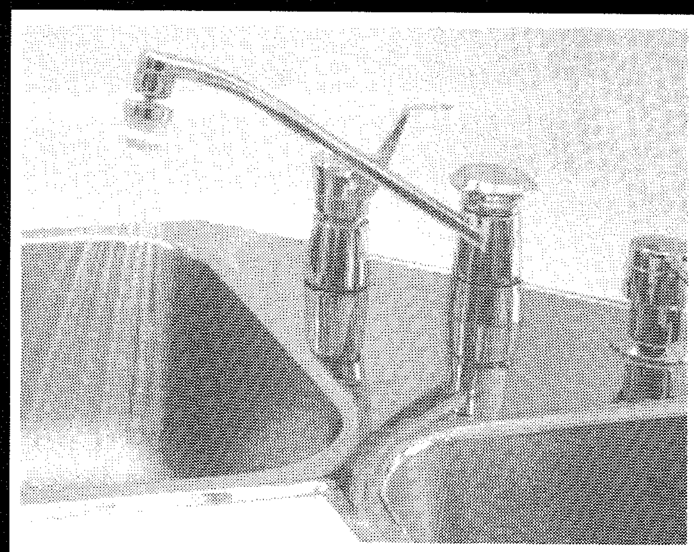
WATER IN THE WORKS

ADVANCED HOUSE TECHNOLOGIES



CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

Energy, Mines and Resources Canada
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The Advanced House, a home in Brampton, Ontario, incorporates state-of-the-art, energy efficient products and technologies that respond to environmental concerns. The Advanced House was designed and built with financial support from CANMET, the Ontario Ministry of Energy, Ontario Hydro and the Fram Building Group. In addition, more than 50 firms contributed their services and products to the project.

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WATER IN THE WORKS

What makes the Advanced House so advanced? In part, leading-edge technologies make the house energy efficient. Energy efficiency is seen as a key component of efforts to deal with the adverse effects of energy production and consumption on the natural environment. The house is also considered advanced because of its response to environmental concerns — concerns such as water quality and availability.

The Advanced House demonstrates the concept of doing more with less, particularly less energy and water. In fact, greater efficiencies can be achieved using today's technology without compromising the way a house is built or the comfort of the occupants.

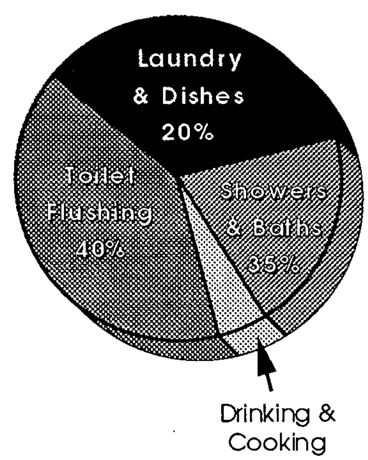
Reflections on Water and the Builder

Although Canada is a water-rich nation, Canadians should be concerned with water quality and quantity issues. A serious imbalance exists between the location of supplies and centres of demand. As demand for water has risen over the years, so has the volume of wastewater. For many municipalities, the cost of providing and expanding sewage treatment and water purification facilities has become prohibitive. For the builder, the consequences have ranged from lower density subdivisions to outright bans on further development.

Water conservation, on the other hand, can extend inadequate supplies, reduce wastewater flows and alleviate the demands of population growth. And it's simple — the Advanced House shows you how.

Water-Efficient Technologies: The State-of-the-Art

Residential water needs can be efficiently and effectively reduced — by 30 to 50% — using readily available water-efficient technologies. In fact, wherever water is used in the home, there is a potential for using less.



Residential Water Use

Toilets

Toilets account for 40% of residential water use. Conventional toilets use about 20 litres per flush. Most manufacturers make a water-saving toilet that uses about 13 litres per flush. It is possible, however, to go lower still. The toilet in the Advanced House uses just 6 litres per flush. For a family of four, that alone could account for a reduction in water use of more than 20 000 litres per year.

The toilet is the IFO Cascade, manufactured by Mansfield, in Perrysville, Ohio. Made of vitreous china, it fits a 12-inch rough in, and is virtually indistinguishable from a conventional toilet.

Some low-volume toilets use pressurized water or pressurized air to assist in the flushing action. The IFO Cascade relies on an innovative tank and bowl design to reduce the amount of water used in flushing. With the IFO, the tank discharge is split into two streams of water, one on each side of the bowl. The resulting jet stream action gives the water increased velocity and force. It also creates a vortex in the bowl, which enhances the wash-down action.

Showerheads

The second largest drain on residential water resources is the showerhead. A typical showerhead averages flow rates of 20 litres per minute. Low-flow showerheads have flow rates between 6 and 10 litres per minute.

There are two types of low-flow showerheads: aerated and non-aerated. Aerated showerheads reduce the amount of water in the flow, but maintain pressure by mixing in air. With the non-aerated showerhead, the water is pulsed.

Low-flow showerheads are comparable in price to conventional units, are installed in the same manner, and are widely available.

Faucets

Low-flow aerators for faucets are also readily available at competitive prices. They can reduce flow rates by 50% or more.

The faucet in the main floor powder room of the Advanced House has an added twist. It has a built-in infrared sensor, which turns water on and off by detecting the presence or absence of an object under the tap. The manufacturer claims an 85% savings on water consumption and energy. However, the high initial cost of the automatic faucet ($420) may deter most builders from going to this extent.

Note: It is important when installing faucet aerators to match the technology with the intended use. In bathrooms, a flow rate of 2 litres per minute will be sufficient. In the kitchen, a flow rate of 6 to 9 litres per minute is required. Low-flow aerators are not recommended on faucets where large volumes of water are needed over a relatively short period of time, such as in a laundry-utility room.

Appliances

The washing machine and dishwasher in the Advanced House are of European design and manufacture, and use significantly less water than typical North American machines. The front-loading washing machine can cut laundry water use by 30%. No verifiable figures were available for the dishwasher.

Both of these machines come with a significantly higher price tag than North American machines. If these are not suitable for your market, look for appliances that come with water-saving features such as variable load settings and variable time settings.

An added bonus of water-efficient appliances is that less water use means less hot water use, translating into energy savings.

Application	Water-Saving Device	Function	Water Savings	Unit Water Savings L/d per capita (gallons per capita per day)
Toilet	Low flush 13 L/flush (3.5 gallons)	Reduce flush volume	8 L/flush (2 gal/flush)	30.3 (8.0)
Toilet	Ultra-low flush 6 L/flush (1.5 gallons)	Reduce flush volume	14 L/flush (4 gal/flush)	60.6 (16.0)
Shower	Reduced-flow showerhead 11 L/min	Reduce shower flow rate	5.7 L/min	27.3 (7.2)
Faucet	Aerator with flow control	Reduce flow-rate and splashing	—	1.9 (0.5)
Appliance	Water-efficient dishwasher	Reduce water requirement	19 L/load (5 gal/load)	3.8 (1.0)
Appliance	Water-efficient washing machine	Reduce water requirement	23 L/load (6 gal/load)	6.4 (1.7)

Water-Efficient Devices and Appliances for New Construction
Source: Brown and Caldwell Consulting Engineers, Walnut Creek, California

Landscaping

When building a house, the landscape you install locks the residents into a water consumption pattern for years to come. Over a single growing season, an average lawn will soak up about 100 000 litres of water — most of which is lost to runoff and evaporation.

To reduce the amount of water required to maintain the lawn, try employing landscaping techniques developed in the water-poor U.S. southwest. These techniques, known as xeriscaping, include:

- Limiting turf grass

  Exotic turf grasses, such as Kentucky Bluegrass, are the thirstiest of all residential greenery. Limiting the amount of turf grass and switching to hardier native grasses is the quickest and surest way to reduce outdoor water use. In general, turf grass areas should not exceed what is useful for social and play activities. To be of the most use, turf grass should be planted where residents spend most of their time — in the backyard.

  Hardscapes—decks, patios and walkways — can replace some lawn area and provide for more interesting landscapes.

- Planting native trees and shrubs

  Native trees and shrubs require less water than exotic species; in many cases, they survive on what nature provides through precipitation. In addition, native fauna is hardier and better able to withstand drought, disease and insect infestation.

Plants with similar watering needs should be grouped together to maximize watering efficiency.

- Drip irrigation

Watering equipment also plays a role in how efficiently outdoor water is used. Sprinklers can lose 25 to 50% of their spray through runoff, application to paved areas and evaporation, both on the ground and in the air.

Drip irrigation is the most effective and efficient means of applying water. Soaker hoses — hoses with microscopic holes that leak water at a constant rate — can cut irrigation loses in half.

The drip irrigation system at the Advanced House is buried underground, which reduces evaporative and runoff losses to an even greater extent. In addition, water is supplied directly to the root zone where the plants can use it the most.

- Other Benefits

Employing these landscaping techniques provides a number of spin-off benefits. Primarily, the use of fertilizers, insecticides and herbicides can be reduced, if not eliminated.

Landscape and Energy

The landscape surrounding a residential dwelling can be configured for more than just water savings: it can have an effect on the energy efficiency of the residence itself. Proper choice and planting of trees, shrubs and vines can moderate the microclimate surrounding the house, resulting in lower heating costs during the winter and lower cooling costs during the summer. The landscape surrounding the Advanced House was designed with this goal in mind.

Three simple design objectives were set and followed to achieve maximum energy efficiency:

- Maximize solar heat gain in the winter.

  To maximize solar heat gain in the winter, deciduous trees were planted on the south, southwest and southeast faces of the house. Because deciduous trees lose their leaves in the winter, winter sunlight is able to penetrate to the south-facing windows.

- Minimize solar heat gain in the summer.

  The deciduous trees also serve to minimize solar heat gain in the summer by blocking the sun's access to the south-facing windows, and by shading the southwest wall. Shady deciduous trees can lower the local temperature by up to 12°C, and reduce air conditioning needs by up to 75%.

- Minimize heat loss in the winter.

  To minimize heat loss in the winter, the north and west walls are protected by windbreaks. The windbreaks consist of a mixture of coniferous trees, evergreen shrubs, deciduous shrubs and perennial plants. The windbreaks serve to reduce wind speed, reduce air infiltration (by up to 65%) and consequently reduce air exchange within the house (by up to 22%).

An arbor is located over the deck. Arbors should be designed with angled louvers to block the summer sun but allow the winter sun to penetrate.

Landscape Ontario (a horticultural trades corporation) in conjunction with Humber College and the Ontario Association of Landscape Architects, coordinated the Advanced House landscaping. According to Landscape Ontario, landscapes can also achieve the following effects:

- an eight foot Norway spruce hedge can reduce noise by 6 to 12 decibels;
- streets with trees are 5 to 6 °C cooler in the daytime, and stay warmer at night;
- a 70-foot shade tree can evaporate 100 gallons of water a day, equal to five average room air conditioners.
- it is possible to obtain an average of 15% energy savings through the efficient use of vegetation.

Coming Down the Pipes: The Future of Water

The day that builders will **have** to utilize water-efficient strategies and technologies in their houses may not be that far off. It is predicted that, in many parts of the country, water rates may increase by as much as 50% over the next five years.

Several U.S. states have already made water-efficient fixtures mandatory. And, as U.S. experience has shown, water conservation can indefinitely delay the need for costly expansion of treatment facilities.

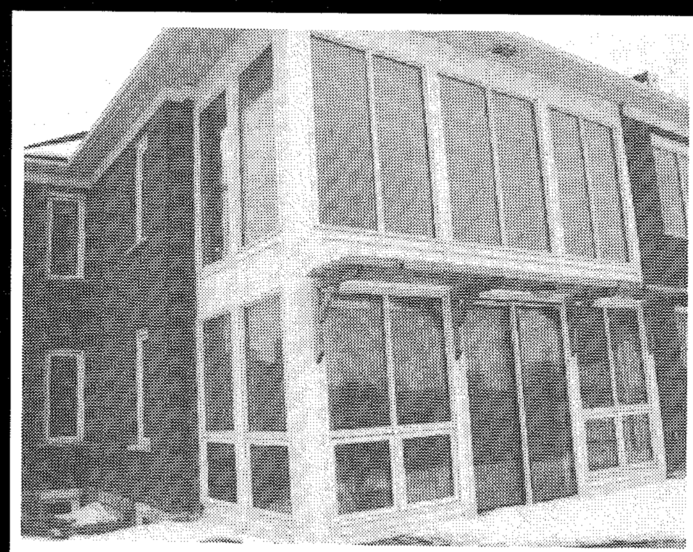
Already, organizations such as the Canada Mortgage and Housing Corporation and plumbing code committees, both nationally and provincially, are taking a look at ways to reduce residential water consumption.

New standards are being drawn up by the Canadian Standards Association for water-conserving fixtures and devices, and for ways of streamlining the existing testing procedures to make such devices more widely available.

Some time in the future, municipal governments will probably exercise some initiative by, for example, requiring developers to show innovative ways of reducing water use because there is no water supply or sewage treatment capacity to pass a development as proposed.

A ROOM WITH A VIEW OF THE FUTURE

ADVANCED HOUSE TECHNOLOGIES



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A ROOM WITH A VIEW OF THE FUTURE

Of all the recent developments in building technology, the most dramatic has been the advent of high-performance windows. Window performance improvements of more than 500% have captured the attention of builders and homeowners alike. CANMET has been very active in the development of advanced window technologies. In cooperation with other stakeholders, CANMET has championed the development of test methods, standards, design tools, labelling and training packages to encourage the adoption of high-performance windows. These efforts and those of utilities, provincial governments, engineering firms, window manufacturers and their association (the Canadian Window and Door Manufacturers Association) will help realize the vast potential for these products in the retrofit market and in new buildings.

One project which demonstrates the leading edge in window technology is the Advanced House. The House uses one quarter of the energy of a similar home built to Ontario Building Code standards and less than one half the energy of a similar R-2000 home. A large part of the House's superior energy performance is because of the super high-performance windows which were chosen for the project.

Window Specifications

Typically, windows have been the weakest link in the thermal envelope. However, the gap between window and wall performance has been narrowing steadily with improvements to window technology. The high-performance windows in the Advanced House contribute a 34% energy savings compared to standard double glazed windows. The chart below shows the design specifications for the Advanced House windows together with the features of the Loewen windows which won the tender call.

Design Considerations

The experience gained with the Advanced House showed that there are two major design factors which should be considered when incorporating high-performance windows. Attention paid to the glazing area and location and to the type of window will optimize overall performance.

Specifications	Loewen Windows
• RSI 0.88 (R5) glazing or better	• glazing R value RSI 1.36 (R7.7): triple glazing, two sputtered low-emissivity coatings, two 12 mm (1/2") airspaces, both airspaces filled with argon gas,
• improved edge seal techniques using organic spacer materials	• Tremco Swiggle Strip, low conduction spacer
• high-quality, thermally broken frames	• wooden frames
• overall thermal resistance of the whole window at RSI 0.88 (R 5) or better	• tested thermal performance values of RSI 0.88 (R5) with an overall solar heat gain coefficient of .57
• improved air and weather seals for operable windows	
• durable exterior finish	

Glazing Area and Location

The old rules of glazing to floor area ratios apply equally to high-performance and conventional glazing. Before the design for the Advanced House was finalized, a computer model of its performance was developed using the Enerpass program. The modelling showed that the south main floor and basement window areas should be increased and the north window areas decreased in order to optimize performance. In the final design, the south glazing area equaled 11.7% of the house floor area. East and west window exposures were kept to the minimum required for aesthetics and daylight. In other words, even with high-performance windows, house energy performance is best if the design can maximize south facing windows and minimize the amount of glazing on other exposures.

Window Type

Envelope performance can be further improved by selecting a few large windows instead of many small ones. With insulating windows, the thermally-weakest areas are the window frame and edge. The better the performance of the glazing, the more significant the effect of the edge losses on overall performance. Selecting larger windows reduces the proportion of frame to glazing and optimizes overall performance.

In selecting the window type, the opening of windows should be limited to locations where ventilation or emergency egress is required by code. Whatever the thermal performance of the glazing, fixed windows perform better than operating windows. The reduced frame and sash area and reduced air leakage contribute to better overall window performance. Optimizing solar gain through the window is also important to overall window performance. Windows with clip-on muntins were not chosen for the Advanced House since they create additional shading and reduce solar gain.

Benefits of High-Performance Windows

Besides the improvements in energy consumption, high-performance windows have a number of other advantages which have implications for building design and marketing. These additional benefits include improved comfort, reduced condensation, and reduced fabric fading.

Comfort: Because the radiative heat losses through the window are reduced, people will feel more comfortable sitting near a high performance window, even on a winter night.

This allows more options in furniture placement, seating design and window coverings.

Reduced Condensation: Similarly, because of reduced radiative losses, the interior temperature of the glazing will be higher. As a result, the house will be able to handle higher humidity levels without experiencing window condensation.

In addition, higher humidity levels are more comfortable for the occupants while the reduced window condensation contributes to the durability of the frame and surrounding area.

Reduced Fabric Fading: Ultraviolet light is the component of sunlight which is responsible for fading fabrics, upholstery and carpet. Low-E (low emissivity) glass filters out some of the ultraviolet light, allowing for lower maintenance costs and greater homeowner choice in furnishings and furniture placement.

Selecting a Window Model

The windows in the Advanced House were specially built by Loewen windows in Winnipeg but the technology is within reach of window manufacturers and builders across Canada.

Glazing: Most manufacturers of sealed units offer a Low-E option. Many can also provide argon-filled spaces. The Insulating Glass Manufacturers Association of Canada (IGMAC), can provide a list of suppliers who offer these features. (The address for IGMAC is listed at the end of this fact sheet.)

Low-Conduction Spacer: Traditionally, window spacers have been metallic. Recent advances in our understanding of heat losses have led to the development of non-conductive, non-metallic spacers.

Selecting Options: The windows in the Advanced House incorporate Triple glazing, two Low-E coatings, argon fill **and** the Tremco Swiggle Strip, a low-conduction spacer made of butyl rubber.

If all four of these features are not available, what is the next best choice? Where other features are equal, the spacer can account for a 20% difference in overall thermal resistance of the window. This would indicate that after Low-E coating, the non-metallic spacer is the next most important feature.

Comparing Windows

Of course, the thermal resistance of the glazing is just one aspect of window energy performance; other critical factors are thermal performance of the frame, air leakage and solar heat gain. As well, windows must meet other performance requirements such as resistance to water leakage and wind. There are several organizations involved in the development of standards for windows in Canada.

- The Canadian Standards Association (CSA) standard CAN/CSA A-440 specifies rates of air leakage, water leakage and wind load resistance. The testing of windows to determine if they meet the CSA standard is conducted at a number of independent laboratories across the country and test results should be reported in the manufacturer's literature.
- The CSA standard also specifies a number of prescriptive requirements such as the use of preservatives on wood frames. The Canadian Construction Materials Centre (CCMC) evaluates windows and provides a list of products which meet the requirements. The CCMC listing number should appear on the product.
- The Insulating Glass Manufacturers Association of Canada (IGMAC) provides a certification program which requires manufacturers to meet quality control standards and Canadian General Standards Board (CGSB) performance standards for the edge seal. Sealed units should bear the IGMAC label.

The first step in ensuring window performance is to check that the products selected meet minimum standards.

In terms of energy performance, the CSA Committee on window labelling has developed an energy rating (ER) system for windows. The rating will be assigned following the combination and weighting of: thermal resistance of the window assembly (glazing and frame); infiltration; and solar heat gain coefficient.

The ER system now forms the basis for the new CAN/CSA A-440.2 window energy performance standard. As a result, a voluntary window labelling procedure, once developed, will assist consumers in comparing window products as well as enable them to understand the benefits of high-performance windows. In addition, the ER system will make it possible for regulatory bodies to specify certain performance standards for windows.

Warranty

The same warranties apply to high-performance windows as to other windows with sealed units.

- There is a warranty for the sealed unit itself; it is normally guaranteed against failure of the seal for seven years or more. Failure of the seal can be easily spotted by the presence of condensation, frosting, fogging or discolouration between the panes.
- The window as a unit is usually under warranty for one year under normal operating conditions.
- The installer's workmanship should also be covered by a warranty.

Incremental Costs, Marketing and Availability

High-performance windows typically cost 10-15% more than standard double-glazed units. According to the 1990 PULSE Survey conducted by Fibreglas Canada and the Canadian Homebuilders Association, (CHBA), 63% of Canadian builders now offer Low-E coatings on windows as an option. In Saskatchewan, where the option is available, 61% of buyers choose Low-E. The survey also reported that 40% of builders now offer gas-filled units as an option. No figures were available for units combining triple glazing, Low-E and gas fill.

In Canada, high-performance windows have found their greatest initial acceptance in the Prairie provinces where the winter climate is severe. Manufacturers who distribute windows across the country will sometimes not display the high-performance model in regions with milder climates. If you don't see a high-performance window in your local showroom, ask for the 'Prairie model'.

On-Site Handling

Windows (especially high-performance windows) represent a sizeable portion of the builder's material costs. Careful checking of the product on delivery can save costs and avoid delays later if faulty units need to be replaced. In addition to checking units for correct size and style on delivery, it is wise to check for the following:

√ Conformity to standards in the Code: sealed units should bear the IGMAC name.

√ Conformity to specifications: the windows should bear a mark indicating the presence of special features such as the Low-E coating, argon gas or non-metallic spacer.

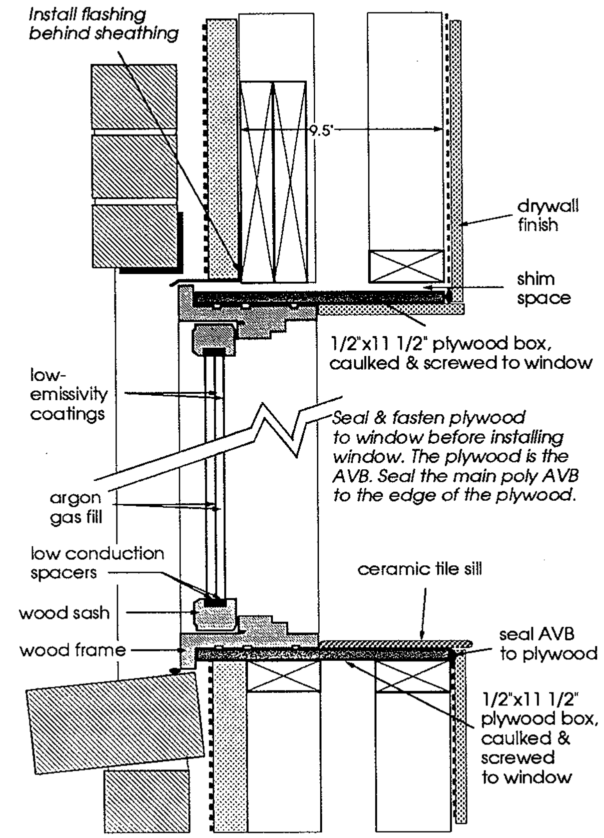
√ Condition of the windows: report any excessive deflection of the glass, evidence of seal failure or discolour-ation to the manufacturer.

When on site, all sealed units should be carefully handled to reduce the number of seal failures and potential warranty call-backs and to protect the builder's investment. When possible, delay installation of windows in sensitive locations until after delivery of other bulky materials.

Installation Techniques

A key requirement when installing windows is to seal the house air barrier to the window frame in order to prevent air leakage around the window opening. This is especially important with high-performance windows because poor installation techniques can negate their superior thermal performance.

Windows at the Advanced House were installed with a plywood wrap technique. Before being installed in the rough opening, a plywood jamb extension was caulked and screwed into the window frame. The wall air barrier was sealed to the edge of the plywood to provide a continuous air barrier. This method is less time-consuming than the poly wrap approach; however, care must be taken not to fasten the screws near the edge of the glass where they could puncture or stress the edge seal.



Advanced House — Window Section

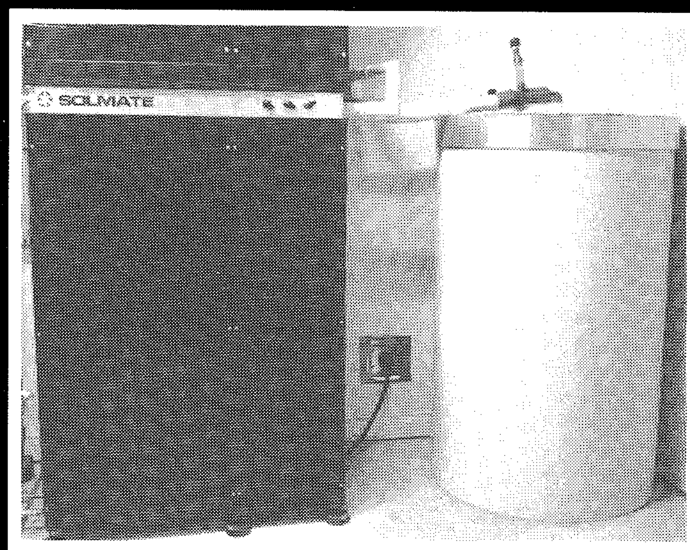
Resources

Canadian Window and Door Manufacturers Association
27 Goulburn Avenue
Ottawa, Ontario K1N 8C7
(613) 233-6205

Insulating Glass Manufacturers Association of Canada
5 Highland Road
Brantford, Ontario N3T 5L7
(519) 449-5788

INTEGRATED MECHANICAL SYSTEM

ADVANCED HOUSE TECHNOLOGIES



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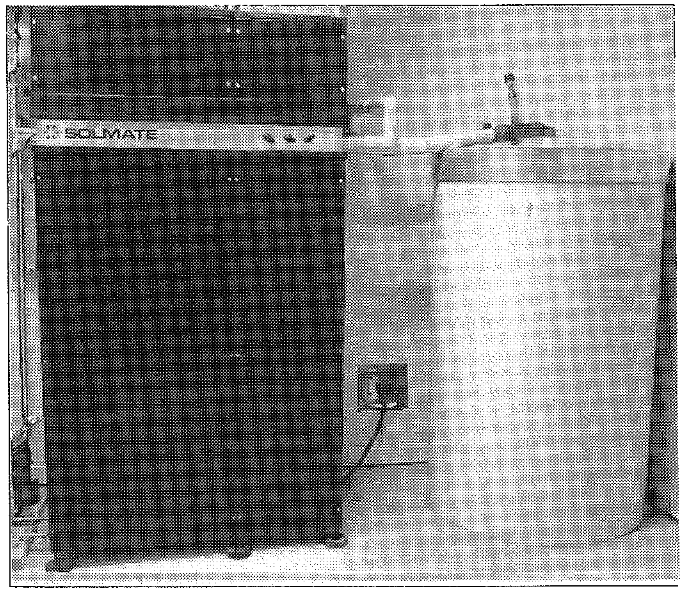
INTEGRATED MECHANICAL SYSTEM

Perhaps the most novel of all the leading edge technologies demonstrated at the Advanced House is the Integrated Mechanical System (IMS). This unit alone provides space heating, hot water, ventilation and heat recovery. The IMS accounts for a sizeable portion of the energy savings at the Advanced House. In fact, it cuts the energy consumption for heating and cooling by more than half.



Combining mechanical functions

The term 'integrated mechanical system' (IMS) is used to describe systems that link the thermal energy flows in a house. In most integrated mechanical systems, a heat pump is used to provide the link between various energy uses and to upgrade energy that is recovered from exhaust air or water. Energy storage is frequently a part of most integrated mechanical systems.

An integrated mechanical system replaces most or all of the functions normally provided by separate pieces of mechanical equipment such as the furnace, hot water heater, heat recovery ventilator and air conditioner.

The chart on the next page shows the mechanical functions that are standard in today's homes and the equipment available to provide these functions.

From the chart, we can see that a variety of systems have preceded the development of the IMS by combining two or sometimes three of the mechanical functions. A heat recovery ventilator (HRV) is a basic form of integrated mechanical system, combining the functions of ventilation and heat recovery and making use of the house heating distribution network.

Heat-pump water heaters are another example combining space cooling with water heating, while hydronic heaters combine the functions of space and water heating.

The IMS at the Advanced House is the Solmate™ developed by Allen Associates. It combines space heating, water heating, passive solar storage, ventilation, heat recovery and also provides partial cooling. In summary, the IMS replaces **all** of the House's mechanical equipment dealing with thermal energy, with the exception of the refrigerator.

	Hydronic heaters	Furnace	DHW	HRV	AC	Heat pump water heaters
Heating						
space heating	●	●				●
water heating	●		●			●
heat recovery				●		●
Cooling						
space cooling					●	●
Ventilation						
filtration		●		●	●	
humidification		●		●	●	
supply and exhaust		●		●		

Development of the IMS

Several factors have set the stage for the development of integrated mechanical systems: improvements in the building envelope, the advent of controlled ventilation, and better applications for heat pumps.

Building Envelope

Improvements to the building envelope have reduced the space heating load to the point where, in highly energy efficient homes, it can be met by the smallest furnace or by auxiliary equipment such as a duct heater or a fan coil in the water heater.

Ventilation

The National Building Code (NBC) requires some means of mechanical ventilation where tight building envelopes are installed. Heat recovery ventilators were developed in response to the need for ventilation systems which could provide fresh air without adding to the house heating load. However, HRVs have some limitations.

- They depend on a balanced system. Intake and exhaust flows must be equal and this is not always easy to achieve.
- Air leakage without heat recovery will occur unless the envelope is airtight.
- HRVs may not be suitable for retrofit situations where it is difficult to achieve the air tightness standards required.
- HRVs preheat incoming air, they do not fully condition it.

Heat Pumps

Heat pumps have been used for space heating and cooling but wide market acceptance has been limited by their efficiency and cost. Both seasonal efficiency and the coefficient of performance (COP) can be greatly improved by adding energy intensive functions such as heat recovery, domestic hot water, ventilation and refrigeration.

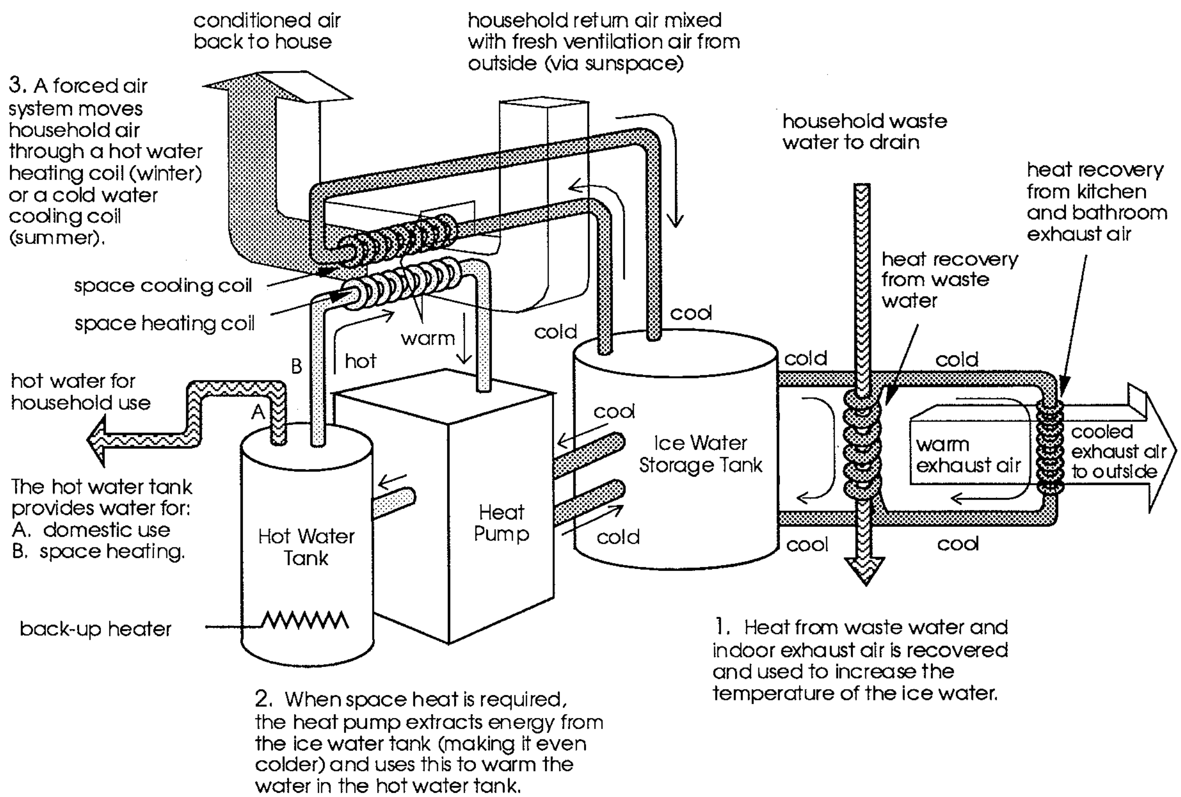
Heat recovery heat pump systems offer several advantages.

- The air flows need not be balanced.
- The building envelope need not be especially tight.
- The heat recovery heat pump can also be used to meet the building's space heating load.

How does it work?

The IMS at the Advanced House is based on a heat recovery heat pump. As well as providing standard mechanical functions such as space heating, water heating, ventilation and heat recovery, the system also provides two additional functions, heat recovery from grey water and heat storage. The addition of grey water heat recovery to heat recovery of ventilation air enables the system to make use of all the waste energy from the home. And, with the addition of storage, the mechanical system is able to make use of passive solar heat gain and internal gains in an efficient manner.

The heart of the IMS is a liquid to liquid heat pump which moves heat between an ice water storage tank and a hot water tank. During the winter, when heat is required for both space and water heating, the heat pump extracts heat from the water in the ice water tank and dumps it into the hot water tank. Potable hot water is delivered directly from the hot water tank for household use. Space heating requirements are met by a forced air system that is connected to the hot water tank via a fan coil unit. Household return air mixed with fresh ventilation air is directed over the fan coil and delivered from there to the house. In the summer, hot water is supplied in the usual manner and partial space cooling is



Integrated Mechanical System Schematic

provided by directing the household return air over a cooling coil that is connected to the ice water storage tank.

Additional inputs to the system allow for greater energy efficiencies. Firstly, household ventilation air is warmed by being ducted through the sunspace, before it is heated by the fan coil unit. Secondly, heat gains from the sunspace, energy efficient fireplace, lights, appliances and occupants are stored in the mass of the house. Thirdly, heat is recovered from household waste water and from kitchen and bathroom exhaust air and used to warm the ice water storage tank. During the summer cooling season, this heat recovery coil is by-passed to increase the cooling capacity of the ice water tank.

What are the advantages, benefits of integrated mechanical systems?

Integrated mechanical systems offer three major benefits: improved efficiency, comfort and savings.

Efficiency

- The IMS serves several functions and represents efficient use of equipment. An IMS makes it possible to tap into more of the energy flows in the house. Adding functions such as grey water heat recovery and heat storage increase the possible energy savings.
- The heat pump itself operates more efficiently with the addition of functions.

Comfort

- The storage capability of the IMS smooths out temperature swings from passive solar gains and internal gains and adds to the comfort level of the house.

Savings

- An IMS system can generate significant energy savings compared to a standard mechanical system with furnace, hot water heater, HRV and air conditioner. Economic analysis has shown a payback of approximately 2 years for an electrically heated house constructed to the NBC Measures and less than 5 years for the same house with a gas-fired furnace and DHW tank.

Potential applications

The IMS concept is suitable for both new and retrofit applications. As shown above, houses do not need to be super energy efficient. IMS systems have the capability of reducing energy needs by 38% in a moderately insulated building and producing savings of 60% in a highly insulated building envelope.

Status

Early development of IMS systems in Canada saw the emergence of two prototypes, the Habitaire system from Fibreglas Canada and the Solmate™ from Allen Associates. With the closing of Fibreglas Canada's research division, the Habitaire system has been withdrawn from development. The Solmate™ was developed to the prototype stage with assistance from NRC's Solar Program and from Energy, Mines and Resources Canada. Following development of two prototypes, 3 field units have been produced; one is installed at the Advanced House and the two others are installed in private homes.

Allen Associates is presently working to bring the Solmate™ into commercial production.

Implications for builders

The potential Canadian market for integrated mechanical systems has been estimated at 30,000 units a year by the year 2000. While commercialization of the IMS concept may be some time in the future, more changes to house mechanical systems are expected in the near term. These changes will be driven by further improvements to the house envelope and concerns about the environmental effects of various forms of heating.

Further improvements to the envelope will reduce the space heating load to the point where it will make sense to combine space heating with another function. Some jurisdictions are considering possible bans on electric resistance heating and more stringent requirements for efficiency of combustion appliances in response to environmental concerns. This will encourage the adoption of heat pump technology and efficient gas appliances.

For today's builder of energy efficient homes, hydronic heaters and heat pump water heaters are two types of appliances that integrate some mechanical functions and that offer improved efficiency.

Hydronic heaters are sealed combustion, gas water heaters with a fan coil attachment to provide the space heating function. While fan coil technology is certainly not new, products for the residential market combining a fan coil with a high efficiency gas water heater have only been available for 3 or 4 years. The first high-efficiency water heater intended for use with a fan coil unit was introduced in 1987.

High-efficiency gas-fired space and DHW systems based on either a forced air furnace with an attached water heater or a gas water heater with a fan coil, are available on the market.

Heat pump water heaters have been developed which combine space heating and cooling with water heating. These units also have the capability of simply providing water heating when there is no space heating or cooling load. For those occasions when the heat pump cannot satisfy both the space and water heating load, an electric resistance element in the water heater provides backup heat.

Some Swedish models combine an exhaust only ventilation system with a heat pump and use the hot water tank as a heat sink. These models have been used as a basis for products combining the functions of ventilation, heat recovery, water heating, space heating and cooling.

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THE FUTURE OF LIGHTS AND APPLIANCES

ADVANCED HOUSE TECHNOLOGIES

CANMET

Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

Energy, Mines and Resources Canada

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THE ENERGY OF OUR RESOURCES • THE POWER OF OUR IDEAS

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The Advanced House, a home in Brampton, Ontario, incorporates state-of-the-art, energy efficient products and technologies that respond to environmental concerns. The Advanced House was designed and built with financial support from CANMET, the Ontario Ministry of Energy, Ontario Hydro and the Fram Building Group. In addition, more than 50 firms contributed their services and products to the project.

CANMET (the Canada Centre for Mineral and Energy Technology) is the main research and development arm of Energy, Mines and Resources Canada. CANMET works with industry and other partners to develop safer, cleaner and more efficient methods to extract and use Canada's mineral and energy resources. In the buildings sector, CANMET supports technology development and implementation to improve energy efficiency in houses and commercial buildings.

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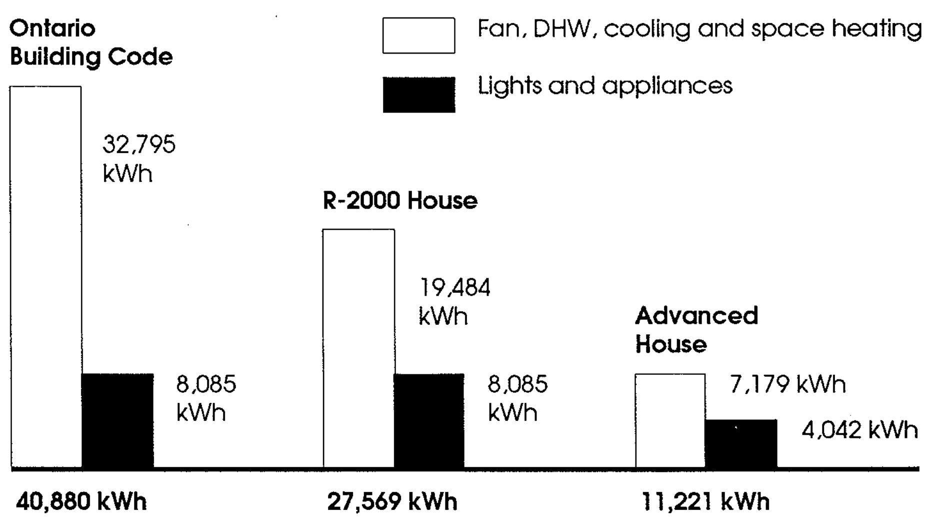
THE FUTURE OF LIGHTS AND APPLIANCES

The Advanced House represents the state-of-the-art in energy efficient house design and construction — as far along an evolutionary continuum from its predecessor, the R-2000 Home, as the R-2000 was in its day from conventionally constructed housing. In terms of energy, the Advanced House operates on less than half of what an R-2000 requires, and one-quarter of what a conventional house of similar shape and size would need.

Many of the additional efficiencies were gained through improvements to the building envelope. But, with every kilowatt hour counting as a black mark against the success of the house, energy savings were sought wherever energy would be used. Lights and appliances came under particular scrutiny — and with surprising results.

Lighting and appliance efficiency have not, for the most part, been a big concern of builders. Outside of the envelope (or, in this case, inside the envelope), attention has been focused on the big three: space heating, cooling and domestic hot water. However, with reduced energy requirements, lights and appliances potentially became the most energy-intensive feature of the house (8 085 kWh/y) more than for heating, cooling and DHW combined (see chart below).

Through a combination of structural considerations, innovative design, and state-of-the-art equipment, the Advanced House designers were able to cut the energy consumption of lighting and appliances in half (4 042 kWh/y). Here's how it was done.



Advanced House predicted annual energy consumption, compared with a conventional house and an R-2000 house of the same design

Appliances

Appliances installed in the Advanced House include: fridge, range, washer, dryer, and dishwasher. The appliances were chosen primarily on the basis of energy efficiency, although consumer acceptability and marketability played a role in the decision-making process. The table on the next page presents a comparison between the tested energy consumption of the appliances in the Advanced House, and their conventional counterparts.

All of the appliances, except for the fridge, were of German design and manufacture (AEG), and supplied by Euroline of Toronto. In general, European appliances are more energy efficient than Canadian-made goods, and these were no exception.

As an added bonus, the water-using appliances were also extremely water efficient, which meant additional savings on hot water heating.

The fridge, a Sunfrost RF-16, manufactured by Sunfrost of Arcata, California, is amongst the most energy efficient refrigerators in the world. This model consumes an estimated 18 kWh/mo. And, because it gives off less waste heat, air conditioning costs in the summer months will be lower.

As with all appliances, there are two costs that need to be considered, the purchase price, and the lifetime electricity cost of each unit. The purchase price of the appliances in the Advanced House was high, with the refrigerator topping out at $2 600. However, the cost of running the equipment is relatively low, which means in most cases and in most parts of the country, the initial cost will pay for itself over the lifetime of the equipment. Take the refrigerator for example:

Sunfrost: 18 kWh per month x 12 months x 5.7¢ per kWh = a yearly cost of $12.31. Over a twenty year lifespan, the Sunfrost would cost $246.20 to operate.

Other: 105 kWh per month x 12 months x 5.7¢ per kWh = a yearly cost of $71.82. Over a twenty year lifespan, that fridge would cost $1 436 to operate.

Despite the advantages, and pay back periods, some builders and plenty of buyers will balk at the initial cost. As a general rule, you should buy the appliance with the lowest energy rating you can find. However, substantial savings can still be attained by buying appliances with low Energuide ratings. Cost differences in these cases should not be substantial, and where there is a cost difference, the pay back period should be relatively quick.

Other

Sometimes, going forward means taking a look back. As another energy-saving feature, the Advanced House includes a cold cellar under the front porch, which is vented to the outside. This space provides year-round cool temperatures for storing perishables. In some parts of the country, an unheated porch could be used for cold storage.

Finally, while there were no special installation requirements associated with the appliances, the Advanced House builders recommend taking extra time and double-checking all measurements during the planning stages when working with anything new or 'unconventional' — in other words, "measure twice, cut once".

Appliance	Rating (kWh/y)	Usual Range (kWh/y)
Refrigerator • Sun Frost 16 cu. ft. • Rating 18 kWh/mo.	216	876-1980
Dishwasher • AEG Favorit 5251 • 2.5 L.	672	1007-1382
Range • Thorn 4 burner ceramic cooktop • Halogen infrared heat source	Not available	324-444
Oven • AEG B88L double wall convection and conventional heating	348	372-432
Clothes Washer • AEG Lavamat — front loading European style	708	600-1536
Clothes Dryer • AEG Lavatherm 620 • 110 L. drum	612	552-1200

Advanced House Appliance Ratings

Lights

Lights generally account for about 2% (1 000 kWh/y) of household electrical energy needs, not a large amount in the scheme of things. That 1 000 kWh/y, however, would equal nearly 10% of the Advanced House's total energy needs. Through a combination of structural considerations, design strategies, and state-of-the-art lighting technologies, the lighting needs of the Advanced House were reduced to 250 kWh/y.

Structural Considerations

Reducing the need for artificial lighting is the first step in reducing lighting energy needs. The provision of daylighting is one reduction strategy, and one of the main purposes behind the skylight over the central stairwell in the Advanced House.

In order to reduce the possibility of heat loss in the winter and overheating in the summer, the skylight is supplied with high-performance glazing at the ceiling level. For summer venting, the skylight itself is controlled by a motorized system.

It's also important to have your interior designers/decorators aware of your aims regarding energy efficiency. While the Advanced House decorators were 'on board', for many of them, working on an energy efficient home was a new experience. This in large part explains how dark wallpaper came to be used in the stairwell, where a lighter shade would have maximized the use of natural light.

Design Strategies

Interior designers were given a fixed "wattage" for each room. While they tended to trade-off — when less watts were used up in one room, more watts were used in another — they did stay within the overall total.

Lighting is generally divided into general room lighting (ceiling or wall fixtures that provide overall light to an area) and task lighting (lighting used for specific purposes, such as reading lamps). Using general lighting as task lighting can result in an inefficient use of light. In the Advanced House, a good mix between general and task lighting was provided, allowing occupants to adjust lighting levels in concordance with specific room functions. As part of this strategy, more lights were controlled by individual switches. This allows the individual to light specific areas of a room independently.

State-of-the-Art

It has long been known that incandescent bulbs are energy liabilities, turning most of the electricity that reaches them into waste heat rather than light. However, until the recent development of compact fluorescents, few alternatives were available. The Advanced House is a virtual show case of compact fluorescent technology, employing eight different variations throughout the home. All of the lights were supplied by Philips Lighting, a division of Philips Electronics Ltd., who became interested in the aims of the Advanced House at an early stage in its development.

Compact fluorescents use 75% less energy than incandescents, and have a lifespan approximately ten times longer that regular bulbs. In addition, lower watt fluorescents can be used in place of higher watt incandescents. The chart on the next page indicates the difference in equivalent energy consumption between fluorescent and incandescent bulbs.

As with the cost of appliances, the compact fluorescents carry a large price tag. Again, however, it is the second price tag, the cost of operation, which is most important. As the following example shows, the operating cost of an incandescent may exceed the capital cost by 400%.

Assume a 60-Watt incandescent bulb:

Purchase price	=	$0.80
Lifetime	=	1 000 hours
Watts	=	60
kWh	=	60
(1 000 hours x 60 Watts / 1 000)		
Operating cost	=	$3.30
(60 kWh x 5.5 cents per kWh)		

Ten 60-W incandescent bulbs would cost a total of $41.00 ($8 capital cost and $33 for operation), based on 1 000 hours of operation.

Compare to a 9-W fluorescent bulb:

Purchase price	=	$25.00
Lifetime	=	10 000 hours
Watts	=	9
kWh	=	90
(10 000 hours x 9 Watts / 1 000)		
Operating cost	=	$4.95
(90 kWh x 5.5 cents per kWh)		

One 9-W fluorescent bulb would cost a total of $29.95 ($25 capital cost and $4.95 for operation).

As shown above, one 9-W fluorescent bulb is much less costly than ten 60-W incandescent bulbs for 10 000 hours of operation.

Fluorescent	Incandescent
5 Watt	25 Watt
7 Watt	40 Watt
9 Watt	60 Watt
13 Watt	75 Watt
18 Watt	75 Watt to 100 Watt
22 Watt	150 Watt

Bulb Replacement

In addition, despite the "warm" light that compact fluorescents are reputed to give off, the designers found the lights ugly and the light uninviting. As a consequence, the designers put more emphasis on the fixtures.

Finally, remind designers about your energy efficiency concerns. For most designers, lighting is their chance to make a statement — but not necessarily a statement about energy efficiency.

Total wattage installed in the Advanced House using energy efficient lights was 1 750. Had conventional bulbs been used, total wattage would have been 4 000.

Other Issues

There are several points the builder should be aware of when using compact fluorescents. Firstly, the lamps are only now becoming widely available, though every major lighting manufacturer makes them. It is anticipated that as demand escalates, so will availability.

Installation is not an issue. They srew in like any other bulb, though some models do require adaptors. The issue is the lighting fixtures. In general, the bulbs are longer than incandescents and standard fixtures will not always suit them. In the case of the Advanced House, most lighting contractors had to adapt to existing fixtures, though some, such as Raak, manufacture suitable fixtures. The bottom line is to ensure that fixtures and bulbs match before the start of the project, to prevent searching at the last minute.

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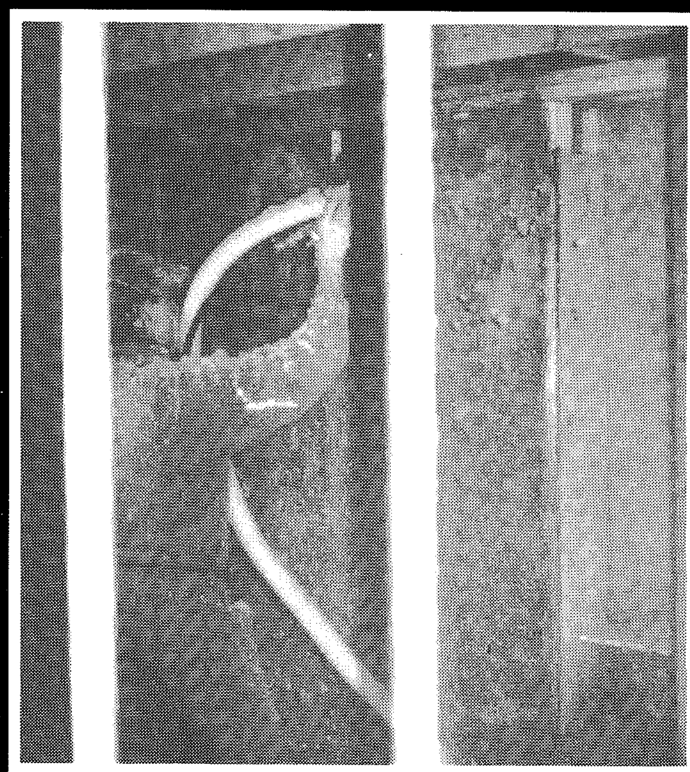
INSIDE THE WALLS: SPRAY CELLULOSE INSULATION

ADVANCED HOUSE TECHNOLOGIES



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Également disponible en français sous le titre *"Technologies de la Maison Performante : Projection d'isolant de cellulose à l'intérieur des murs"*.

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ISBN 0-662-18923-X

INSIDE THE WALLS: SPRAY CELLULOSE INSULATION

The Advanced House represents a remarkable improvement in energy performance over conventional houses and even over the energy efficient R-2000 home. By using new technology in each aspect of the construction, from the building envelope to the mechanical system, the Advanced House realizes a 75% saving in energy consumption in comparison with a similar home built to the Ontario Building Code and more than 50% to a house built to R-2000 standards. With the assistance of the Cellulose Insulation Manufacturers Association of Canada (CIMAC), the Advanced House demonstrates a new approach to wall insulation and a new product, spray cellulose. The choice of this product is even more remarkable, given the concern in recent years about preventing condensation and moisture accumulation in wall cavities.

Above-Grade Walls

The insulation technique at the Advanced House begins with a double stud, exterior load-bearing wall, one which is quite familiar to builders of R-2000 homes. A structural wall of 38 mm x 89 mm (2 x 4 in.) lumber is constructed on the platform frame in the usual way. A second, non-load bearing wall is then built on the interior, and erected so that it is spaced sufficiently apart from the structural frame to allow for appropriate insulation thickness. The wall cavity at the Advanced House can accommodate 241 mm (9.5 in.) of insulation. The thermal resistance of the completed wall assembly is RSI 7.0 (R40).

Compared to other wall systems, the exterior load-bearing, double stud wall presents several advantages. The system uses conventional platform framing and dimensioned lumber. Also, since framing of the second stud wall and all of the sealing work takes place inside the house, more of the work can be completed during bad weather.

For environmental, cost and performance reasons, cellulose was the preferred insulation at the Advanced House. Since the material is made from recycled cellulose, the raw material is inexpensive and environmentally friendly. Cellulose insulation can also fill all voids in the wall cavity, thereby reducing convection within the wall, and contributing to a reduction in air leakage as well.

Standard dry-blown cellulose was used in the ceilings and in the interior wall cavity on the basement walls. Spray cellulose was chosen for the above-grade walls at the Advanced House because it could be applied to an open cavity and because it is less expensive and more fire resistant than spray-applied foam insulation.

Spray Cellulose

Spray cellulose consists of dry cellulose material mixed with water on application. Although the moistened cellulose forms a cohesive mat and adheres to the surface on its own, the addition of a small amount of dry adhesive during manufacture improves the finished product.

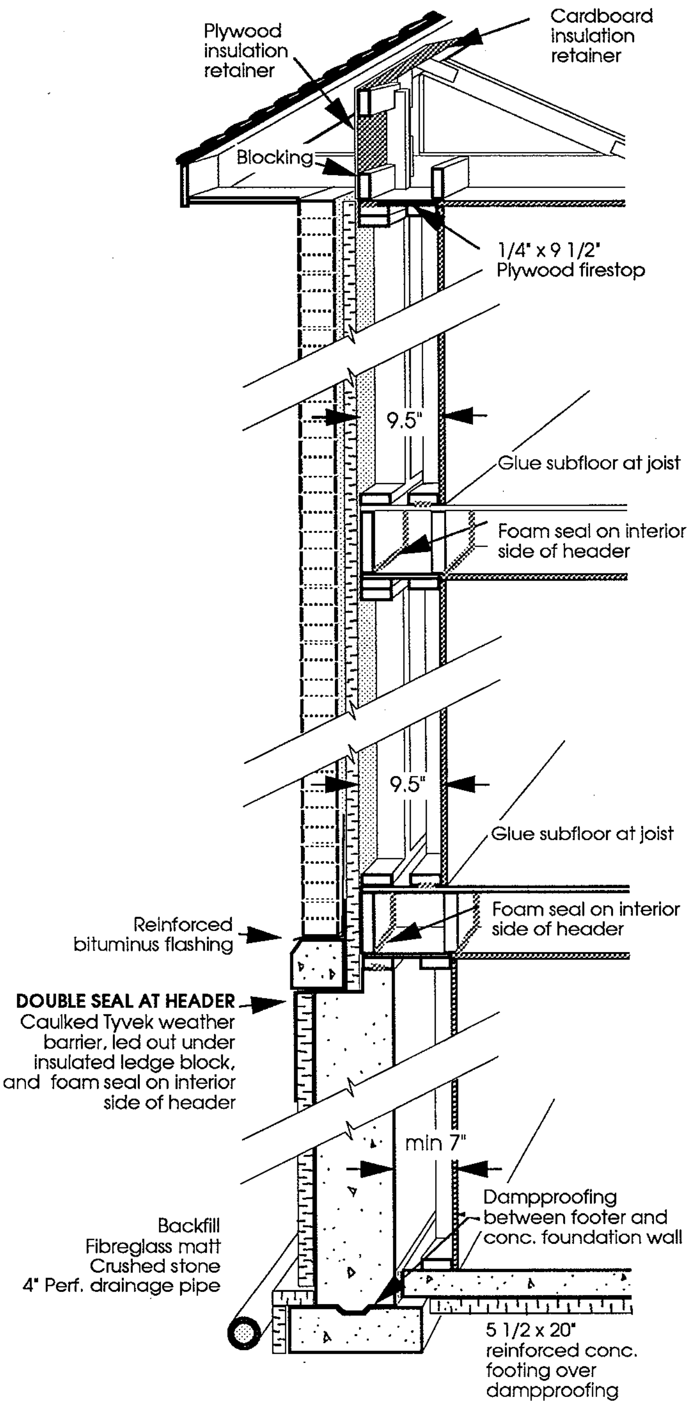
Three types of spray cellulose are currently in use. The first type is used in commercial and industrial applications. It consists of a finely ground dry material and an equal amount of water by weight. The second, used at the Advanced House, is the spray type. It is based on the same cellulose material used in attics; the dry material is mixed with an equal weight of water during application. A small amount of adhesive may be added to the dry material before or during application. No adhesive was used in the installation at the Advanced House. The third spray system uses a drier mix (twenty parts of water to every 100 parts of insulation). An adhesive is added to the dry material and a mesh retainer is used to hold the insulation in place.

In Canada, the most common application for spray cellulose has been in commercial and industrial buildings where the material is applied to exposed surfaces and serves as the interior finish. The use of spray cellulose for residential applications is not as widespread for two main reasons. Firstly, compared to batt type insulation, the installation is complex, requires additional equipment and specialized trades which results in a slightly higher installed cost. Lastly, there is a concern that moisture seeping into the cavity of a wood frame wall causes rot.

In the Maritime provinces and in Alberta, spray cellulose insulation is a preferred alternative because of its ability to reduce convection and air leakage in the walls. An Alberta company, Can-Cell Industries, introduced this concept in Canada after it found that the spray system was extensively used by residential builders in the United States. In 1988, Can-Cell conducted a study of the technology under the Alberta Municipal Affairs Innovative Housing Technology Grants Program, in order to develop the technology for Canadian conditions. Part of the study included testing which determined that moisture added to the wall cavity from the wet-spray insulation dissipated over a relatively short time after installation. Another study in the Maritimes showed that the spray cellulose dried out even in a humid climate and that it retarded mould growth in the wall cavity.

Since the completion of the Advanced House, a new insulation system has become available. Developed in Denver, Colorado, the product uses dry-blown type cellulose mixed with water and a latex adhesive; a fine nylon mesh is stapled across the studs to retain the insulation.

The mesh retainer allows the installer to apply the material at a comparable density to the direct spray method, but with less water. This allows less exposure of the framing materials to moisture. Some reduction in labour cost is also achieved: by using the mesh retainer, the cleanup and recycling of over-spray material experienced with the direct spray method can be avoided. The direct spray system however, avoids the cost of supply and installation of the mesh. On balance though, both systems appear to achieve the aim of providing a full, form-fitting cavity fill insulation that performs very effectively.



CEILING R-60
18" insulation

ABOVE GRADE WALL R-40
brick veneer
1" air space
building paper
1 1/2" Glasclad, seams taped
2 x 4" bearing stud with diagonal bracing
2 1/2" space
2 x 4" non-bearing stud
9 1/2" blown insulation
6 mil sealed poly AVB
1/2" drywall

HEADER BAND R-40
brick veneer
1" air space
building paper
1 1/2" Glasclad, seams taped
2" header c/w cont. foam seal
7" blown insulation
2" extruded polystyrene blocking, foamed in place

ABOVE GRADE WALL R-40
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7" blown insulation
2" extruded polystyrene blocking, foamed in place

FLOOR SLAB R 4.2
4" conc. slab
6 mil poly dampproof membrane
2" baseclad insulation
5" crushed stone on compacted fill

High Levels of Insulation

Availability and Acceptance

Spray-on materials are mixed on site. Consequently the manufacturer of the raw material (the dry cellulose) has a different relationship with installers. Instead of simply purchasing the material, the installer becomes a licensed agent of the manufacturer, supplying the 'finished' product on site. The manufacturer, in turn, provides training for installers and quality assurance for customers.

Approvals for materials that are manufactured on site include specifications for the 'raw' materials and directions as to how the material must be applied. All cellulose, whether blown or sprayed must meet acceptable or mandatory levels for corrosion resistance, smoulder resistance, flame spread classification, fungi resistance, thermal resistance, density and moisture absorption. In addition, the standard CAN-CGSB 92.2-M90 stipulates requirements for both cellulose and mineral fibre materials that are spray applied.

Spray-on insulation is not dealt within the National Building Code, or in some provincial codes, but provincial authorities often determine the acceptability of materials. For example, Can-Cell's Weathershield wet- spray insulation has a product listing in Alberta.

In addition to these codes and standards, materials must receive Canada Mortgage and Housing Corporation (CMHC) approval before they can be used on some types of buildings. To obtain CMHC approval, materials are tested through the Canadian Construction Materials Centre (CCMC). The dry-blown type cellulose system was evaluated in CCMC Report 11790-R and approved for use as thermal insulation under the National Building Code. CMHC is reserving judgment on the spray cellulose system until the results of field installations are available. An industry-government Task Force has been set up to oversee the field tests, determine the performance parameters of spray cellulose in house walls and develop a draft standard (CCMC 07215).

Design and Installation Considerations

Staff at the Canadian Construction Materials Centre raise several issues surrounding the use of the spray cellulose that will need to be resolved before the material gains universal approval. The major concerns are the manufacture of the basic material, design of the wall system, control of the application and suitability for different climates.

Manufacture: The addition of borates to the cellulose will help prevent mould growth in the wood framing as well as in the cellulose. The addition of adhesives allows for a drier application, shorter drying time and less exposure of the framing to moisture.

Wall Design: Care should be taken in the design of the wall system and choice of exterior sheathing to avoid a double vapour barrier situation. The wall must be able to breathe to the outside in order to allow the cellulose to dry out completely.

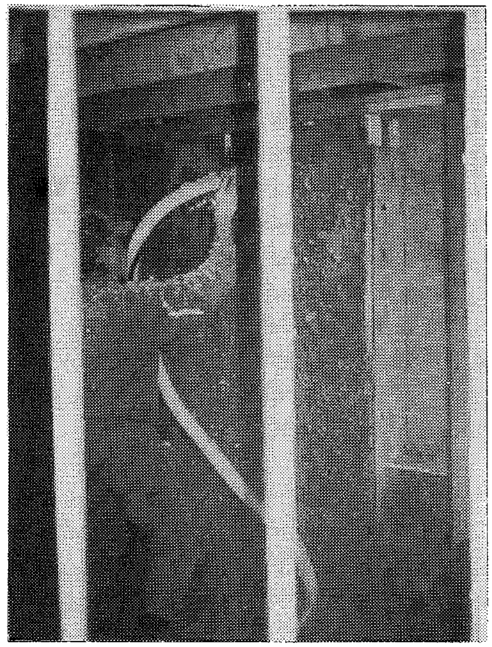
Installation: Successful application and performance will rest on several factors, some of which are controlled by the installer and some by the builder. The installer will control the applied density and the moisture content of the material, while the builder is responsible for leaving the walls open for a period sufficiently long to allow the material to dry properly. Care should be taken during installation to ensure that there are no voids or gaps in the material.

Climate: All of the above considerations will affect the moisture of the insulation material and its effect on the surrounding framing. These considerations will be even more critical in a damp climate, such as the Maritimes or Coastal British Columbia, where framing material may not be very dry to begin with. However, a study for Alberta Municipal Affairs conducted in St. Albert, Alberta indicated that moisture added during insulation was dissipated over the one-year study period.

Using Spray Cellulose

If you are considering using wet-spray cellulose in residential building, the following checklist will help to make your project a success.

- √ Ensure that appropriate changes are made to the wall design to accommodate the use of spray cellulose.
- √ Make sure that the installer you choose is a licensed agent/applicator of the manufacturer, trained in the installation of spray cellulose.
- √ Check to see that the product is approved for use in the particular application and in the jurisdiction where the project is located.
- √ Also ensure that the product is approved for use by CMHC or other financing agency, as applicable.
- √ Review the job schedule to ensure that appropriate changes are made in sequencing of trades to allow for sufficient drying time of the material before the walls are boxed in.



Resources

Cellulose Insulation Manufacturers
Association of Canada
Minto Place Postal Outlet
Box 56067
Ottawa, Ontario
K1A 7Z1
(613) 235-3027

Canadian Construction Materials Centre
Institute for Research in Construction
National Research Council
Montreal Road
Ottawa, Ontario
K1A 0R6
(613) 993-2607

Alberta Municipal Affairs
Innovative Housing Grants Program
16th Floor, City Centre
10155 - 102 Street
Edmonton, Alberta
T5J 4L4
(403) 427-8150