A attains this prerequisite.

ID Prerequisite 2.2: Quality Management for Durability – Indoor Moisture Control

- Non paper-faced drywall is used in all tub and shower areas. The paperless drywall was also applied on the lower 4' of walls in all wet rooms.
- A combination of ceramic tiles, cork and slate are used in the bathrooms, kitchen and all entranceways.

- The water heater is located in the basement adjacent to a floor drain in case a leak occurs it can drain without affecting the basement finishes.
- The washer and dryer are installed on the main floor in a sunken laundry with water resistant flooring and a dedicated floor drain to protect against leaks and burst pipes.

Implementation photographs of ID 2.2 are included in Figure 18, Figure 17 and Figure 18.

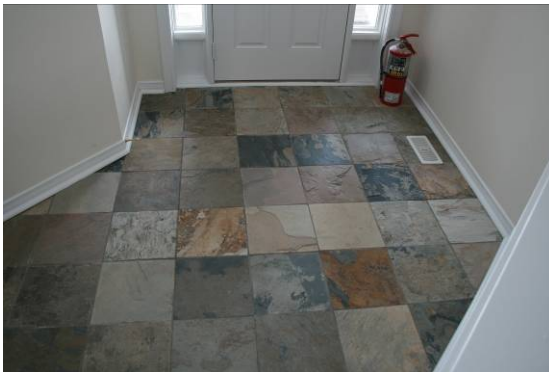


Paperless Drywall



Kitchen Cork Flooring

Figure 16 - Indoor Moisture Control Measures



Entryway Slate Flooring



Bathroom Tile Flooring

Figure 17 - Indoor Moisture Control Measures



Laundry Room Tile with Drain



Single Throw Shut-off for Laundry

Figure 18 - Indoor Moisture Control Measures

ID Prerequisite 2.3: Quality Management for Durability – Quality Management

Quality management was carried out throughout construction via daily site visits, weekly construction team meetings, and by-weekly engineering/management team meetings. Attached in Appendix A is an example of the contractor meeting handout. The meeting notes show the different facets of the project and each contractor's areas of concern.

ID Credit 2.4: Quality Management for Durability – Third Party Durability Inspection

The durability plan for this project was verified by third-party site visits and completion of the durability inspection checklist. A copy of the durability checklist can be found in Appendix A.

4.3.2 Location and Linkages

LL Credit 3.2: Preferred Locations – Infill Site

Lot 4027 is situated as an infill site between two existing homes and backing onto existing construction. The following table summarizes the perimeters. Because the lot borders more than 75% existing construction it satisfies the infill site requirements as shown in Table 11.

Table 11 - Prototype House Perimeter Calculations

	Length (m)	Length (ft)
North Side	13.20	43.28
East Side	34.21	112.21
South Side	13.33	43.71
West Side	35.60	116.77
Total Perimeter	96.33	315.97
Perimeter Bordering Existing Development	83.01	272.26
Percent Perimeter Bordering Existing Development	86%	86%

LL Credit 6: Access to Open Space – Publicly Accessible Green Space

Figure 19 shows the 0.92ha (2.3 acre) publicly accessible green space with trail denoted by a green circle and lot 4027 in red. The distance between these areas is approximately 200m (650ft) via sidewalks and pathways.

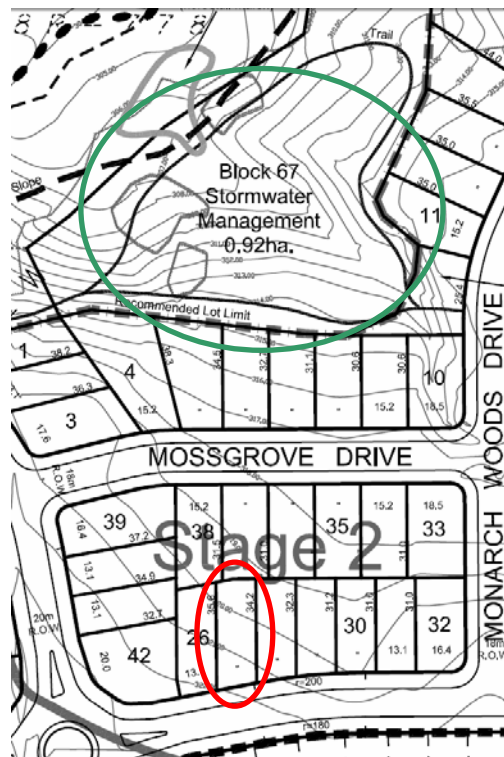


Figure 19 - Prototype House Accessibility to Open Space

4.3.3 Sustainable Sites

SS Prerequisite 2.1: Landscaping – No Invasive Plants

The planting schedule for lot 4027 only includes local and regional species requiring no irrigation or synthetic chemicals. These plants meet the requirements for prerequisite 2.1.

SS Credit 4.1: Surface Water Management – Permeable Sites

The entire area that is not under the roof and other than the driveway is considered permeable. This area will consist of permeable walkways, landscaping and native turf. More than 85% of the site is permeable, as calculated in Table 12, therefore 2 of 4 points are achieved.

Table 12 - Prototype House Permeable Areas

Lot 27	m	ft
Lot Area	461.1	4961
House Area	160.7	1729
Driveway Area	42.7	459
Area Not Under Roof	300.4	3232
Permeable Area	257.7	2773
Percentage Permeable Area	85.8%	85.8%

SS Credit 5: Non-Toxic Pest Control – Pest Control Alternatives

For lot 4027 Monarch has implemented all of the following non-toxic pest control alternatives. In addition, this lot is not within an area that has a high probability of termite infestation. The site photographs in Figure 20 show the implemented alternatives.

- All of the wood has been raised to 12” above the finished soil
- All exterior cracks are sealed
- Rodent screens are installed over intentional exterior openings
- All wood to concrete connections are separated by metal or plastic spacers.



Wood to Concrete with Sill Gasket



Brick Vent/Pest Screen



Caulked exterior Cracks/Openings



Rodent Screens

Figure 20 - Prototype House Non-Toxic Pest Controls

SS Credit 6.1: Compact Development – Moderate Density

Lot 27 is less than 1/8 of an acre and hence its density is more than 7 units per acre. Therefore two points are achieved. Table 13 contains the density calculations.

Table 13 - Prototype House Density

	m ²	ft ²	acre	unit/acre
Lot Area	461.1	4961	0.114	8.8
				> 7

4.3.4 Water Efficiency

WE Credit 3.1: Indoor Water Use – High Efficiency Fixtures

The toilets are Vorten Vienna RF-DF dual flush high-efficiency units. The 4:1 ratio as discussed with the LEED-H rater produces an average flush volume of 1.2 gpf. This earns 1 of 3 points.

WE Credit 3.2: Indoor Water Use – Very High Efficiency Fixtures

The shower heads are SSI Tapware Statesman units with a 1.5 gpm aerator, attaining 2 of 6 points. The lavatory faucets installed will be Moen L64600 with 1.5 gpm aerator. The kitchen faucet will be the Moen 67424 with 1.5 gpm aerator, attaining 2 of 6 points.

4.3.5 Energy and Atmosphere

EA Credit 1.2: ENERGY STAR Labeled Home – Exceptional Energy Performance

The basic ENERGY STAR certification was attained. A Home Energy Rating System (HERS) index of 49 was also attained at lot 4027. The baseline comparison home has a HERS index of 100. For each 1% increase in energy efficiency the HERS index is decreased by 1 point. The rating is a result of:

- Very well air sealed home at 1.2 ACH50
- Insulation levels exceeding the building code and ENERGY STAR
- Window performance exceeding the building code and ENERGY STAR
- High efficiency space heating and water heating equipment

- All mechanical equipment and venting is sealed and contained within the building envelope.
- All applicable appliances are ENERGY STAR certified

This provides 19.7 LEED points. The HERS rating is attached in Appendix A.

4.3.6 Materials and Resources

MR Prerequisite 1.1: Material-Efficient Framing – Waste Factor in Framing Order

Waste factors for lot 4027 were calculated from the overall wood ordered to site. The quantities of wood were translated into weights from densities listed in the 2001 Canadian Wood Council Wood Design Manual. The total mass of wood delivered was 38,830lbs (17,651kg), the total wood waste sent to landfill that was produced by framing was 319lbs (145kg). The framing waste factor is 0.82% therefore MR prerequisite 1.1 has been achieved. Table 14 contains the calculations to verify the framing waste factor. Figure 21 is a site photograph showing the minimal amounts of scrap wood left by the framing crew.

Table 14 - Prototype House Framing Waste Factor

Item	Mass (kg)
1x4 SPF	105.2
2x4 SPF	2851.4
2x6 SPF	5014.1
2x8 SPF	131.0
2x10 SPF	4032.2
2x12 SPF	52.2
2x14 SPF	0.0
1 3/4 x 9 1/2 LVL	345.4
12" OC 2x10 SPF Bridge	15.7
16" OC 2x10 SPF Bridge	22.4
1/4" OSB	324.0
5/8" OSB	2790.0
7/16" OSB	441.0
3/8" Sheeting	1632.0
Total Mass	17651.5
Wood Waste Recycled	1400.0
Wood Waste Sent to Landfill	145.48
Framing Waste Factor	0.82%



Figure 21 - Prototype House Wood Waste Example

MR Credit 1.2: Material-Efficient Framing – Advanced Framing Techniques

The material efficient framing techniques implemented at 4027 include exterior diagonal wind bracing in lieu of wood sheathing, appropriately sized headers, and 2-stud corners with drywall clips rather than 3 stud corners. All headers were sized by the engineer and were pre-cut and labeled to help ensure each header was installed in the proper location. These choices attain 1.5 of 3 points. The advanced framing techniques implemented were photographed and are shown in Figure 22 and Figure 23.



Sized and Labeled Headers

Figure 22 - Prototype House Advanced Framing Techniques



Two-Stud Corner

Diagonal Wind Bracing and Insulated Sheathing

Figure 23 - Prototype House Advanced Framing Techniques

MR Credit 2.2: Environmentally Preferable Products – Environmentally Preferable Materials

This section encourages the use of components (cement, lumber, insulation, drywall, paints and finishes etc.) with recycled content that are low emitting or that are locally produced. The following list depicts the EPPs that were selected for the prototype home.

- FSC Certified Framing
 - All framing, exterior walls, floor, interior walls and roof are framed using FSC certified lumber.
- 100% Recycled Flooring
 - All carpet installed at lot 4027 is 100% recycled.
- Carpet is Locally Sourced
 - The carpet is extracted, processed and manufactured within 800kms (500 miles) of the site.
- Flooring Bonus
 - Greater than 90% of flooring area is either cork or 100% recycled carpet.

- Foundation Aggregate and Cement Locally Sourced
 - All aggregate and cement is extracted, processed and manufactured within 500 miles (800kms) of the site.
- Foundation Cement with >30% Slag Content
- Gypsum Board
 - All gypsum board in the home exceeds the minimum 25% recycled content requirements.
- Paints
 - All paints used meet the low off-gassing GS-11 specifications.
- Interior Doors Locally Sourced
 - All interior doors are extracted, processed and manufactured within 500 miles (800kms) of the site.
- Interior Trim Locally Sourced and Recycled Content
 - All interior trim is extracted, processed and manufactured within 500 miles (800kms) of the site. The trim also exceeds the minimum 25% requirement for recycled content.

MR Prerequisite 3.1: Waste Management – Waste Management Planning

This prerequisite was met with the development and implementation of the waste management plan in Appendix A.

MR Credit 3.2: Waste Management – Waste Reduction

The framers were provided with their own waste bin solely for clean wood waste. This waste was taken to a local hydroponic farmer who recycled over 3000 lbs (1400kgs) of wood waste as a heat source. The brick and concrete waste due to their high compressive strength was used as clean backfill beneath the garage floor slab. This resulted in an estimated waste weight savings of approximately 5500lbs (2500kgs). Table 15 shows a summary of the wastes as well as the total waste per square foot achieved at lot 4027. The total waste of 0.95 lbs/sqft achieves 2 of 3 points.

Table 15 - Prototype House Waste

Item	Mass (kg)
Sealant Tubes and Paint Pails	16.7
Insulation bags and remnants	28.1
Shingles	172.7
Cardboard	61.4
Mixed	316.9
HVAC Steel	19.4
Steel Straps	21.6
Wood Waste	164.4
Interior Trim Waste	72.8
Tile Scraps	113.8
Drywall Wastes	122.6
Styrofoam/EPS	26.9
Carpet	70.3
Total (kg)	1207.6
Total (lbs)	2656.8
Finished Area (sqft)	2800
lbs/sqft	0.95

To verify the quantities of waste produced on site a careful weighing process was developed. All waste, other than brick, concrete and wood was stored in covered bins. The bins, in three stages of construction, were emptied and sorted. The sorted waste was weighed and recorded. The pictures provided in

Figure 24 show a sample of the segregated waste during the initial weighing session as well as the brick and concrete backfill.



Wood Waste



Styrofoam and XPS



Shingles



Steel Straps



Leftover Concrete as Backfill



Leftover Brick as Backfill

Figure 24 - Prototype House Waste

4.3.7 Indoor Environmental Quality

IEQ Prerequisite 2.1: Combustion Venting – Basic Combustion Venting Measures

The furnace installed at lot 4027 is a Lennox Elite Series G61 with sealed and power vented combustion. The instantaneous water heater is a 0.84EF Rinnai 2520-FFUN which is a natural gas fired unit with sealed combustion. Carbon monoxide detectors were installed on each floor and in the laundry room where the entrance from the garage is located.

IEQ Credit 4.2: Outdoor Air Ventilation – Enhanced Outdoor Air Ventilation

The VanEE HRV 60H is a fully ducted heat recovery ventilator installed to provide a dedicated outdoor air supply conforming to ASHRAE 62.2.

IEQ Prerequisite 5.1: Local Exhaust – Basic Local Exhaust

The local exhaust fans installed in all bathrooms as well as the primary exhaust fan are all ENERGY STAR rated and conform to ASHRAE 62.2. The bathroom fans and primary exhaust fan are rated at 90cfm while the kitchen range hood is rated at 150cfm. These specifications fulfill the requirements of this prerequisite.

IEQ Prerequisite 6.1: Distribution of Space Heating and Cooling

The distribution of space heating and cooling is done in conformance to ACCA manual J and D and each room was third party tested for sufficient return air flow.

IEQ Credit 6.2: Distribution of Space Heating and Cooling – Third Party Performance Test

The air flow consultants completed testing to verify the flow rates provided to each room meet the ACCA and LEED-H standards.

IEQ Credit 7.3: Air Filtering – Best Filters

MERV 16 air filters were installed with the Lennox G61 furnace as shown in Figure 25. This achieves 2 of 2 points. The Lennox MERV 16 air filter removes over 95% of particles down to 0.3 micron and it also removes 90% of microorganisms down to .01 micron (Lennox,

2008). The typical fiberglass filter is only a MERV 1 and will only catch particles such as 30 micron pollen.



Figure 25 - Prototype House MERV 16 Air Filter

IEQ Credit 8.1: Contaminant Control – Indoor Contaminant Control During Construction

Once the supply venting was put in at lot 4027 Monarch specific vent covers with integrated air filters were installed (Figure 26). The return air vents were covered with polyethylene and taped to ensure contaminants did not enter the system (Figure 27). The return air covers remained in place until the painters had completed their work (Figure 28). The house was then heated with the furnace while the interior trim and flooring were installed. The vent covers remained in place until construction was complete and the floor registers were installed.



Figure 26 - Prototype House Supply Air Vent Cover



Figure 27- Prototype House Return Air Cover Pre-Drywall



Figure 28 - Prototype House Return Air Cover Post Drywall

IEQ Prerequisite 9.1: Radon Protection – High Radon Risk Areas

Information on radon mapping in Ontario is unavailable as it was only recently deemed a concern. Upon examination of the USA radon mapping it was extrapolated that the area in which 4027 is located is unlikely to fall within a high radon risk locale.

IEQ Credit 9.2: Radon Protection – Moderate Radon Risk Areas

Passive radon protection was installed at 4027 to ensure that in the event that a radon threat develops over the life of the home the effects of the gas entering the home will not be experienced.

IEQ Credit 10.2: Garage Pollutant Protection – Minimize Pollutants from Garage

The garage at 4027 is finished space. The area was drywalled, taped and painted. All penetrations are sealed in the walls and ceiling, the ceiling joist bays are sealed with spray polyurethane foam. The laundry room, adjacent to the garage, has a weather stripped door and there is a carbon monoxide detector installed close to the garage entrance.

4.3.8 Awareness and Education

AE Prerequisite 1.1: Education of the Homeowner/Tenant – Basic Operations Training

This prerequisite was met with the development and implementation of a homeowner's manual. The typical homeowner's manual includes:

- Rating Certificate
- Features Checklist
- Accountability Forms
- Durability Plan
- Manuals for all installed equipment
- General recommendations for efficient living
- Operations and maintenance suggestions and guidelines
- Additional information on green power options

4.4 Conclusions

Monarch Corporation has applied for Gold certification for lot 4027 and is currently awaiting approval from the USGBC. Although the rating system appears to require a significant amount of documentation, attaining LEED certification is not insurmountable. For an environmentally responsible homebuilder already complying with OBC 2006 and ENERGY STAR with a high level of quality control, the actual building practices and methods do not vary significantly from standard. The total upgrade cost of all materials and labour was found to be 6% more than the standard OBC compliant version of this home plan.

5.0 Next Generation: An Economic Case for Better Homes

5.1 Introduction

The previous chapter was an in-depth case study of a LEED home built by a production builder. This home is expected to cost approximately 6% more than a standard home and use 35% less energy than a 2006 OBC home, thereby emitting over 36% fewer greenhouse gas emissions. LEED homes, or other green rating systems, are however, not needed to save energy and GHG emissions, other technical solutions are available.

The common belief that building low-energy homes is costly is not necessarily true. It is often true that the capital cost of energy efficient homes will be greater than that of standard homes. However, the vast majority of homes are purchased with financing, and it is the monthly cost of ownership that governs the house most people can purchase, not the capital cost. As mortgage interest rates drop, consumers are able to buy more expensive homes because a fixed monthly financing charge can support a more expensive house. Similarly, as the monthly cost of purchasing the energy required to operate a house drops, some or all of the savings can be directed towards supporting increased capital costs.

The goal of this chapter is to show that it is possible to build a low-energy home for less total carrying cost than a home built to minimum code levels. For a few dollars a day, an even healthier, more durable, and more environmentally friendly home can be built. To show how this is possible, a range of cost-effective and practical-to-implement upgrades are identified, and quantitative projections of cost-savings and benefits gained by the homeowner are generated.

It has long been argued within the building science community that the most economical way to reduce the environmental impact and monthly utility cost of a home is to reduce energy demand (Lovins, 2004), not to implement costly energy production methods and equipment to create supply. Once a home's energy demand has been greatly reduced it should be possible to implement energy production equipment (such as solar- and wind-generated electricity) to further reduce the monthly cost and reliance on public systems. This approach

to housing is termed the “Next Generation House” to distinguish it from another green- or performance rating system.

5.2 Parametric Modelling Approach and Assumptions

To investigate the economic potential for energy-saving, a relatively simple single detached home on a standard 25’ wide lot in Toronto, Ontario is chosen for a parametric modelling study. The house has a floor area of 1800 square feet, is 2 storeys in height and built into an existing community.

Figure 29 shows a preliminary model for the home. This is a proposed house designed by Alex Lukachko and McCallum Sather Architects.

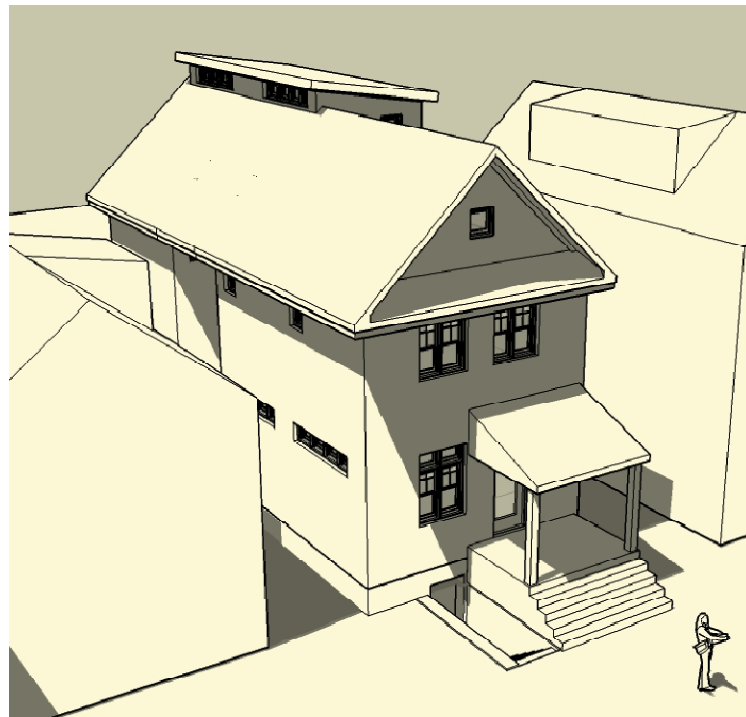


Figure 29 - Next Generation House Massing Model

All of the energy predictions are based on computer simulations using HOT 2000 version 9.33. This program calculates the energy requirements of a house based on a wide range of

user inputs. This evaluation takes into account the thermal effectiveness of the building and its components, the passive solar heating owing to the location of the building and the operation and performance of the building's ventilation, heating and cooling systems (NRCAN, 2008). HOT 2000 utilizes a bin method of calculation. Rather than calculating every data point throughout a given time period, the data points are grouped into bins of similar information and each bin is calculated. This method is widely used because it generally requires less computing power and can accurately estimate the building's energy requirements quickly.

The following assumptions are the basis of the simulation.

- The home faces roughly north-east
- Toronto weather data were utilized
- Little shading is provided in the front and rear of the home
- Overhangs are all approximately 12"
- Window areas were calculated from plans provided by the architect
- Square footages are also calculated from plans provided by the architect

The occupants within a home can have a large impact on energy use. Energy use has been monitored and shows up to a 300% variance for the same house design, in the same area with the same number of occupants (Straube, 2007). An average family of four people who are typically energy conscious was assumed for these calculations.

Ontario Building Code 2006 construction is considered the baseline scenario. The base model included air conditioning as it is standard in most new homes in Toronto. A 92% efficient furnace, poured concrete foundation, and standard ceiling construction as well as an HRV (not normally included in today's homes) remained the same for all variations (Table 16).

Three different air tightness values were modeled; 1.5, 2.5 and 3.5 ACH at 50 Pa for comparison. Eight different exterior wall cross-sections were considered (Table 17). The change in the walls was initially the replacement of the OSB sheathing with 1" of extruded polystyrene (XPS) foam insulation board. Each model then received additional 1" layers of

XPS insulation. The use of the foam sheathing often requires the use of furring strips to aid the installation of siding. Four different window systems were considered (Table 18).

Each wall type was analyzed with each window type at each air change rating resulting in 108 different energy models. Advanced framing, a system that removes excess and redundant wood framing elements, was assumed for all but the base model homes.

Table 16 shows the constant details and mechanical variations; B-AC, B and AW. B denotes Base, AC that the model has air conditioning and AW that advanced framing was implemented.

Table 16 - Next Generation Common Details and Mechanical Systems

	B-AC Model	B Models	AW Models
Air Conditioning - Conventional - Add-on	√		
HRV - 74% at 0C - 68% at -25C - 60W Fan			√
Natural Gas, 92% AFUE, Condensing Furnace	√	√	√
Vented Attic - R55 - 2"x6" at 16"o.c. - 16" Cellulose	√	√	√
Catherdal Ceiling - R50 - 2"x6" at 16"o.c. - SPUF - 4" XPS Exterior	√	√	√
Foundation Floor - R12 - Poured Concrete - 2" Exterior	√	√	√
Foundation Walls - R24 - Poured Concrete - 2"x16" at 16"o.c. - 2" XPS	√	√	√
Air Tightness - 2.5 ACH at 50pa.	√	√	√

Table 17 - Next Generation House Wall Details

	B26-AC	B26	AW26	AW26+1	AW26+2	AW26+3	AW26+4	AW26+5	AW26+6
2 Layers Latex Paint	√	√	√	√	√	√	√	√	√
1/2" Gypsum Board	√	√	√	√	√	√	√	√	√
R20 Fiberglass Batt Insulation	√	√	√	√	√	√	√	√	√
2x6 Standard Framing	√	√							
2x6 Advanced Framing			√	√	√	√	√	√	√
1/2" OSB	√	√	√						
1" Exterior Insulation				√					
2" Exterior Insulation					√				
3" Exterior Insulation						√			
4" Exterior Insulation							√		
5" Exterior Insulation								√	
6" Exterior Insulation									√
3/8" Strapping	√	√	√	√	√	√	√	√	√
Fiber Cement Cladding	√	√	√	√	√	√	√	√	√
R Value	17	17	18	24	29	34	39	44	49

The numerical denotation following the mechanical specification relates to the wall construction details. 26 indicates 2"x6" stud framing and the '+' indicates the addition of the specified amount of exterior insulated sheathing.

Table 18 - Next Generation House Window Details

	V1	V2	FD	FT
Low E Coating	√	√	√	√
Argon Filled	√	√	√	√
Double Glazed	√	√	√	
Triple Glazed				√
Insulating Spacer		√	√	√
Vinyl Frame	√	√		
Fiberglass Frame			√	√
R Value	2	2.5	3.5	4
Air Tightness (m3/hr/m)	2.79	2.79	0.55	0.55
Cost Increase	0%	18%	45%	250%

The window variation denotations are V for vinyl frame construction, 1 for windows without an insulating spacer, 2 for windows with an insulating spacer, F for fiberglass construction, D

for double glazed and T for triple glazed construction. It was assumed that windows with fiberglass frames would always have glazing units with insulating spacers. The total base cost of windows was assumed at \$5,000. The cost upgrade to double glazed vinyl was assumed at 18%, 45% for fiberglass framed double glazed and 250% for fiberglass framed triple glazed. These percentages were representative of the associated costs at the time this analysis was completed. The fenestration companies are rapidly changing to meet the needs of the housing industry. The costs of the upgrades are decreasing and the higher performance windows are more readily available than even one year ago.

The key metric for the cost calculations is the net monthly cash flow for the homeowner. The aim was to provide energy savings that would offset the monthly increase in mortgage payments. The mortgage duration, fuel cost escalation and interest rates were included. Monthly utility costs were calculated based on the 2.5 ACH rating which is achievable by almost any builder. 2.5 ACH50 can be reduced greatly if the air barrier system is pre-planned to ensure the proper materials are used and continuity as well as firm placement are maintained.

Construction cost data were assumed to increase with insulation thickness and window type. The wall area of the home was calculated at 2832 square feet, the material costs for XPS insulation was determined to be \$0.50 per board foot and the installation cost was assumed at \$0.90 per square foot. Table 19 shows the upgrade costs as they were estimated for this analysis.

Table 19 - Next Generation House Upgrade Costs

Wall Section	Window Type	Windows Upgrade	Upgraded Framing	Inches XPS	XPS Installation	XPS Mat'l	HRV Cost	Lighting Package	Total Upgrade Cost
B26-AC	V1	\$0	\$0	0	\$0	\$0	\$0	\$0	\$0
	V2	\$900	\$0	0	\$0	\$0	\$0	\$0	\$900
	FD	\$2,250	\$0	0	\$0	\$0	\$0	\$0	\$2,250
	FT	\$12,500	\$0	0	\$0	\$0	\$0	\$0	\$12,500
B26	V1	\$0	\$0	0	\$0	\$0	\$0	\$0	\$0
	V2	\$900	\$0	0	\$0	\$0	\$0	\$0	\$900
	FD	\$2,250	\$0	0	\$0	\$0	\$0	\$0	\$2,250
	FT	\$12,500	\$0	0	\$0	\$0	\$0	\$0	\$12,500
AW26	V1	\$0	-\$1,000	0	\$0	\$0	\$1,000	\$300	\$1,300
	V2	\$900	-\$1,000	0	\$0	\$0	\$1,000	\$300	\$2,200
	FD	\$2,250	-\$1,000	0	\$0	\$0	\$1,000	\$300	\$3,550
	FT	\$12,500	-\$1,000	0	\$0	\$0	\$1,000	\$300	\$13,800
AW26+1	V1	\$0	-\$1,000	1	\$0	\$1,416	\$1,000	\$300	\$2,716
	V2	\$900	-\$1,000	1	\$0	\$1,416	\$1,000	\$300	\$3,616
	FD	\$2,250	-\$1,000	1	\$0	\$1,416	\$1,000	\$300	\$4,966
	FT	\$12,500	-\$1,000	1	\$0	\$1,416	\$1,000	\$300	\$15,216
AW26+2	V1	\$0	-\$1,000	2	\$0	\$2,832	\$1,000	\$300	\$4,132
	V2	\$900	-\$1,000	2	\$0	\$2,832	\$1,000	\$300	\$5,032
	FD	\$2,250	-\$1,000	2	\$0	\$2,832	\$1,000	\$300	\$6,382
	FT	\$12,500	-\$1,000	2	\$0	\$2,832	\$1,000	\$300	\$16,632
AW26+3	V1	\$0	-\$1,000	3	\$2,549	\$4,248	\$1,000	\$300	\$8,096
	V2	\$900	-\$1,000	3	\$2,549	\$4,248	\$1,000	\$300	\$8,996
	FD	\$2,250	-\$1,000	3	\$2,549	\$4,248	\$1,000	\$300	\$10,346
	FT	\$12,500	-\$1,000	3	\$2,549	\$4,248	\$1,000	\$300	\$20,596
AW26+4	V1	\$0	-\$1,000	4	\$2,549	\$5,663	\$1,000	\$300	\$9,512
	V2	\$900	-\$1,000	4	\$2,549	\$5,663	\$1,000	\$300	\$10,412
	FD	\$2,250	-\$1,000	4	\$2,549	\$5,663	\$1,000	\$300	\$11,762
	FT	\$12,500	-\$1,000	4	\$2,549	\$5,663	\$1,000	\$300	\$22,012
AW26+5	V1	\$0	-\$1,000	5	\$5,097	\$7,079	\$1,000	\$300	\$13,476
	V2	\$900	-\$1,000	5	\$5,097	\$7,079	\$1,000	\$300	\$14,376
	FD	\$2,250	-\$1,000	5	\$5,097	\$7,079	\$1,000	\$300	\$15,726
	FT	\$12,500	-\$1,000	5	\$5,097	\$7,079	\$1,000	\$300	\$25,976
AW26+6	V1	\$0	-\$1,000	6	\$5,097	\$8,495	\$1,000	\$300	\$14,892
	V2	\$900	-\$1,000	6	\$5,097	\$8,495	\$1,000	\$300	\$15,792
	FD	\$2,250	-\$1,000	6	\$5,097	\$8,495	\$1,000	\$300	\$17,142
	FT	\$12,500	-\$1,000	6	\$5,097	\$8,495	\$1,000	\$300	\$27,392

The advanced framing package has been shown to save over \$1,000 per home in material and labour when properly planned and implemented (BSC, 2008). The first two inches of exterior insulation do not have an installation labor cost because the exterior sheathing needs to be installed regardless and whether the contractor is applying wood-based sheathing (such as OSB) or XPS insulation the installation costs would be very similar. The wood-based sheathing material cost savings is applied to the advanced framing savings. XPS is readily available in thicknesses of two inches and hence the installation costs only increase in 2” increments. The windows, HRV and lighting package prices are assumed based on knowledge of pricing available to builders in the Toronto area.

5.3 Results

Energy consumption was compared in units of kWhr/m²/yr and then converted to monthly costs using an average for electricity at \$0.09/kWhr (Waterloo North Hydro, 2008) and natural gas at \$0.40 /m³ (Union Gas, 2008). These values represent the cost of utilities including distribution, connection, network and administration fees. Annual energy costs for each of the models can be seen in Figure 27. This figure also shows an asymptotic curve typical of many engineering optimization problems: increasing efforts in upgrades result in decreasing benefits after the initial easy wins.

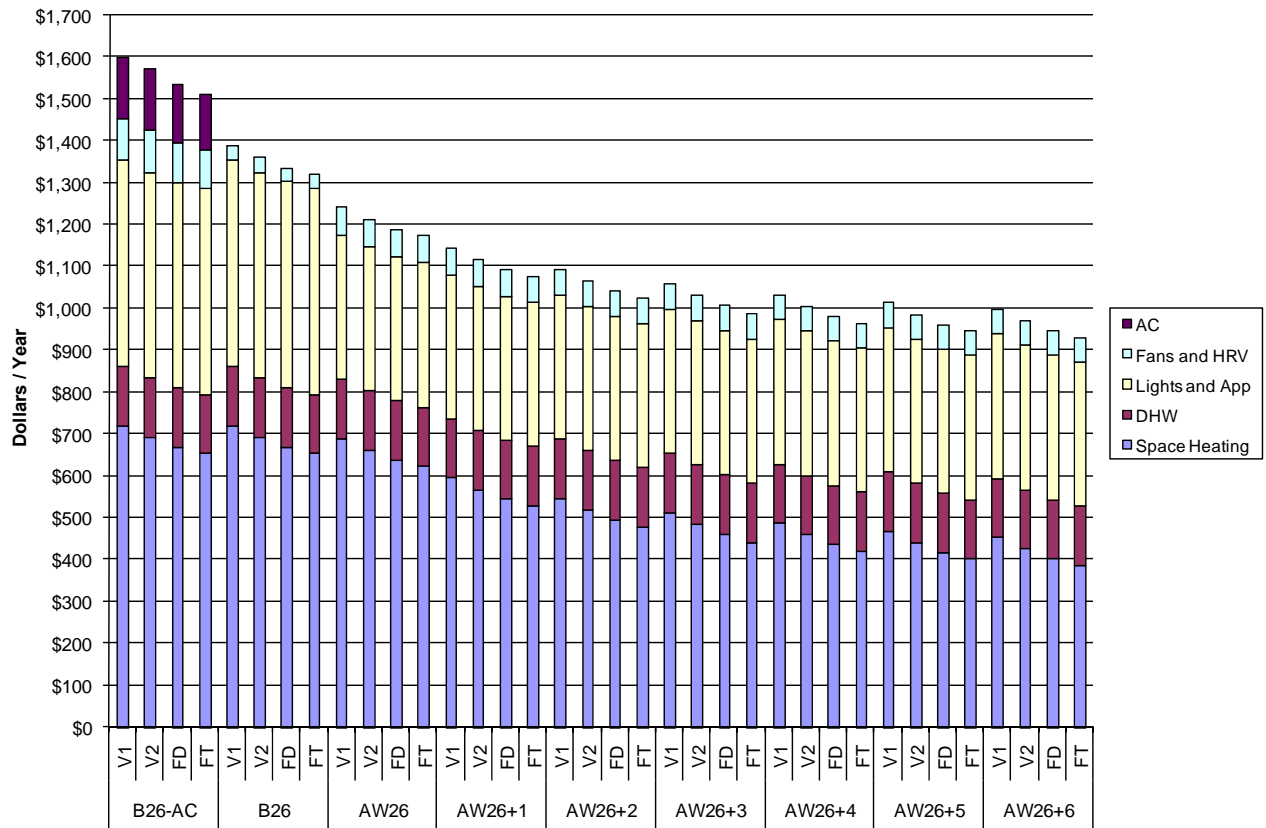


Figure 30 - Next Generation House Annual Utility Costs

These values were then extrapolated using net present value (NPV) calculations including both a 6% energy escalation rate and a 6% discount rate which were deemed to be conservative estimates (Straube, 2007). The NPV determines the value of an investment in upgrades that could be made today so that the energy savings attained from those alterations

would return that value over the 25 year life of the mortgage. This is based on the upgraded model utilizing less energy than the baseline comparison model.

Figure 31 shows the NPV of future energy bills less the upgrade costs for each model. Subtracting the upgrade costs allows us to focus on the vertical zero division to determine which assemblies do not change our summation of mortgage and utility costs. From the graphed NPV for varying models we can pinpoint which assemblies make economic sense, which assemblies do not, and which will soon make sense if energy costs grow at a rate greater than expected.

NPV less Upgrade Costs
(6% Fuel Escalation and 6% Discount Rate)

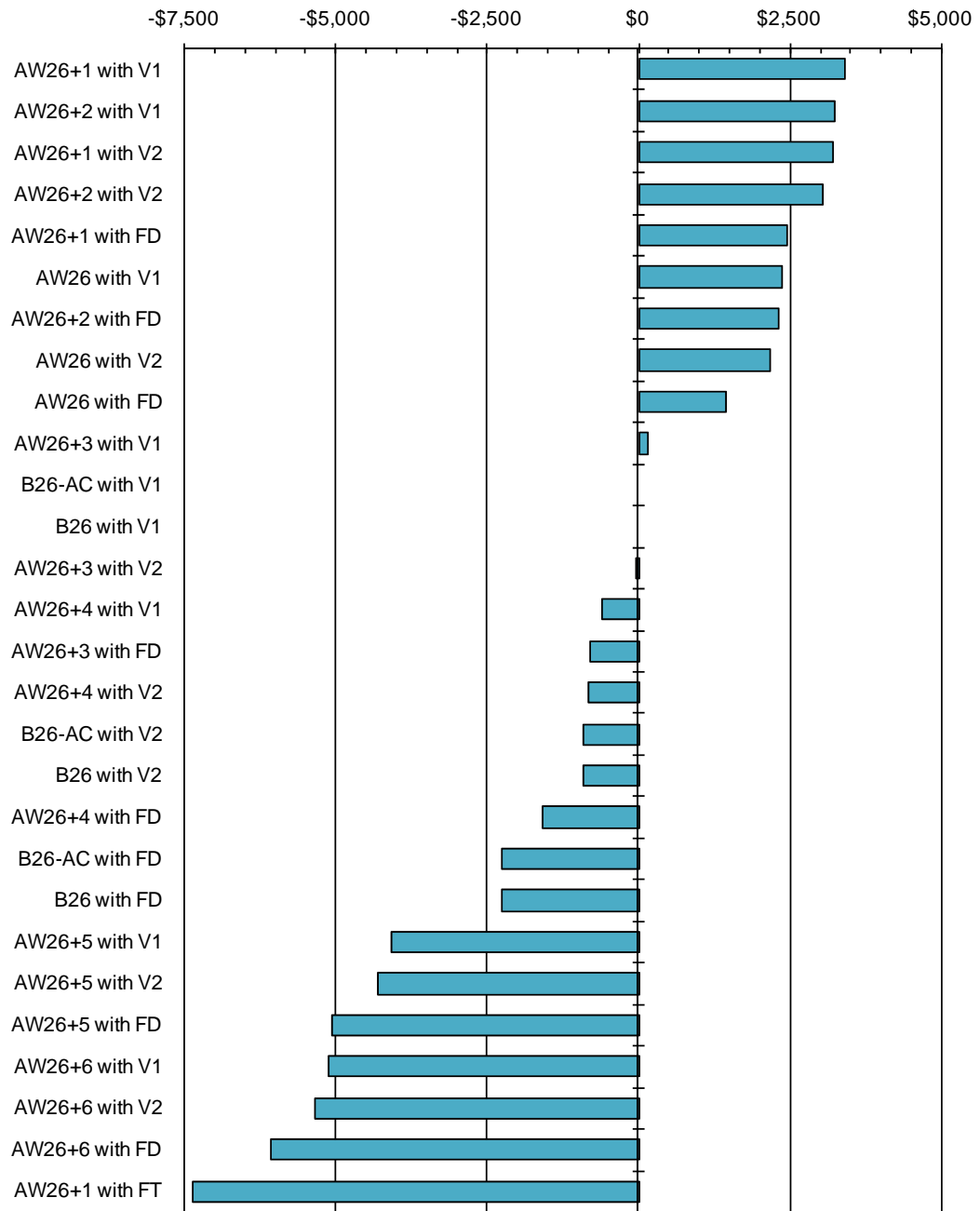


Figure 31 - Next Generation House Net Present Value

The top of the graph shows upgrades which would save money in the long run and make economic sense to implement. The extreme bottom of the graph shows upgrades that do not make economic sense at this point in time with the assumed rates of fuel cost increase. The

area in the centre where the values are small and negative are the upgrades that may cost slightly more but still make economic sense and may have other benefits which cannot be modeled by HOT2000 such as CO₂ or greenhouse gases (GHG) savings as well as added comfort. If fuel costs were to escalate more than the 6% utilized in this analysis, the \$0 NPV vertical axis will shift to the left and the central (no cost change for upgrade) area will shift down. This shows that if the fuel cost escalates greater than estimated, items such as AW26+5 and AW26+6 (5" to 6" of exterior insulation) along with fiberglass framed windows having double or even triple glazed panes will make economic sense. With a wide range of options in the Toronto area and new manufacturers eager to provide energy efficient products, it would be financially viable to implement the AW26+4 with AFD. A house with this construction and occupant loads would use over 30% less energy than a standard Toronto home.

Assuming each new home in Canada is constructed with the standard method and each home consumes approximately 33,000kWhr annually (Trudeau, 2005), every year that changes to the residential construction industry are delayed 10,000kWhr per new house of economic energy savings are missed. This extrapolates for all of Canada to 7 billion kWhr per year more energy in new homes alone which are themselves only 6.25% (Trudeau, 2005) of the housing stock in Canada. An easy-to-attain 10% energy reduction would result in saving 2 billion kWhr per year from new home construction alone.

In addition to the wasted energy, it is also important to quantify the amount of greenhouse gas (GHG) the residential sector is adding to the environment. A simple-to-implement reduction in energy consumption could greatly reduce environmental impacts. The graph presented in Figure 32 has the GHG output for each model added, this will aid in deciding which advancements should be considered financially and environmentally.

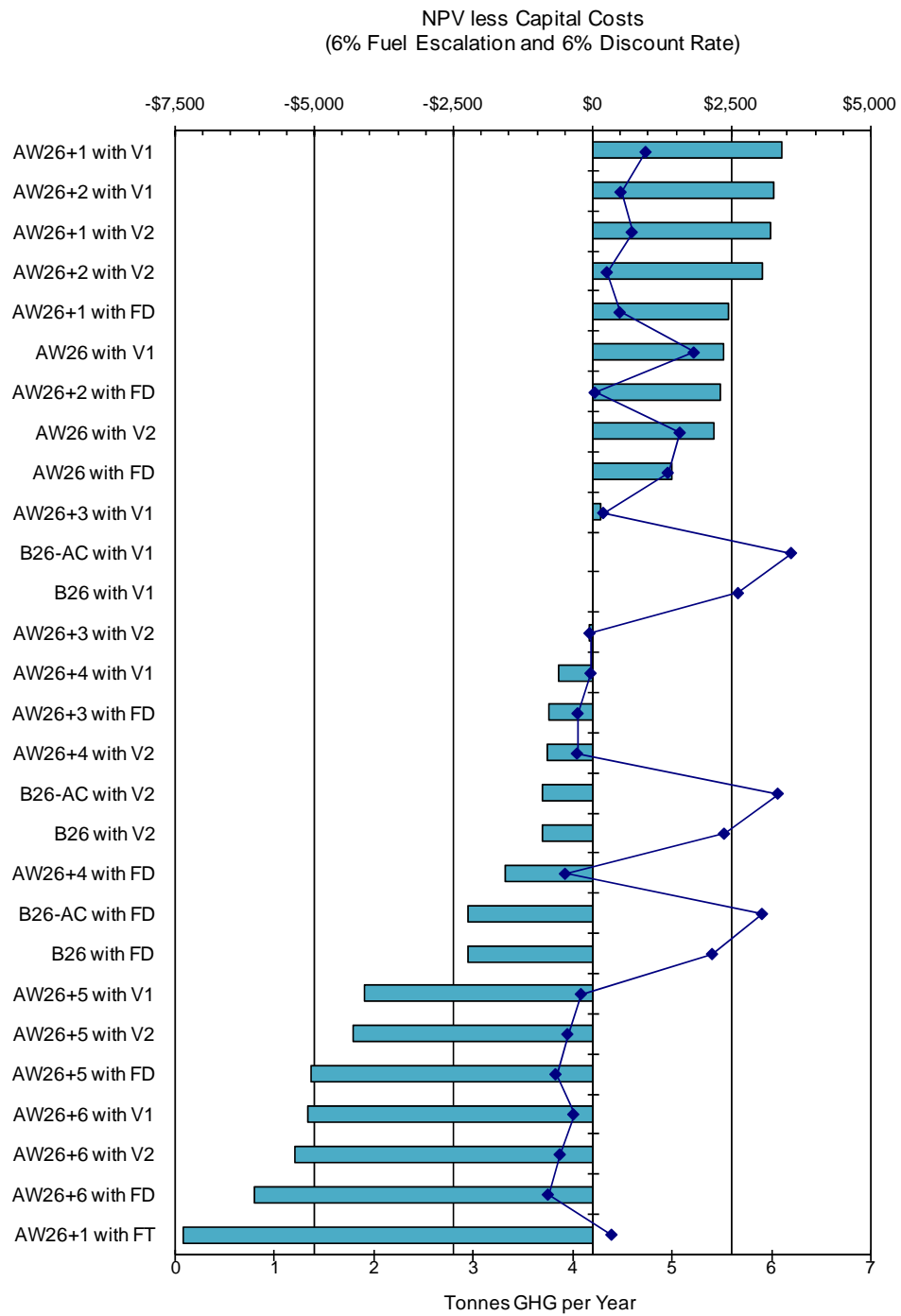


Figure 32 - Next Generation House Net Present Value with Greenhouse Gas Production

The emissions were calculated at 0.053 tonnes of GHG (Greenhouse gas) per GJ of natural gas energy and 0.064 tonnes of GHG per GJ of electrical energy in Ontario (Trudeau, 2005). The electric GHG emission rate changes as the generating mix changes. As the Ontario grid becomes less carbon neutral (assuming more wind, solar and hydro power and less coal in the future), the GHG intensity should drop.

Even though a standard Ontario home with air conditioning (B26-AC with AV2) has an NPV that is close to break-even, at over 6 tonnes of annual GHG output, it could hardly be described as environmentally-friendly with regard to greenhouse gas output. For less NPV cost a home could be built with 30% less GHG output (e.g. AW26+3 with AFD) but these options are rarely considered because they are deemed to be too expensive or too far from the construction normal.

The construction methods described in this section would be similar to the specifications required to build a LEED gold or platinum home. The additional cost to attain varying levels of LEED certification was investigated by the US Department of Energy and was shown on average to cost slightly less than 2% more than their code built equivalents and LEED buildings on average use 25-30% less energy (Kats, 2003). The majority of the cost increases are due to added architecture and engineering time and these values were also shown to decrease over time and with experience. One LEED Silver project in Portland reported a 0% cost premium, and LEED Silver projects in Seattle have seen a premium decline from 3-4% to 1-2% over the past few years (Kats, 2003). The case study in Chapter 1.0 attained a modeled energy savings of 35%, greenhouse gas savings of 36% with an increased cost of 6%. The increased cost of the home was slightly higher than the average found by Kats because this was the first house built and was breaking new ground in terms of methods and materials used by the trades. The increased cost determined by Kats was for LEED as a whole and not solely LEED for Homes. The project management for Monarch Corporation anticipates that the increased cost can be reduced significantly when implemented on the larger development of 200 homes.

5.4 Conclusions

There is significant room for improvement in the insulation and airtightness requirements of the Ontario Building Code (Part 9). The new Ontario Building Code (in effect in 2007) has been changed to require production builders to alter some practices, but the analysis shows more changes are justified. For example, above-grade wall insulation was raised from R17 to R19 whereas the parametric study found R34 would be financially feasible. The fenestration requirements in the new building code require windows to attain at least R2.8 which is 67% greater than the R1.7 minimum in the 1986 and 1997 codes. This investigation shows that a further 25% increase to R3.5 will soon be financially sensible.

The analysis presented in this chapter shows that homes built to the 2006 Ontario Building Code could be designed to consume 30% less energy without an increase in the homeowner's combined monthly mortgage and utility bill. A major obstacle to wide-spread deployment is that the building code does not demand levels of thermal insulation or enforce air tightness levels that are shown in this analysis to be financial favourable for the consumer or society. However, the production home building industry is currently motivated purely by the sale price, and consumers are not sufficiently informed to ask for total monthly costs. Hence, some argue that without the building code changes the industry will not build to higher levels of performance. Building green doesn't have to be expensive or out of reach for production home builders and hence every single person that buys a home could be saving energy, money and the environment.

6.0 Conclusions

The interest in, and demand for greener, less energy consumptive homes is increasing. While oil prices are rise, climate changes, landfills becoming overburdened and water restrictions more frequent, the public is pushing harder than ever for change. The residential housing sector has seen demand for energy efficient homes incorporating green features, high efficiency appliances and mechanical systems. The increased environmental concern has put 'Green' in demand. Whether it is rooted in the consumer's need to reduce pollution from energy production, trim down their energy bills or to minimize their effects on landfills, homeowners and society are demanding higher performance. Programs such as ENERGY STAR and LEED for Homes are attempting to move the building industry towards low-energy use, low environmental impact homes by providing consumers information and confidence.

This thesis has reviewed some of the housing technology available, the historical development, and current rating programs for low energy and green homes such as LEED and ENERGY STAR from the perspective of the Ontario Canada new home market.

The literature review showed that homes that use 75% less heating energy than a standard house could be built in the 1980s for a mere 5% construction cost premium. With quality design and specification and diligent care taken to ensure details are properly finished these types of homes can be built almost anywhere. Some of the technology and strategies that were so successful in the 80's have found their way into Canadian houses. The result is that standard new homes consume less energy than in the past.

The Ontario building code is currently one of the most stringent provincial codes in Canada in terms of required thermal insulation and energy performance. The most recent revision in 2006 has increased its demands significantly for windows and shown steady improvement in terms of all other categories. Although the code has shown gradual improvements there are both environmental and economical justifications for requiring homes to consume less energy. Significantly more can be done to economically reduce house energy consumption. The increase in energy costs and the reduction in cost of highly efficient mechanical heating,

cooling and ventilation systems and exterior insulation and airtightness strategies means that low-energy houses can actually be built economically.

Several rating programs were reviewed, starting with the Ontario Building Code as the baseline. The R2000 program is the oldest program, having been developed in the early 80's. Although the R2000 program was originally developed nearly 30 years ago it has managed to maintain a standard of performance that has always exceeded the OBC. It has a wider range of requirements than either the building code or ENERGY STAR, but falls short of the LEED for homes program in terms of breadth of environmental concerns. The main shortfall of the R2000 program was its lack of ability to gain traction in the home building industry. Early adopters found the program difficult and because the public was not yet pushing for green building, builders did not pursue the program.

ENERGY STAR was developed as a program to protect the environment and to save money by saving energy. The program has been able to gain an enormous amount of traction in the building industry and globally for energy efficiency. In terms of energy performance the ENERGY STAR rating system compared to the current OBC does not have many significant changes. Because the OBC has recently been updated the Canadian ENERGY STAR system only appears to excel in a few categories. The main difference is the inclusion of the house air leakage testing, which at 2.5 ACH50, is achievable by many home builders.

Although the LEED program is very in-depth in terms of credits available for environmental concerns and energy consumption there is room for improvement. Achieving the Certified level can be done relatively easily with little concern for energy conservation or the environment because the prerequisites and minimums are not overly demanding. Proper selection of suitable points in an effort to attain an energy efficient, environmentally sustainable, durable home with better indoor air quality can meet the requirements of the Certified level. The rating system appears to require a significant amount of documentation, but the step forward to LEED certifications is not that large. For an environmentally responsible homebuilder already complying with OBC 2006 and ENERGY STAR with a high level of quality control, the actual building practices and methods do not vary significantly from standard.

A parametric analysis of a representative urban house found that there is significant room for improvement in the minimum Ontario Building Code requirements especially with regard to the insulation and air tightness specifications. The new Ontario Building Code (in effect in 2007) has been changed to require production builders to alter some practices, but the analysis shows more changes are justified. Above grade insulation in Ontario construction was raised from R17 to R19 in walls whereas this investigation found R34 would be financially feasible. The fenestration requirements in OBC 2006 require windows to attain at least R2.8 which is 67% greater than the R1.7 in the 1986 and 1997 OBC. This investigation shows that a further 25% increase to R3.5 will soon be financially sensible.

Dr. Feist, the co-developer of the successful ultra-low energy German Passivhaus standard has been quoted as saying “Don’t be afraid of insulation.”(EDU, 2008). When a very well insulated enclosure is coupled with the best windows available a small home can use less energy than the passive house standards even when built in Illinois. Amory Lovins suggests that an integrated whole-building design approach must be taken to ensure the very best building is developed from the ground up. Exterior insulation has proven to be the most cost-effective means of increasing thermal performance and decreasing thermal bridging (CMHC, 1999).

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Appendices

Appendix A

Homeowners Manual

LEED Certificate

Contractor Meeting Example

Durability Plan

Durability Checklist

HERS Rating

Waste Management Plan

introduction: your Monarch home



Congratulations!

Your high performance home is built to stringent LEED for Homes criteria. It has been designed and constructed to deliver superior:

- ❖ energy-efficiency
- ❖ comfort
- ❖ indoor air quality
- ❖ environment responsibility, and
- ❖ durability

This has been achieved by treating your home as an integrated system with building materials, equipment and their installation tuned for performance and value.

But every home requires operation and maintenance. Just how well you operate and maintain your new home can determine just how superior its performance will be. A little maintenance on a regular basis may prevent some big problems or headaches in the future.

But fear not, this is a short manual.

With attention to some key components, key systems, and periodic inspections, you will be spending most of your time at home without this manual, but be glad that Monarch put just the right amount and type of information in your hands.



Monarch

moving into your green home

GETTING STARTED IN YOUR NEW HOME

The following are suggestions for helping you settle into your new home:

- Establish new utility service to your home in your name (gas, electric, water, television, telephone).
- Check the temperature setting on your thermostat - it may have been set quite a bit outside your comfort zone while the house was not occupied. Then, be patient; if the setting you have chosen is significantly different, it could take from a couple of hours to a couple of days to reach constant temperature and humidity, depending on just how extreme the weather is outside when you move in.
- Notify the post office, insurance companies and doctor's offices, credit card companies, magazine subscriptions and newspapers, professional organizations of your new address.
- Remember to change the address on your driver's license and passport or apply for a new one if you are moving from another province.
- Update your voter registration especially if you are moving to another electoral district.
- Do not use the job site dumpsters for your move-in trash; recycle your moving boxes by offering them to someone else who's moving.

Helpful Hints:

- Fill-out and mail the appliance warranty information cards.
- Locate the water main and gas main shut-off valves.
- Place fire extinguishers on each floor of your home, in your kitchen, and in your garage.
- Locate the electrical service panel and main shut-off.
- Put emergency telephone numbers in an easy to reach place near the telephone or on speed dial.
- Put together a first aid kit.
- Start a basic tool kit including a hammer, pliers, screw drivers, utility knife, scissors, tape measure, duct tape, flashlight, batteries and a pencil.
- Vacuum out behind the filter grille wall assembly to remove any construction dirt or debris so it isn't blown through the house when the system is turned on.
- Store touch-up paint and other flammable items in a safe location away from the water heater, air handler, fireplace or any other combustion sources.
- Smoke detectors are located in every bedroom and common areas.

Important Note:

We recommend you have an emergency evacuation plan in place that everyone in your household understands and can remember. Determine which is the best way to safely escape from different parts of the house when there is a fire, threat of fire, or gas leak. Have a safe, prearranged place to meet outside the house to be sure everyone who was in the house got out safely. Also, be available to answer any questions the fire or police department or gas company may need to have answered when they arrive. Notify your babysitter and/or house-sitter of the plan as well.



Monarch

about your green home

WHY IS MONARCH BUILDING “GREEN”?

For Monarch, the choice to build green was a natural one. Homes built to green specifications have a reduced impact on our environment. As Canada’s oldest homebuilder, Monarch knows about the value that homeowners place on their home, their community and their environment. By building green, we can help ensure a sustainable future.

Monarch’s green home building program addresses:

- ❖ Community location
- ❖ Site and landscaping
- ❖ Energy and water use
- ❖ Long-term durability
- ❖ Indoor environmental quality
- ❖ Characteristics of materials and finishes
- ❖ Homeowner awareness and lifestyle
- ❖ Construction process

YOUR CERTIFIED GREEN HOME

Your new Monarch home has been certified as a green home by a third-party organization.



LEED[™]
FOR HOMES

LEED for Homes (Leadership in Energy and Environmental Design) is a voluntary, consensus-based rating system that promotes the design and construction of high-performance green homes.

A green home uses less energy, water and natural resources; creates less waste; and is healthier and more comfortable for the occupants. Benefits of a LEED home include lower energy and water bills; reduced greenhouse gas emissions; and less exposure to mold, mildew and other indoor toxins.

More information about the LEED for Homes system and the benefits of owning a green home can be found on the US Green Building Council’s website at www.usgbc.org



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FEATURES OF YOUR GREEN HOME

Building on Quality...

1. Third-party certified LEED for Homes rating
2. Third-party certified ENERGY STAR for Homes qualification
3. Thermal insulation exceeds building code requirement
4. High performance exterior insulating sheathing
5. ENERGY STAR qualified high-performance windows
6. Advanced basement insulation system
7. Third-party inspection of insulation installation
8. Advanced wood framing techniques
9. Increased whole-house airtightness
10. Expanding foam air seal around windows and doors
11. Caulking or expanding foam air seal around exterior vents, electrical boxes and piping
12. Third-party testing of whole house airtightness

Location, Location, Location...

13. Evergreen is built into an existing community
14. Stores, restaurants and services within walking distance
15. Great access to public transportation
16. Reduced automobile use for community

Affordability, Comfort and Health...

17. Monthly energy savings estimated with whole house energy modeling program
18. Increased level of thermal insulation reduces heating and cooling operating costs
19. Timers on bathroom fans
20. High-efficiency, sealed combustion furnace
21. High-efficiency, sealed combustion tankless hot water heater
22. Programmable thermostat
23. Air conditioner-ready forced air system
24. Improved efficiency ductwork system
25. Mechanical systems commissioned after installation to ensure proper operation
26. Third-party confirmation of mechanical system commissioning
27. ENERGY STAR qualified washer and dryer
28. Energy-saving backyard clotheslines
29. ENERGY STAR qualified kitchen appliances
30. Energy efficient compact fluorescent lighting
31. Exterior lights equipped with motion sensors
32. Rough in for future solar renewable energy system
33. Durability planning to extend building life and reduce maintenance costs
34. Third-party verification of durability plan measures during construction
35. Foundation wall designed to keep basement dry
36. Landscape designed to move rainwater away from the home
37. Low-maintenance exterior siding material
38. Selection of low off-gasing interior finishes
39. Fiberglass batt wall insulation is formaldehyde free and has 25% recycled content.





40. Non-toxic pest controls on exterior openings
41. Green Seal certified paints
42. Tightly air-sealed surfaces between the garage and living space to minimize exposure to pollutants and combustion gases
43. Sealed combustion appliances to keep combustion gases safely out of the indoor environment
44. Dedicated outdoor air intake for ventilation system
45. Improved filtration of ventilation air
46. Ventilation system with energy efficient heat loss recovery
47. Ventilation system protected from dust and debris during construction
48. Carbon monoxide detectors placed on each floor
49. ENERGY STAR qualified bathroom fans
50. Passive radon mitigation system - installation of sub-slab to roof vent with rough-in for future fan
51. Ability to create an active radon mitigation system without major construction

Air, Land and Water...

52. Energy saving features contribute to reduced greenhouse gas emissions
53. Energy saving features contribute to reduced air pollution from power sources
54. House is planned to minimize construction waste through efficient use of materials
55. Wood waste recycled instead of sent to landfill
56. Construction waste sent to landfill reduced by more than 50% through reuse and recycling
57. Soil erosion controls in place during construction
58. Reduced use of energy-intensive cement in house foundation and basement floor
59. Engineered wood floor joists
60. Gypsum board with high recycled content
61. Cellulose attic insulation with high recycled content
62. Carpet with 100% recycled content
63. Locally-sourced interior wood trim
64. Ultra low water use dual-flush toilets
65. Ultra low water use faucets and showerheads
66. Permeable paving used to reduce storm water run-off
67. Limited use of water-intensive grass in landscape design
68. No invasive plants allowed in landscape design
69. Native planting used to reduce water use

Homeowner Experience...

70. Homeowner's manual provided to explain house operation and green features
71. Complete walk-through of home given to new green homeowners
72. Public tours given to increase awareness of green building practices
73. Sustainable living information package and resources provided to homeowner
74. Electricity use monitor to help homeowners understand and reduce energy use



ENERGY FOR YOUR GREEN HOME

Energy consumption is a major part of our environmental impact. Monarch has designed your home to be more energy efficient than a typical house but for the energy that you do use, you should know that environmentally preferable energy alternatives are available.

1. Purchase Green Power

There are now many “green” power companies in Ontario. These companies supply energy to the provincial power grid from renewable energy sources such as solar power, wind power, or low-impact hydro installations. You can buy green power for your home and support the development of renewable energy technology.

2. Buy Renewable Energy Certificates

Renewable Energy Certificates (or RECs) represent the environmental impact reduction of energy produced from renewable sources. These “benefits” are sold separately from the actual electricity so that consumers in areas without access to on-grid renewable energy can support the development of this technology.

3. Invest in On-site Generation

You can purchase renewable energy systems for your house and generate energy yourself! The most common systems include photovoltaic panels, which generate electricity from the sun, and solar thermal panels, which use the sun’s energy to heat water for your home. Both systems can be expensive but as energy costs increase, you may find them to be a worthwhile investment.



Green Power Companies in Canada

Company	Energy Source	More Information
Bullfrog Power	Wind, Low-impact hydro	www.bullfrogpower.com
Oakville Hydro Energy Services	Small Hydro, Wind, Biogas and Solar RECs	www.oakvillehydro.com
TransAlta Wind	Wind RECs	www.visionquestwind.com

operating & maintaining your green home



INSIDE OPERATION

The home you have purchased is different than any other home in Toronto. These homes and their site have been designed over the last two years by architects, engineers and building scientists as a team to be healthy, durable, comfortable, affordable, and have a greatly reduced effect on the environment. Here is an explanation of how the house was designed to operate and how you can get the most out of your home.

Space Heating and Cooling Equipment

All of the rooms in your home have a different shape, size, number of windows and likely face in different directions. Each room will have different heating and cooling needs. The heating and cooling system has been designed to maintain a minimal variation in temperature throughout the home. The relationship of window area to floor area is of particular importance. Rooms with large or numerous windows that face the sun will gain heat and may require shading. This added heat may be welcomed in the winter but may add significantly to utility bills during the summer months.

The space heating and cooling equipment as well as venting have been designed specifically for your home size and floor plan. The aim with this equipment is to maximize energy efficiency. The thermostat in your home is programmable, allowing you to set day and night temperatures according to the season. This thermostat also carefully controls the household ventilation when the system is set to automatic. "Set-back" programming allow the home's heating set point to drop during hours when the home is not in use such as overnight or when it is vacant. Likewise the system can be set to "step-up" during cooling months when the home is vacant. Your high performance heating system can easily recover from a set back to return the indoor temperature to its set value. Allowing the system to automatically control the temperature, within your pre-set values, as well as ventilation translates into cost savings for you as well as a healthier and more comfortable home. The recommended heating range is from 20°C to 22°C. Forcing your system to operate outside of this range may compromise performance and efficiency.

The high efficiency home you have purchased will have heating and ventilation equipment that is properly sized for your home. This means that a smaller home will have smaller equipment and larger homes will have larger equipment. Because we have chosen equipment for each home instead of placing the same unit in each house across the development each piece of equipment can run at its optimal efficiency. When your system is right-sized it may run longer than a larger system but it runs on less energy and operates more efficiently creating an energy savings for the homeowner. The short-cycling associated with larger, over-sized equipment decreases its lifespan and efficiency.



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Although your heating and ventilation system and ducting have been designed for your home, some adjusting of the air flows may be required. This adjustment is called air balancing. Due to the orientation of your home, rooms use, and personal comfort demands the variations in temperature may not be set to your needs. During the heating season the vents on the upper floor may need to be closed slightly due to the fact that hot air rises and heats these spaces naturally. While during the cooling season you may need to open these vents and slightly close the ones on the main floor to ensure the cool air reaches the upper floor. Overall the home may need slight room-to-room vent setting changes to achieve the desired temperatures. Rooms that have computers, extra lighting or windows that absorb a large quantity of solar heat will not require as much heating as rooms that are shaded and do not contain any heat-creating electronic devices.

Mechanical Ventilation Equipment

Your new home has a built-in Heat Recovery Ventilator (HRV). The purpose of an HRV is to bring fresh outdoor air into the home while exhausting indoor air and exchanging the heat from the outgoing air to the incoming air. In this way the incoming air gets pre-heated and your furnace requires less energy to heat the incoming air to acceptable indoor levels.

In addition to the HRV, your home also has exhaust fans located in all bathrooms, the kitchen, laundry room, and the garage. These fans are vented directly to the outdoors and are designed to remove air contaminants and excessive moisture from these locations. The use of these fans during and after use of the area ensures that build-up of moisture and contaminants does not occur.

Radon Protection System

Radon is a colourless, odorless, radioactive soil gas that can cause lung cancer. It can be drawn from the soil into a building where it can accumulate to high levels. The US Environmental Protection Agency (EPA) and Health Canada have identified radon as a major health concern. Updated building codes will address radon protection measures.

Monarch has installed a passive radon protection system to provide the first stage of protection should a radon problem be discovered in your home in the future. The system consists of a collection system located below your basement floor that is ducted through a sealed system vertically up through the roof of the home. The basement concrete floor has been constructed in an airtight manner to be a barrier to soil gas. This “passive” system will collect and vent soil gas that may otherwise have entered your home.

Should a serious radon problem be discovered in the future, the passive system can be easily converted into an active system by adding a fan to the vertical vent stack in the attic space. In fact, Monarch has wired in an electrical circuit for this purpose.

Lighting and Electrical

The lighting system that is installed in your home uses GU24 compact fluorescent bulbs (CFL). GU24 is a self ballasted CFL with twist lock installation system. The fixtures built into your home do not allow use of any other bulb. The purpose of this system is to move away from using standard, inefficient incandescent bulbs as much as possible. Compact fluorescent bulbs use 70% less energy and last 10 times longer than incandescent bulbs. CFL's are available in many colour temperatures to suit the lighting needs of each space in your home.

Although CFLs are installed, energy conscientious use of the lighting and other electronics in your house will also help to reduce your electricity bills, only have electrical items turned "on" when they are needed. The following table shows the typical wattages of household items.

Appliance	Watts Consumed
Coffee Maker	900 - 1200
Clothes Washer	350 - 500
Clothes Dryer	1800 - 5000
Dishwasher <i>(drying features increases energy consumption)</i>	1200 - 2400
Ceiling Fan	65 -175
Hair Dryer	1200 - 1875
Clothes Iron	1000 - 1800
Microwave Oven	750 - 1100
PC CPU Running	120
PC Monitor Running	150
Radio (Stereo)	400
Refrigerator (Non Energy Star)	725
Refrigerator (Energy Star)	475
29" CRT Television	150
LCD Television (Avg)	266
Plasma Television (Avg)	550
Toaster	800 - 1400
Vacuum Cleaner	1000 - 1400

Beware of 'phantom' loads. Phantom loads are electrical loads imposed by appliances and electronics even when they are off. Many electronic devices require electricity just to remain ready to be used. Almost any item with a transformer, clock, timer, or capacitors that have to be charged to start the item, will draw electricity even when they are off. These phantom loads can add to your energy bill significantly if the devices are left plugged-in at all times to a 'live' receptacle. It is recommended that you put all electronics such as televisions and stereos on switched power bars that can be turned off when not in use. Be sure to unplug chargers for things such as cell phones and laptops when not in use.



Appliances

All of the large appliances installed in your new home meet or exceed the Canadian ENERGY STAR standards. To ensure you get the most out of your high-efficiency, low-energy consuming appliances there are a few operational points to keep in mind. When considering these tips, follow manufacturer's recommendations if they differ from the following.

Laundry Washer

- ❖ Only use hot water when necessary, there are new detergents specifically for use with cold water
- ❖ Run fewer larger loads rather than many small loads
- ❖ Keep the area around the washer clean and clear of all flammable materials
- ❖ Use the appropriate cycle for each load
- ❖ When not in use, turn off the water with the single throw valve located behind the washer

Laundry Dryer

- ❖ Ensure the lint trap is clear before drying each load
- ❖ Run fewer, larger loads rather than many small loads
- ❖ Keep the area around the dryer clean and clear of all flammable materials
- ❖ Use the appropriate cycle for each load
- ❖ On sunny days, consider hanging your clothes to dry

Refrigerator

- ❖ Operate fridge at 3°C to 4°C, operating lower is unnecessary and can waste energy
- ❖ Operate freezer at -16°C to -18°C, operating lower is unnecessary and can waste energy
- ❖ When adjusting fridge or freezer temperatures, allow 24 hours between adjustments
- ❖ Ensure there is adequate airflow behind the fridge to allow the coils on the back to cool the appliance

Stove

- ❖ Only run the appliance when necessary
- ❖ Do not use the stove to add heat to the living space
- ❖ Do not leave gas burners running when not in use

Dishwasher

- ❖ Ensure the cleanout is empty before each load
- ❖ Only run the appliance when the racks are full
- ❖ Always select the appropriate cycle for the load being run
- ❖ "Speed" cycle with "No-Heat" dry is recommended for everyday use
- ❖ For best washing result, fill dishwasher in an organized manner



INSIDE MAINTENANCE

Some of the maintenance your new home needs will require professional aid. Your furnace and water heater should be checked annually by a service professional. They will clean, adjust, lubricate, test and troubleshoot your equipment. This maintenance will ensure that your system is operating at its most efficient and will be saving you the most money. The contacts provided in the important telephone numbers listing will be able to provide these annual services.

Your new home has a highly rated air filter – a MERV 16 filter has been installed rather than a conventional MERV 8 filter (MERV stands for Minimum Efficiency Reporting Value and is the standard for rating air filters). Change this filter as recommended by the manufacturer.

In the event you smell natural gas in the home, have everyone leave immediately and meet at a pre-determined location. Call 911 and they will have the appropriate party come to the house and do what is necessary to make sure it is safe for your to return home. Do not re-enter the home until a professional has verified its safety.

The following is a list of items that should be maintained annually:

- Replace batteries on smoke detectors
- Test smoke detector
- Replace battery on thermostat
- Water shut-off valves - Work the valve to at least partial close to exercise its function and check for leaks
- Sinks
- Toilets
- Washing machine
- Outdoor taps (It is good practice to turn these off during the winter and vacations)
- Natural gas shut-off valves - Work the valve to at least partial close to exercise its function. Completely closing the valve may require you to re-ignite the appliance(s).
- Gas stove
- Furnace
- Water Heater
- Ensure you know the location and verify the function of the main gas and water shut-offs for the home annually
- Check your attic insulation
- It's good practice to periodically inspect attic insulation to make sure that it is still properly placed and to inspect its top surface for any evidence of water or insect/small animal activity.
- Inspect the attic hatch weatherstrip seal
- Ensure the seal is in good condition and continuous. Repair as necessary. Warm moist air exiting through a damaged seal can cause condensation damage within the attic.



Cleaning Materials, Methods and Supplies

The routine cleaning of your home will help ensure the space is healthier for your family and unnecessary dust and dirt do not enter your homes ventilation system. Most commercial cleaning products use harsh chemicals with often-volatile smelling compounds. These chemicals in most cases are not necessary. There is a wide variety of natural compounds that have enough power to clean without the added side effects of the harsh commercial chemicals.



Examples of Environmentally Responsible Cleaning Products

Item	Product	Contact	Availability
Sunshine Makers	Simple Green	www.simplegreen.com	Retail Stores
Shaklee	Most Products	www.shaklee.com	Distributors
National Chemical Laboratories	e-Solution Green Cleaning Solution	www.nclonline.com	Distributors
EnvirOx	Our House	www.ourhouseworks.com	Direct
Seventh Generation	Free & Clear	www.seventhgen.com	Retail Stores

Lighting Selection

The compact fluorescent bulbs in your home will last for up to 10,000 hours. At 2 hours per day of use, this is over 13 years! Although the bulbs will generally last for a long time, some may burn out and need replacement. Replacement is simple with the GU24 bulb, a simple ¼ twist, remove and replace. The bulbs are available in a variety of colours and brightness. Most areas will only require standard 13W bulbs (equivalent to 60W incandescent), but there are also brighter bulbs available if desired.

Appliance Selection

When considering these tips, follow manufacturer's recommendations if they differ from the following.

Laundry Washer

- ❖ When not in use, turn off the water with the single throw valve
- ❖ To clean exterior surface use damp cloth
- ❖ Areas around washer door opening should be kept clean to ensure watertight seal
- ❖ Rinse the washer once per year with 1/3 cup of bleach run on any cycle.

Laundry Dryer

- ❖ Clean lint filter before each use
- ❖ To clean exterior surface use damp cloth
- ❖ Inspect and clean exhaust duct annually
- ❖ Replacement of light bulb – See appliance owner's manual



Refrigerator

- ❖ Replacement of light bulb – See appliance owners manual
- ❖ Leave an open box of baking soda in the refrigerator and freezer to help remove odours
- ❖ To clean exterior surface use damp cloth and mild liquid dish detergent
- ❖ Stainless steel can be cleaned with commercially available stainless steel spray cleaners
- ❖ Use a mild baking soda solution (15ml/L) for cleaning interior surfaces
- ❖ Avoid using hot water on glass shelves, the thermal shock may break the shelf
- ❖ Apply a thin layer of petroleum jelly to the door seal at the hinge side to ensure the door seals do not stick or bend.

Stove

- ❖ To clean exterior surface use damp cloth and mild liquid dish detergent
- ❖ Stainless steel can be cleaned with commercially available stainless steel spray cleaners
- ❖ Ensure surfaces have cooled sufficiently before cleaning
- ❖ Do not allow grease to build up on the cooking surfaces, this may cause a fire hazard
- ❖ Replacement of light bulb – See appliance owners manual
- ❖ See the appliance manual for extensive cleaning and maintenance instructions

Dishwasher

- ❖ See the appliance manual for extensive cleaning and maintenance instructions



OUTSIDE MAINTENANCE

Maintaining your home is essential to ensure the home retains its function, efficiency, value and appearance. The following table shows the recommended outdoor maintenance schedule. Place a copy of this schedule in a convenient location to ensure each measure is completed as required.

Item	When to Check	Homeowner Action(s) Required
Exposed Concrete Slabs	Spring	<ul style="list-style-type: none"> • Visually inspect • Inspect for cracking. Seal all cracks to prevent water penetration.
Roof	Spring & Fall	<ul style="list-style-type: none"> • Inspect for missing or deteriorated shingles
Windows	Spring & Fall	<ul style="list-style-type: none"> • Inspect for broken seals in insulated windows • Clean windows, frames and screens
Exterior Doors	Spring	<ul style="list-style-type: none"> • Clean and refinish if necessary • Check weather stripping and seals • Lubricate hinges
Garage Doors	Spring	<ul style="list-style-type: none"> • Clean and refinish if necessary • Check weather stripping and seals • Lubricate hinges
Central Air Conditioner (outdoor condensing unit)	Spring & Fall	<ul style="list-style-type: none"> • Trim all planting to ensure area around unit is clear • Annual professional maintenance and charge check recommended
Eavestrough	Spring & Fall	<ul style="list-style-type: none"> • Clean and remove all debris • Inspect for leaks and cracking • Annual professional maintenance recommended

The following provides an example of each of the actions recommended in the table above.

Exposed Concrete Slabs

- ❖ Visually inspect both the basement and garage slab looking for cracks. If cracking is found, seal small cracks with sealant to prevent water penetration.

Roof

- ❖ It is especially important to inspect the roof after major storms or wind events. Inspect for missing or deteriorated shingles. Inspect the entire roof for any signs of wear. Check for things that look out of place, broken or worn on the overall surface, all flashings around penetrations, drip edges and ridge caps.
- ❖ Attempt to do most of the inspections from a ladder as it is not recommended to walk on your roof.



Windows

- ❖ Clean the windows, frames and screens in both spring and fall. Inspect for broken seals in insulated windows. The weather stripping keeps water, insects and air outside. Inspect the weather stripping looking for missing portions, tears or worn out sections. Repair, adjust or replace as necessary. Lubricate slides and hinges annually.

Exterior Doors

- ❖ Clean the windows and frames in both spring and fall. Refinish the frame and door if required. Inspect for broken seals in insulated windows. The weather stripping keeps water, insects and air outside. Inspect the weather stripping looking for missing portions, tears or worn out sections. Repair, adjust or replace as necessary. Lubricate hinges annually.

Garage Doors

- ❖ Clean the windows and frames in both spring and fall. Refinish the frame and door if required. The weather stripping keeps water, insects and air outside. Inspect the weather stripping looking for missing portions, tears or worn out sections. Repair, adjust or replace as necessary. Lubricate hinges, bearings and rollers annually.
- ❖ If an automatic opener is installed, inspect the chain and drive system to ensure all parts are functioning properly and are tightened appropriately. If installed, verify function of the safety systems.

Eavestrough

- ❖ To function as designed the eavestrough must be kept clear of all debris, leaves and buildup. Clean and remove all debris twice annually, at the end of the fall and before the spring rains. Inspect for leaks and cracking. Complete repairs as necessary.

Power-washing of homes is almost always a bad idea. It is difficult to avoid spraying water against the normal gravitational flow your home is designed for. It can result in moisture and even liquid water being driven into wall assemblies where damage could occur.

Cleaning Materials, Methods and Supplies

A clean home is essential to a healthy home. Dust and dirt should be controlled so that it doesn't enter your home's ventilation system. To keep your home clean, standard chemical based cleaning products are often more than what is required and can release harsh chemicals into the indoor air. There are a wide variety of natural based cleaning products that have enough power to clean without the added side effects of the harsh commercial chemicals.





Examples of Environmentally Responsible Cleaning Products

Item	Product	Contact	Availability
Sunshine Makers	Simple Green	www.simplegreen.com	Retail Stores
Shaklee	Most Products	www.shaklee.com	Distributors
National Chemical Laboratories	e-Solution Green Cleaning Solution	www.nclonline.com	Distributors
EnviroX	Our House	www.ourhouseworks.com	Direct
Seventh Generation	Free & Clear	www.seventhgen.com	Retail Stores

Water Efficient Landscaping and Irrigation

Irrigating landscaping can add a significant load to the fresh water systems of the city. Your landscaping has been designed to require minimal water. All of the plants are native to the area and drought tolerant - meaning they can withstand considerable periods without extensive care or watering. The following is a brief list of care for the landscaping on your property.

Deciduous Trees:

- Prune any dead branches flush with the trunk and seal cut wound with approved wound dressing
- Maintain protective trunk wrap at base of tree to 18" above grade to protect against trimming and rodent damage
- Newly planted trees should be watered thoroughly once per week from May to September for the first year of establishment
- If leaves turn yellow or begin dropping prematurely contact a local tree expert for a consultation

Coniferous Trees:

- Inspect new growth leaders for needle blight and fungal infestations and obtain professional advice on treatment methods if encountered
- Newly planted trees should be watered thoroughly once per week from May to September for the first year of establishment

Pruning:

- Plants respond to pruning at different times of the year based on species
- Prune all plants in accordance with species recommendations. Refer to readily available pruning guides for recommendations.

Impacts of Chemical Pesticides, Insecticides and Fertilizers

Chemical pesticides, insecticides and fertilizers are often man-made chemicals that are poisonous to living things both inside and outside the house - that's actually why the pesticides and insecticides are effective against pests! However, there are effective alternatives to chemical controls.



In an effort to decrease or eliminate the amount of chemicals we introduce to our environments certain non-toxic pest controls have been built into the structure of your new home. The vents transporting ventilation air into or out of the home, supplying or exhausting combustion air from mechanical equipment as well as the bathroom and kitchen exhaust fans have all been constructed with screens to limit the chance of pests entering the ventilation system or mechanical equipment. All of the windows in the home that are operable have screens affixed. All of the normal exterior separations in construction have been caulked or have screens installed to help prevent pests from entering your home.

But you as a homeowner have an important role to play in a holistic approach to pest control - specifically by taking steps to eliminate sources of food, points of access into your home, and sources of water and shelter for common pests. Listed below are a few recommendations and you as a homeowner can do to reduce the chances of having pest problems in and around your home.

- Do not feed pests water or food.
- Take the trash out frequently to a sealed container.
- Rinse items to be recycled before storing them.
- Do not store large quantities of paper or plastic bags which can make perfect nests.
- Keep your home clean.
- Always put food away. Do not leave food out where it can be found.
- Do not over-water plants.
- Do not leave standing water anywhere, especially outdoors where it will be a spawning ground for mosquitoes.
- Avoid leaving spaces cluttered giving pests places to hide.

Rainwater Management

Although your foundation has been well protected from water penetration, it is highly recommended that you maintain the drainage around your foundation.

- Keep the ground sloped so that water will run away from your house.
- Keep the water leaving your spouts slowed enough that erosion does not occur; this can be done with splash blocks, gravel or hearty grasses.
- Ensure pooling or ponding does not occur. After heavy rains examine your lawn as soil settlement is inevitable and some re-grading or patching will be necessary.
- Ensure when irrigation is necessary that it is kept away from the home and is never directed at the home.
- Keep your landscape and your home structure separate. Plantings can interfere with the buildings ability to drain and dry.

If at any time you plan on digging to install fences posts, plant a new tree or installing posts for a new deck on your property, for your safety call the Ontario 1 Call program (www.on1call.com). This service will ensure that there are no electrical, natural gas, water, cable or telephone lines buried below where you are about to dig.



homeowner walkthrough checklist



Homeowners Manual Review

	Reviewed	Located	Discussed
Basement			
Mechanical System	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Instantaneous Water Heater	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
HRV	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sealed Sump	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Drain Cleanout	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Electrical Panel	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Floor Drain	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Main Floor			
Laundry, Floor Drain and Single Throw Valves	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bath fans Energy Star and How to Run them	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Co2 Detector	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Interior Finishes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Programmable Thermostat and Function	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Windows - Better than Energy Star	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Appliances - Energy Star	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Upper Floor			
Bath Fans	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Faucets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Shower Heads	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dual Flush Toilets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Attic			
R40	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exterior			
Landscaping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Finishes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water Drainage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exhausts and Intakes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lighting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Homeowner(s) _____

Monarch Corporation Representative(s) _____



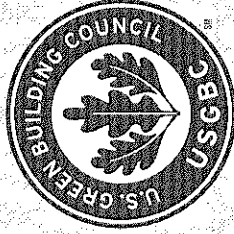
leed for homes documents

1. LEED for Homes Rating Certificate
2. Completed Checklist of LEED for Homes Features
3. Copy of LEED for Homes Accountability Forms
4. Durability Plan and Checklist

Manufacturer's Product & Equipment Manuals

Product	Manufacturer	Model
Hot Water Boiler	Rinnai	
Heat Recovery Ventilator	VanEE	60H
Toilets	Vorten	Vienna RF-DF
Clothes Washer	General Electric	GCVH6260HWW
Dryer	General Electric	PDVH515GFWW
Dish Washer	General Electric	PDW7912NSS
Stove	General Electric	P2B912SEMSS
Refrigerator	General Electric	PDS22SBSRSS
Furnace	Lennox	G61
Windows	Pollard	
Thermostat		





U.S. Green Building Council

Monarch Corporation

Toronto, Ontario, Canada

is recognized as a builder participating in the LEED for Homes Pilot Demonstration, with a commitment to actively promoting the transformation of the mainstream home building industry toward more sustainable practices.

2007



Monarch LEED-H Prototype House

Topper Woods, Kitchener ON

Construction Team Meeting – 2007.08.15

Team members present:

- Benfica – Framing

Background

Monarch is constructing a LEED-H Prototype House at its Topper Woods development in Kitchener ON. We are asking all Monarch sub-contractors, suppliers and other members of the construction team to help us in the construction and certification of this house to the LEED for Homes Pilot Rating System Ver. 1.11a.

What is LEED-H?

The United States Green Building Council (USGBC) developed the LEED (Leadership in Energy and Environmental Design) system to rate how “green” or sustainable a project is. LEED is much broader than EnergyStar and other systems. It offers 129 possible credits in 8 categories:

- Innovation & Design Process (ID)
- Location & Linkages (LL)
- Sustainable Sites (SS)
- Water Efficiency (WE)
- Energy and Atmosphere (EA)
- Materials & Resources (MR)
- Indoor Environmental Quality (IEQ)
- Awareness & Education (AE)

The United States Green Building Council has developed LEED rating systems for 8 different types of building projects. The Canadian Green Building Council (CaGBC) licenses and administers two versions in Canada: LEED-NC (for new commercial and multi-unit projects) and LEED-CI (for commercial interior design).

LEED for homes is a new version of the rating system and is just completing its pilot phase. This means that we will be working with a LEED-H provider from Maine to certify the Monarch LEED-H Prototype House.

Why Build to LEED-H?

Obviously it is in the interest of the planet and everyone on it to minimize the amount of resources we use and eliminate the harmful wastes that we produce. LEED-H helps us decide where to focus our efforts and gives us a system to measure how successful we are at accomplishing these goals.

But, there are also business reasons for pursuing LEED:

- The US housing market has gone into a recession and the only market that is currently growing is “Green Housing”
- A number of municipal governments are at least considering if not requiring that developers build LEED-H as a condition of their project approval

What is our Goal?

Only one LEED-H project has been completed in Ontario to date: the Reid’s Heritage demonstration house in Guelph, which received platinum rating (90+ credits) at an estimated premium to the home buyer of \$150,000!

Our goal is to build a house that receives a LEED-H certified rating (55+ credits) that is desired by our buyers, affordable, profitable and can be produced without the need for government subsidy.

What will Our LEED House look like?

The Monarch LEED-H Prototype house will include many “green” features. Some of these are:

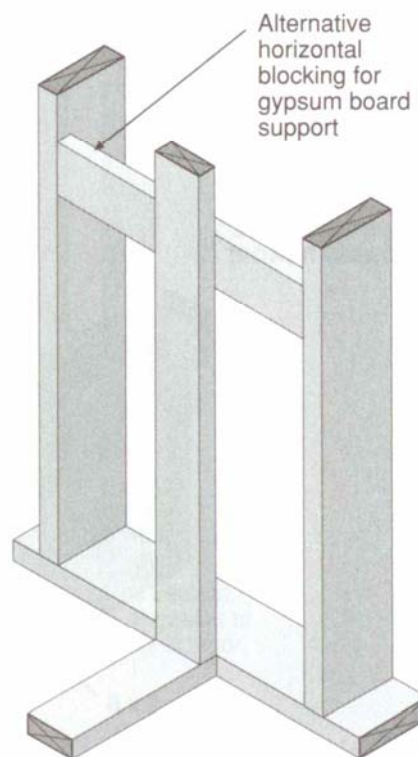
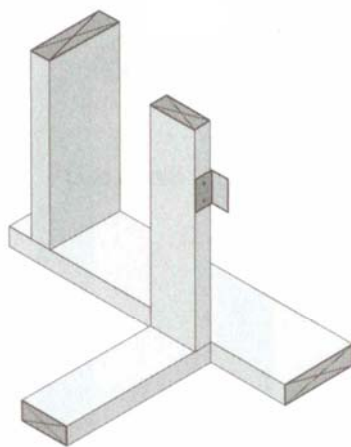
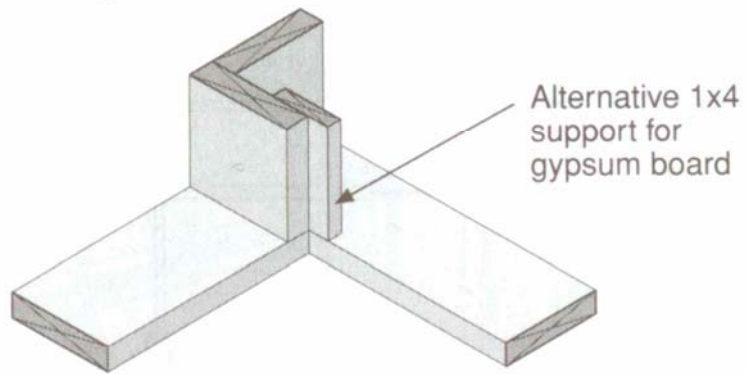
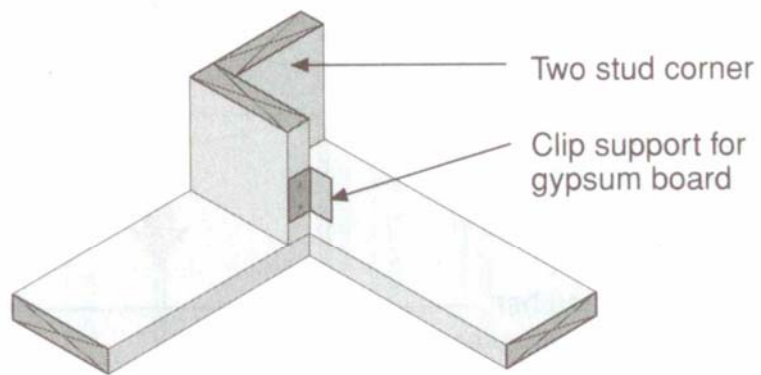
- SUSTAINABLE SITES
 - use non-toxic Insect and pest control alternatives
 - avoid the use of invasive plants
 - use drought-tolerant plants
- WATER EFFICIENCY
 - High-efficiency shower heads (flow rates less than 7.6 L/min)
 - High-efficiency lavatory faucets (flow rates less than 7.6 L/min)
- ENERGY AND ATMOSPHERE
 - tightly seal building enclosure and ductwork
 - increase insulation levels (exceeding code specifications)
 - ENERGY STAR Windows
 - ENERGY STAR Advanced Lighting Package
 - Heat Recovery Ventilation system
 - HVAC substantially exceeding ENERGY STAR specifications (15 SEER A/C & 94% AFUE Furnace)
 - use of R410 chlorine free refrigerants
- MATERIALS AND RESOURCES
 - reduce waste sent to landfill by 40%
 - use of Environmentally Preferable Products (EPPs) – favor products or services that have a lesser or reduced effect on human health and the environment. For example:
 - locally manufactured interior trim, cement and drywall (reduce emissions due to transportation)
 - all exterior walls, framing and roof trusses are constructed of Forest Stewardship Council (FSC) certified lumber
 - Carpet - 100% Recycled

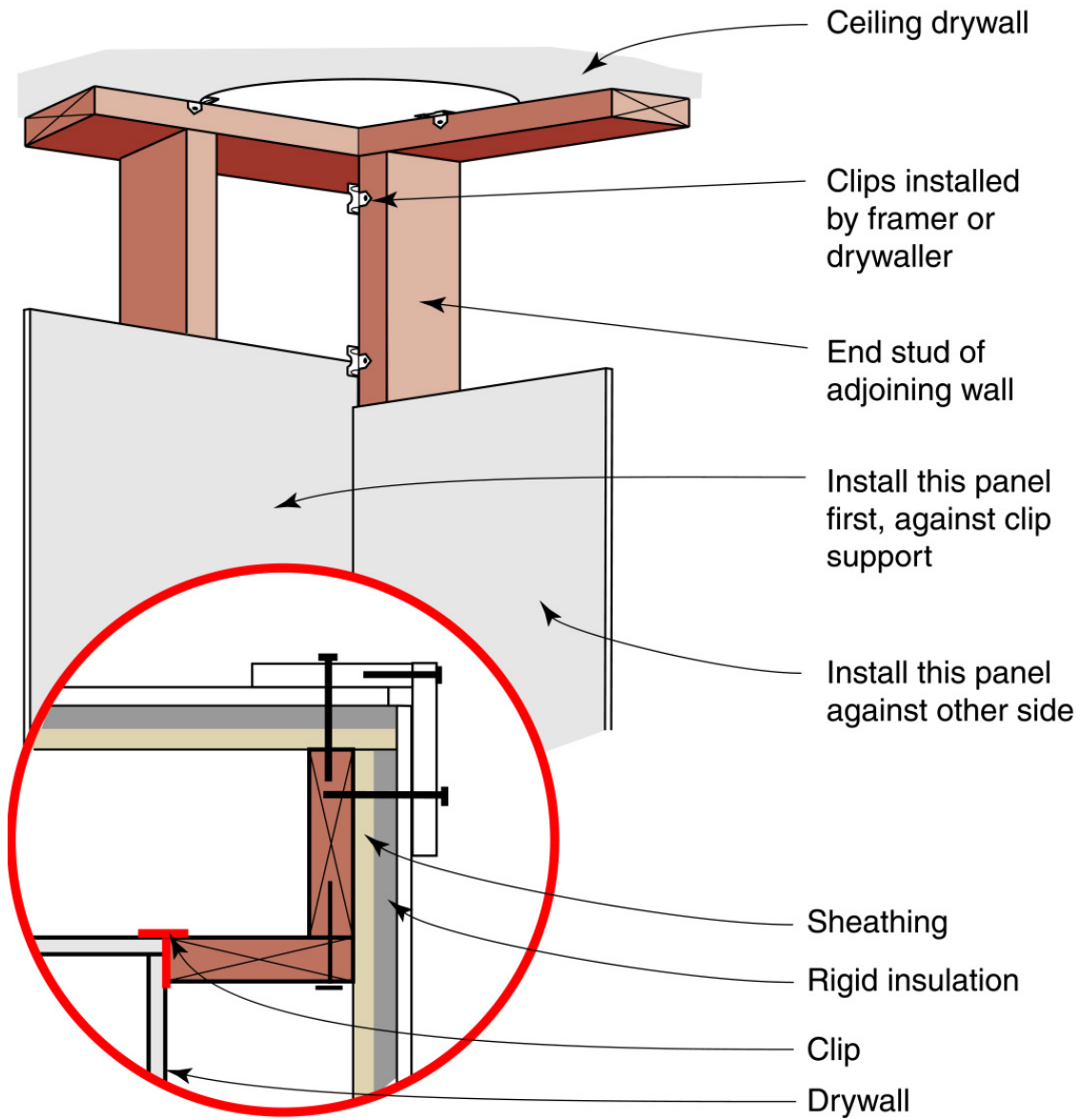
- Underpad – 90% Recycled
- Concrete – 30% Slag (a waste product from steel production) reduces the use of mined aggregates
- Drywall – 96% Recycled
- INDOOR ENVIRONMENTAL QUALITY
 - use Low VOC (volatile organic compound) paints
 - install sealed combustion equipment (prevents backdrafting of combustion gasses)
 - protect duct work during construction (keep dust and contaminants out of the air distribution system)
 - construct sealed walls and floors between the garage and house (keep auto exhaust and garage chemical fumes out of the living space)
 - use MERV 8 or better air filters
 - design plan specific ventilation system to maintain safe moisture levels
 - install automatic controls for exhaust fans to remove concentrated moisture from specific locations (e.g. bathrooms, kitchen)
 - employ Radon Resistant Construction (sealed slab & sump with passive / active soil vent system) to prevent soil gasses from entering the living space

What do We Need to do?

Almost every member of the construction team (sub-contractors, suppliers, etc.) will be asked to substitute materials, use slightly different construction methods or provide additional documentation to help us reach our goal. Attached is an explanation of the specific items that we need you to help us with at this time.

1 Sub/Supplier	Sub/Supplier Name	Benfica
2 Sub/Supplier Scope	<i>What do they do?</i>	Framing
3 LEED Related Work	A LEED Requirement <i>LEED Correlation</i> <i>LEED Title</i>	A Advanced Framing MR 1.2 Material Efficient Framing Efficient framing practices can reduce the amount of redundant lumber, while providing sufficient structural support. Conventional framing techniques use about 15% to 20% more framing than structurally required. A reduction in lumber demand reduces material, but can also reduce labor and shipping costs.
	<i>Why Do This?</i>	
	B LEED Requirement <i>LEED Correlation</i> <i>LEED Title</i>	B Overall Framing Waste Factor <10% MR 1.1 Prerequisite! Material Resources Experience suggests that there the amount of framing material used can vary from site to site by more than 40%. A portion of this wood is used as redundant framing, but much of it comes from wasted framing eg. large cut-offs from boards that were supplied too long, materials that were damaged on-site due to poor storage, wood that was used for temporary bracing, etc. This waste is typically diverted to landfill. Through proper material ordering and use we aim to waste to less than 10% of the lumber delivered to site.
<i>Why Do This?</i>		
3 LEED Related Work	C LEED Requirement <i>LEED Correlation</i> <i>LEED Title</i>	C Waste Reduction/Organization MR 3.2 Waste Management By investigating the sources of waste materials we hope to be able to reduce, reuse or recycle materials and divert them from landfill. Our goal is to reduce the waste from each home going to landfill to less than 2.5 lbs/sqft of finished living space - 40% less waste being sent to landfill than standard practice.
	<i>Why Do This?</i>	
4 Details	A How do we achieve	A Proper placement of Sized Headers as per construction drawings 2 Stud Corners Use of Drywall Clips at corners and intersecting walls See attached information sheet on 2-stud corner and drywall clips as well as Figure 11.3 from Builder's Guide to Cold Climates and The Future of Framing article
	B How do we achieve	B Ensure all waste stays on-site in designated locations Minimize waste when ordering materials, framing layout and cutting
	C How do we achieve	C All waste materials must be kept on-site in the specified locations. Materials to be reused must be documented. A letter from the responsible party must be provided and should identify the material being reused, the quantity (lbs, sqft, etc) what its next use will be, final disposal method (recycling, landfill) as well as the estimated number of re-uses.
5 Verification	A What paperwork/verification needs to be done <i>What do we need photos of?</i>	A Inspection by third party rater. Inspect installed measures and review relevant documents to affirm that the requirements have been met. A. Grin to photograph upon completion and before being covered/hidden/buried
	B What paperwork/verification needs to be done <i>What do we need photos of?</i>	B Inspect installed measures and review relevant documents to affirm that the requirements have been met. Preparation of framing waste summary. A. Grin to photograph upon completion and before being covered/hidden/buried
	C What paperwork/verification needs to be done <i>What do we need photos of?</i>	C All waste materials upon project completion will be weighed. Reuse or Recycling will be attempted for most materials. A. Grin to photograph upon completion and before being covered/hidden/buried





Durability Plan

Project Name: Lot 4027 – LEED Prototype
Project Size: 2800 ft²
Project Type: Residential Single Detached Home

1) Project Description

Lot 4027 is located in the second phase of the Topper Woods development in Kitchener, Ontario. The option to complete a prototype was pursued to ensure all steps required to attain LEED for Homes Certified level could be easily completed. The prototype would highlight areas of concern, possible stumbling blocks and act as a training centre for trades, site supervisors, as well as the engineering and management teams that will be involved when Monarch advances towards a full development of LEED-H homes. Durability plays a key role in determining the lifespan of a home and this site specific durability plan was developed in an attempt to increase the lifespan of the home, help improve occupant comfort and increase future re-sale values.

2) Goals

There are many benefits to implementing a well prepared durability plan early in the phases of design and development. The goals of this project are to create a home that is long lasting with few problems, improves occupant comfort, has lower than normal maintenance requirements, and in the future will re-sale for a greater value because it has been designed to last many decades.

3) Durability Discussion

Durability measures that affect each particular facet of construction and long term durability were critically analyzed. Careful selections were made to ensure a long

lasting, healthy, comfortable, dry, and quiet living environment was created. Strategies for durability can vary greatly depending on the project, building type and locale; therefore each project must have a specific set of customized requirements.

A review of Monarch's existing construction practices and site supervisor knowledge indicated an existing high level of construction detail and care. The durability plan developed focuses on several addition areas of improvement. These include:

- Groundwater - Silt-protected perimeter drainage installed; sub-slab gravel bed with connection to exterior perimeter drain; sump system installed; drainage membrane installed on exterior foundation walls.
- Surface Water - Ground sloped away from building; permanent surface features used to control site drainage; comprehensive stormwater management plan made for development site
- Rain - Continuous drainage plane installed and integrated with flashings; building overhangs specified to shelter walls; roof drainage system with appropriate deflectors and flashings used; full roof shingle underlayment used; maintenance instructions included in homeowner manual
- Capillary Rise - Tar based capillary break applied over footing to inhibit capillary rise of ground based moisture from the footing into the foundation. Prevents groundwater from moving through the building assembly and coming into contact with moisture sensitive materials.
- Ice Damming - Ice and water shield applied to the lowest 3' of roof (shingle underlayment under remainder of roof), vented attic design, plane of airtightness at ceiling level
- Interstitial Condensation (Below-Grade Enclosure) - interior rigid insulation to control surface temperature, air barrier, not using moisture sensitive materials
- Spills and Equipment Malfunction - wet room measures (list rooms: laundry room, kitchen, bathroom, mechanical room - and list measures for each); single-throw shut off valves installed for all water using appliances, fixtures and equipment
- Air Barrier System – Additional sealing details added to the standard construction practices in an effort to increase overall building air-tightness. Tyvar compressed between sill plate, wrapped over header and extending inside overlapped 6" with interior air barrier, sealed with acoustical sealing and compressed by drywall; Interior air barrier sealed with acoustical sealing and compressed by drywall extending out between top plates, around header and back inside to second floor interior air barrier sealed same as first floor; All interior air barrier overlaps occur

over locations allowing compression of the acoustical sealant between two hard surfaces

4) Quality management plan

The durability plan was used to create a checklist. A chain of command involving key Monarch personnel was developed to assign responsible for quality management of the durability measures included in this project. The checklist and chain of command were used throughout construction to ensure all durability measures were properly implemented.

- Design – Chris Schumacher – BSC, Review of drawings as prepared by architect for rainwater management, interior moisture loads,
- Pre-Construction – Kevin O’Shea – Monarch- On site training of site supervisor and contractors, review durability checklist, material specifications – ensured all materials met specifications
- Construction – Aaron Grin – University of Waterloo/Monarch – Regular site inspections, provide on-site technical support, verify installation of specified materials with photo documentation, co-ordinate with site superintendent on schedule, workmanship....
- Commissioning – Aaron Grin - - Supervision of mechanical systems commissioning, completion of final durability checklist, coordinate with Air Solutions for LEED inspections and testing, lessons learned summary

5) Completed Durability Checklist



LEED
for HOMES

Builder Name: **Monarch by Taylor Woodrow**

Address of LEED Home (Street, City, State): **Lot 4027 - Topper Woods - Kitchener, Ontario**

Approaches

For each of the high and moderate risk areas indicated above, list the durability responses or, if none are used, provide a brief statement explaining why not. Add lines as needed.

1.0 Water -- Exterior Sources	Location in Drawings, Specs, and/or Scopes	Pre-work Acknowledgement (Builder/trade)	Completion Acknowledgement (Builder/trade)	Construction Verified (Rater)
<p>1.1 Groundwater - Silt-protected perimeter drainage installed; sub-slab gravel bed with connection to exterior perimeter drain; sump system installed; drainage membrane installed on exterior foundation walls.</p> <p>1.2 Surface Water - Ground sloped away from building; permanent surface features used to control site drainage; comprehensive stormwater management plan made for development site</p> <p>1.3 Rain - Continuous drainage plane installed and integrated with flashings; building overhangs specified to shelter walls; roof drainage system with appropriate deflectors and flashings used; full roof shingle underlayment used; maintenance instructions included in homeowner manual</p> <p>1.4 Capillary Rise - Tar based capillary break applied over footing to inhibit capillary rise of ground based moisture from the footing into the foundation. Prevents groundwater from moving through the building assembly and coming into contact with moisture sensitive materials.</p> <p>1.5 Ice Damming - Ice and water shield applied to the lowest 3' of roof (shingle underlayment under remainder of roof), vented attic design, plane of airtightness at ceiling level</p>	<p>Foundation Plan, Specifications</p> <p>Site Grading Plan, Specifications</p> <p>Typical Wall Section, Specifications</p> <p>Foundation Plan, Specifications</p> <p>Typical Wall Section, Specifications</p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>
<p>2.0 Water -- Interior Sources</p> <p>2.1 Spills and Equipment Malfunction - wet room measures (list rooms: laundry room, kitchen, bathroom, mechanical room - and list measures for each); single-throw shut off valves installed for all water using appliances, fixtures and equipment</p> <p>2.2 Meltwater from shoes - tile surfaces in entry areas</p>	<p>Location in Drawings, Specs, and/or Scopes</p> <p>Floor Plans, Specifications</p> <p>Floor Plans, Specifications</p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p>
<p>3.0 Water Vapor Flow</p> <p>3.1 Interstitial Condensation (Below-Grade Enclosure) - interior rigid insulation to control surface temperature, air barrier, not using moisture sensitive materials</p> <p>3.2 Interstitial Condensation (Above-Grade Enclosure) - exterior insulation to control temperature of condensing surface and vapor barrier</p> <p>3.3 Dryable Assemblies - enclosure assemblies are designed to dry to the inside or outside as appropriate to the climate.</p>	<p>Location in Drawings, Specs, and/or Scopes</p> <p>Typical Wall Section, Specifications</p> <p>Typical Wall Section, Specifications</p> <p>Typical Wall Section, Specifications</p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>



Builder Name: **Monarch by Taylor Woodrow**

Address of LEED Home (Street, City, State): **Lot 4027 - Topper Woods - Kitchener, Ontario**

Approaches

For each of the high and moderate risk areas indicated above, list the durability responses or, if none are used, provide a brief statement explaining why not. Add lines as needed.

4.0 Air Flow	Location in Drawings, Specs, and/or Scopes	Pre-work Acknowledgement (Builder/trade)	Completion Acknowledgement (Builder/trade)	Construction Verified (Rater)
<p>4.1 Air Barrier System (Below-Grade Enclosure) - concrete as air barrier in basement; sill plate sealed to concrete with sill gasket</p> <p>4.2 Penetrations (Below-Grade Enclosure) - all penetrations (windows, drains and stacks, concrete control joints) are sealed with acoustic sealant or sprayed polyurethane foam</p> <p>4.3 Air Barrier System (Above-Grade Enclosure) - Tybar compressed between sill plate, wrapped over header and extending inside overlapped 6" with interior air barrier, sealed with acoustical sealing and compressed by drywall; Interior air barrier sealed with acoustical sealing and compressed by drywall extending out between top plates, around header and back inside to second floor interior air barrier sealed same as first floor; All interior air barrier overlaps occur over locations allowing compression of the acoustical sealant between two hard surfaces</p> <p>4.4 Penetrations (Above-Grade Enclosure) - All penetrations passing through air barrier sealed to air barrier, and where thermal expansion could or shifting could occur (i.e., vent stacks), a flexible seal has been detailed.</p> <p>4.5 Air Sealing of Intersitial Cavities - Fire-stopping and sealant are used to seal connections between interior partitions and exterior walls and behind tubs, shower units and fireplaces to prevent unintentional air leakage</p>	<p>Typical Wall Section, Specifications Foundation Plan, Typical Wall Section, Specifications</p> <p>Typical Wall Section, Specifications</p> <p>Typical Wall Section, Specifications</p> <p>Typical Wall Section, Specifications</p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>
<p>5.0 Heat Flow</p> <p>5.1 Clear Enclosure Sections - Increased insulation levels over code requirements</p> <p>5.2 Thermal Bridging - Insulated sheathing has been specified to provide a minimum layer of insulation over all thermal breaks in the framing, raised-heel trusses used to ensure continuity of specified insulation levels at eaves</p> <p>5.3 Control Window Surface Temperatures - low-e, argon-filled glazing units</p>	<p>Location in Drawings, Specs, and/or Scopes</p> <p>Typical Wall Section, Specifications</p> <p>Typical Wall Section, Specifications</p> <p>Typical Wall Section, Specifications</p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>	<p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p>



Builder Name: **Monarch by Taylor Woodrow**

Address of LEED Home (Street, City, State): **Lot 4027 - Topper Woods - Kitchener, Ontario**

Approaches

For each of the high and moderate risk areas indicated above, list the durability responses or, if none are used, provide a brief statement explaining why not. Add lines as needed.

	Location in Drawings, Specs, and/or Scopes	Pre-work Acknowledgement (Builder/trade)	Completion Acknowledgement (Builder/trade)	Construction Verified (Rater)
6.0 Solar (Ultraviolet) Radiation				
No special measures required.				
<i>Rationale: Critical enclosure control layers are protected by cladding materials. Degradation due to ultraviolet radiation does not pose a durability risk for this project.</i>				
7.0 Wildfire				
No special measures required.				
<i>Rationale: Project is situated within an urban area. Nearby forest areas are sufficiently separated from developed areas that wildfire does not pose a durability risk for this project.</i>				
8.0 Pests				
No special measures required.				
<i>Rationale: Typical local pests do not pose a durability risk for this project. Non-toxic pest control measures have been implemented on this project as described in Sustainable Sites Credit 5.0.</i>				
Other				

Home Energy Rating Certificate

TOPPER WOODS

Kitchener, Ont



**5 Stars Plus
Confirmed Rating**

Uniform Energy Rating System

1 Star 500-401	1 Star Plus 400-301	2 Stars 300-251	2 Stars Plus 250-201	3 Stars 200-151	3 Stars Plus 150-101	4 Stars 100-91	4 Stars Plus 90-86	5 Stars 85-71	5 Stars Plus 70-0
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Energy Efficient

HERS Index: 49

General Information

Conditioned Area: 2795 sq. ft. House Type: Single-family detached
 Conditioned Volume: 33539 cubic ft. Foundation: Conditioned basement
 Bedrooms: 5

Mechanical Systems Features

Heating: Fuel-fired air distribution, Natural gas, 94.0 AFUE.
 Water Heating: Instant water heater, Natural gas, 0.80 EF.

Duct Leakage to Outside: 0.00 CFM.

Ventilation System: Balanced: ERV, 96 cfm, 80.0 watts.

Programmable Thermostat: Heating: Yes Cooling: No

Building Shell Features

Ceiling Flat: R-40 Exposed Floor: R-31
 Vaulted Ceiling: R-32 Window Type: U:0.28, SHGC:0.32
 Above Grade Walls: R-23
 Foundation Walls: R-15.8
 Slab: R-0.0 Edge, R-0.0 Under
Infiltration: Rate: Htg: 659 Cfg: 659 CFM50
 Method: Blower door test

Lights and Appliance Features

Percent Fluorescent Pin-Based: 100.00 Clothes Dryer Fuel: Electric
 Percent Fluorescent CFL: 0.00 Range/Oven Fuel: Natural gas
 Refrigerator (kWh/yr): 464.00 Ceiling Fan (cfm/Watt): 0.00
 Dishwasher Energy Factor: 0.68

The Home Energy Rating Standard Disclosure for this home is available from the rating provider.

REM/Rate - Residential Energy Analysis and Rating Software v12.41

This information does not constitute any warranty of energy cost or savings.
 © 1985-2007 Architectural Energy Corporation, Boulder, Colorado.

Rating Number:
 Certified Energy Rater: David Milliken
 Rating Date: 05/29/2008
 Rating Ordered For:

Estimated Annual Energy Cost

Use	Confirmed Rating		Percent
	MMBtu	Cost	
Heating	50.1	\$829	36%
Cooling	0	\$0	0%
Hot Water	20.7	\$338	15%
Lights/Appliances	27.9	\$1097	47%
Photovoltaics	-0.0	\$-0	-0%
Service Charges		\$60	3%
Total		\$2324	100%

This home meets or exceeds the minimum criteria for all of the following:

RATER: DAVID MILLIKEN
HORIZON-RESIDENTIAL ENERGY SERVICES
 405 WESTERN AVE. PMB 240
 SOUTH PORTLAND, ME 04106
 207-221-3221
 207-221-5415

Certified Energy Rater

Waste Management Plan

Project Name: Lot 4027 – LEED Prototype
Project Size: 2800 ft²
Project Type: Residential Single Detached Home

Goals:

The waste management plan is based on the following goals:

- To minimize the amount of construction waste sent to landfill
- To reduce construction wastes produced on-site
- To divert recyclable and re-useable construction wastes where possible
- To surpass the LEED target of less than 1.0 lbs/ft² of construction waste sent to landfill

1. Analysis of Expected Job-site Waste:

General construction debris will include

- Dirt
- Concrete
- Plastics (Bags, Packaging)
- Steel (HVAC and Strapping)
- Wood
- Asphalt Shingles and Underlay
- Drywall
- Paper and Cardboard (Packaging)
- XPS and EPS Insulation
- Fiberglass Insulation (Remnants and Packaging)
- Paints and Sealants
- Other (Lunch wastes, mixed items, sweepings)

2. Wastes Benchmark

To determine the wastes produced on-site from typical Monarch construction a study was completed of a separate completed development (see summary attached). The development's waste weigh bills were compiled and tallied then the total square footage of finished area for the site was used to determine the mass of waste sent to landfill per square foot of construction. The study showed that the average Monarch home produced 4.1 lbs/sqft, which is comparable to published average data on residential construction waste.¹ Within the wastes produced the largest wastes by mass were within brickwork, concrete and wood waste.

¹ NAHB "Residential Construction Waste Management: A Builder's Field Guide."

3. Waste minimization

In an effort to divert excess waste from landfill the team will attempt to reduce wastes produced on-site. The framing order will be minimized and any excess full size lumber will be returned to the supplier. All headers are sized and ordered cut-to-length to ensure no large dimension lumber is unnecessarily cut. Trades will be required to recycle, reuse or salvage their construction waste to the greatest extent possible. The largest weight contributors, concrete and brick, will be utilized as back-fill on-site and will not be sent to landfill. The second largest weight contributor, wood, will be recycled whenever possible. The wood used for footings will be the property of the footing contractor and reused on multiple jobs before being recycled.

4. Removal Methods

At 4027 the team will attempt to minimize the wastes as well as control waste contamination from outside sources. The entire site will be fenced with 7' high fences and locked every night to ensure that only waste produced on the site will be placed into the on-site waste bins. All materials for 4027 will be dropped off directly on-site. All waste materials will remain on-site in the covered waste bins. The wastes will be covered and locked to ensure wastes will not be soaked by rain and that unwanted wastes are excluded. Each trade receives stringent instruction and daily monitoring to verify that all of the wastes produced are stored on-site for measurement. Quantities will be measured in kilograms and converted to pounds. Aaron Grin from the University of Waterloo will arrive once a bin has been filled, separate and weigh wastes, as well as keep records of wastes weighed. Clean wood wastes will be recycled by a local hydroponic potato farmer. Brick and concrete wastes will be used as backfill for the garage. All other debris will be recycled or re-used where possible and the remainder will be sent to landfill. The remaining paints will be sealed and left with the house for future use such as touch-ups by the homeowner.

7. Materials Handling Procedures:

All trades will receive instruction during their respective contractor meetings to ensure all wastes produced at 4027 remain within the fenced area. The framers will have sole access to their own bin specifically for wood wastes. The wood wastes must be placed clean (free of screws/nails) in the bin.

Wastes, other than wood, will be placed within the bins provided. The bins will be emptied, sorted and weighed as they are filled. The sorted wastes will be recycled or re-used where possible and the remainder will be sent to landfill.

8. Personnel:

- | | |
|---------------|--|
| Kevin O'Shea | - Organize and Facilitate Contractor Meetings |
| Aaron Grin | - Oversee and monitor the plan in the field
- Weigh wastes once bins are filled.
- Compile and report of all waste material information sheets.
- Review waste management plan results
- Complete the LEED letter templates. |
| Louis Devlugt | - Supervise the implementation of this plan in the field
- Coordinate bin drop off and removal
- Receive recycling and waste weigh bills
- Organize and keep waste and recycling area tidy. |

9. Hazardous Wastes:

Hazardous wastes will be separated, labelled, stored and recycled or disposed of according to local regulations, workers safety regulations, and provincial and federal regulations under the direction of Louis Devlugt.

10. New Opportunities:

Throughout the construction the team will strive to determine, and where possible explore, new opportunities to reduce, reuse and recycle in an effort to divert any possible wastes from landfill.