Energy-Saving Details

A demonstration house in Canada shows new approaches to energy-efficient, environmentally sensitive construction

Total energy cost: $800 a year. Every system in the Manitoba Advanced House was chosen according to its impact on the environment. The pine roofing is recyclable and produced with less energy than asphalt roofing. The synthetic stucco mitigates air and water infiltration, and the energy-efficient windows hold heat inside in winter while keeping it out in summer.

by Kip Park

Canada has the highest energy use per capita of any country in the world. That's not unexpected, given the country's climate. In Winnipeg, Manitoba, for example—said to have the coldest winters of any capital city outside of Siberia—temperatures can drop as low as -48°F. But in summer, temperatures can soar: The highest recorded in this prairie city of 600,000 is 108°F. That kind of climate boosts both space-heating and air-conditioning costs.

During the oil embargo of the mid-1970's, the Canadian government started the R-2000 Home Program. Houses built to R-2000 standards consumed half the energy of the typical houses being built at the time. The reduction was achieved by increasing insulation, reducing air leakage, improving window performance, using more efficient heating systems and installing a mechanical ventilation system, usually a heat-recovery ventilator (HRV).

But the R-2000 homes still used too much energy. So in 1991, Energy, Mines and Resources Canada started the Advanced House program and proposed building as many as 10 low-energy, environmentally "green" homes across the country to showcase cutting-edge and traditional technologies to chop energy bills to one-quarter of those attributed to a typical house built in 1975.

The program targeted not only space-heating and air-conditioning costs but all energy use, including embodied energy, the amount of energy it takes to produce, manufacture, distribute, install, operate and, eventually, dispose of everything that goes into a house. Advanced House techniques and technology are available from Manitoba Energy and Mines Info Center (Suite 360 Ellice Center, 1395 Ellice Ave., Winnipeg, Man. R3G 0G3; 204-945-4154).

The Advanced House had to be comfortable and convenient to live in, not forcing major changes in lifestyle. And its design had to have market appeal. There's little point in advancing technology if no one is going to buy and use it.

Energy conservation can be stylish and practical-In the fall of 1992, the Manitoba Home Builders Association (231-1120 Grant Ave., Winnipeg, Man. R3M 2A6; 204-477-5110) was the first group in Canada to construct and open an Advanced House (photo, above). According to computer simulations, it would cost about $800 a year to heat, cool, ventilate and provide domestic hot water in Manitoba's Advanced House. That's far from the $2,400 for a typical 1975 house. Both figures include about $200 a year for standby utility charges, fees to keep electrical and natural-gas lines running into the house.

Monitoring sensors and thermocouples were installed around the foundation and in wall cavities to measure moisture and temperature levels; the performance of the home was scrutinized closely through the fall of 1994,

The 1,859-sq. ft., four-bedroom Manitoba Advanced House demonstrates to contractors and tradespeople that it doesn't take a genius to conserve materials and energy. To the public, it shows that energy conservation can be stylish as well as practical and comfortable.

Reducing waste and using whiskey bottles—A major concern throughout construction was the amount of construction waste. It's been estimated that as much as 20% of materials going into landfills is construction waste. Transporting that waste to landfills is an energy cost in itself. Creating landfills eats up valuable and productive land.

"We wanted to reduce the amount of waste as much as possible," said co-designer and home-energy analyst John Hockman of Appin Associates of Winnipeg (472 Academy Road, Winnipeg, Man. R3N 0C7; 204-4884207). So the floor plan was designed to minimize construction-material waste (by using full 4x8 sheets wherever possible, for instance), and scrap lumber was used for blocking. Suppliers were advised that all packaging materials had to be made of recycled materials or be capable of being recycled.

On the roof, pine shakes (Prairie Shake Roofing, 885 Century St., Winnipeg, Man. R3H 0M3; 204-786-0813) were used instead of asphalt shingles, which require large amounts of nonre-

newable energy to produce. Pine shakes cost about 15% more than asphalt shingles, but they have a life expectancy of 30 to 50 years, after which they can be recycled.

The fill under the foundation and over the plastic drain pipes, or weeping tiles, is an indication of the imagination used. About 30% of the fill is empty whiskey bottles, smashed and pulverized on-site when tumbled in a concrete mixer with pea gravel. "We expected some problems with sharp edges of broken glass," said consulting engineer Gary Proskiw, the other designer of the house and head of Proskiw Engineering Ltd. (1666 Dublin Ave., Winnipeg, Man. R3H 0H1; 204-633-1107), which has extensive experience in residential-energy use. "The only problem we did encounter was the smell. It was like a distillery."

The ground-up bottles reduced the amount of gravel required: Gravel must be transported, cleaned and sifted, all of which consume energy. So Canada's energy use was reduced slightly by whiskey drinkers.

Split-stud walls add insulation space–Predictably, there are high levels of insulation in the Manitoba house: R-60 in the ceiling, R-42 on poured-concrete basement walls and rigid insulation under the entire basement-floor slab, totaling R-10. The 12-in. thick exterior walls have an R-value of 46. The walls are a split-stud system (photo, bottom right, where the exterior 2x4s are separated from the interior 2x3s by 6-in. long, ⅛-in. dia. metal rods. Manufactured by Ten Lives Industries (60 Heaton Ave., Winnipeg, Man. R3B 3E3; 204-956-2860), these wall trusses are easier to install than a site-built double wall. The wall trusses use less lumber than a double wall, yet the trusses are stiffer because of the metal rods, which conduct less heat through walls than a full stud. In conventional wall systems, about 18% of the wall area is made up of studs; a 2x6 stud has an insulating value of about R-7.

The high-performance thermal envelope features rim joists covered with housewrap (photo, bottom left), which adheres to the structure with acoustical sealant. On the interior side, a 6-mil polyethylene air/vapor barrier is sealed to the housewrap (drawing, right). The barrier is nearly hole-free; it goes up the wall and into the joist cavities, where it's stapled to the joist faces only.

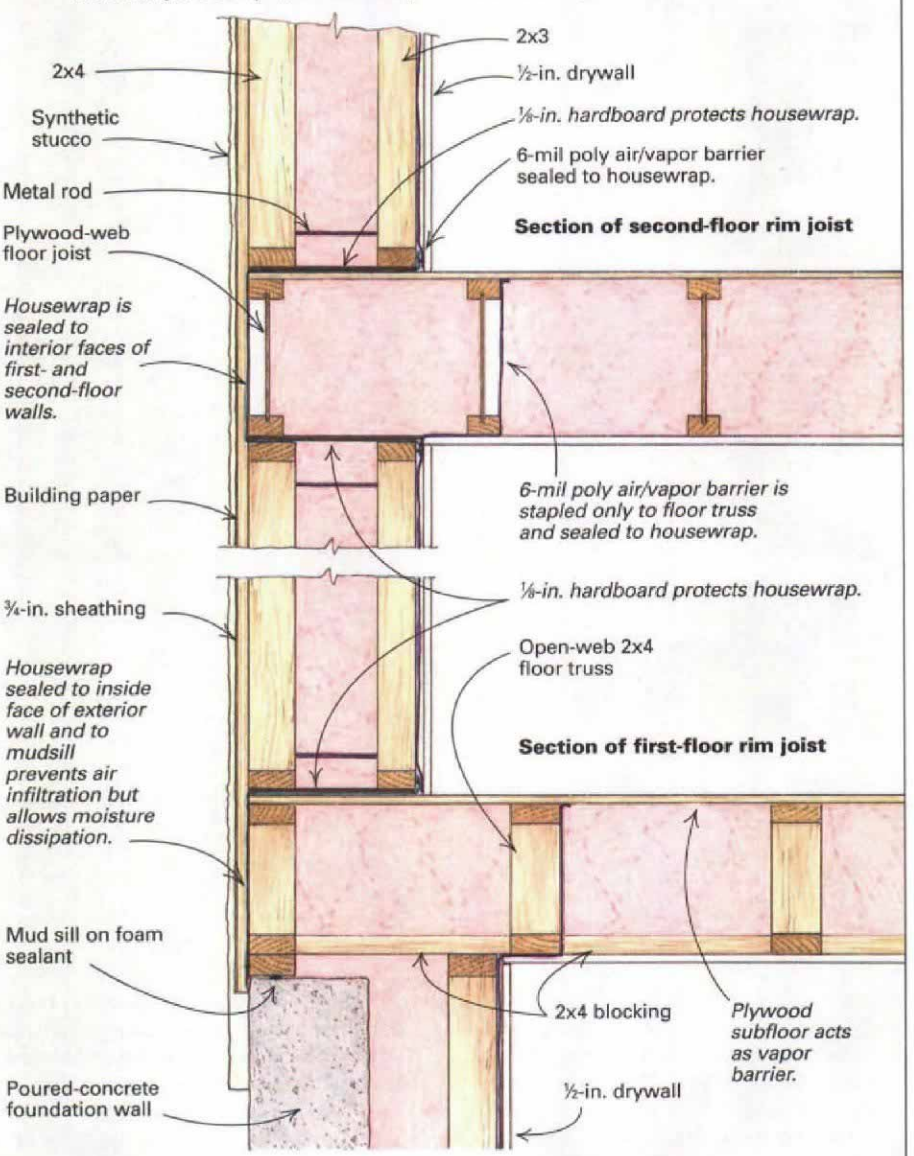
The combination of housewrap and air/vapor barrier is engineered for a cold climate. The poly stops moisture from entering the wall, and the housewrap stops air from flowing in or out, yet it allows any moisture in the wall to escape.

The air/vapor barrier is sealed to the electrical boxes, which have adhesive gaskets (Nu-Tek Plastics Inc., 25-11151 Horseshoe Way, Richmond, B. C. V7A 4S5; 604-272-5550). The Manitoba Advanced House, when tested with a blower door, had an air-change rate (achSO) of 0.78 per hour at 50 Pascals; requirements call for 1.5 ach50 (the tightest house in Canada, also in Winnipeg, had less than 0.20 achSO when it was built in 1982).

Conserving natural resources–Very little large-dimension lumber was used in the Manitoba Advanced House. "The largest pieces

Controlling infiltration at the rim joist.

This combination of housewrap on the rim joist and air/vapor barrier on the inside faces of the walls and the floor trusses prevents wintertime indoor humidity from accumulating in the rim-joist cavity. The housewrap blocks air infiltration but allows any moisture that sneaked past the air/vapor barrier to escape. Acoustical sealant was used because it bonds well to the poly materials and eliminates staple holes.



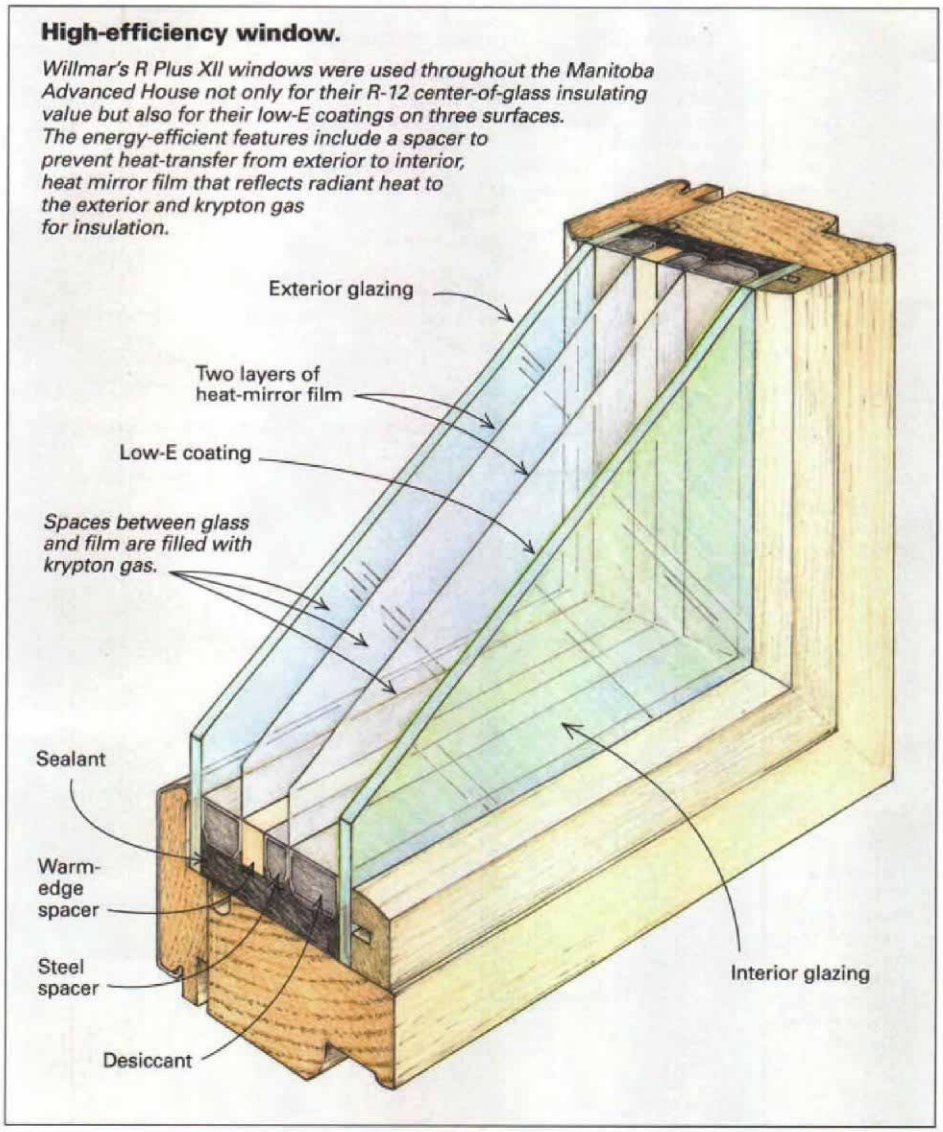
Wrapping the rim joist in Tyvek and then sealing the vapor barrier to it traps interior air but allows moisture to escape.

Manufactured wall trusses, 2x4s and 2x3s joined with metal rods, allow for 12 in. of insulation. The metal rods stiffen walls and reduce thermal bridging.

Photos this page: John Hockman and Gary Proskiw

High-efficiency window.

Willmar's R Plus XII windows were used throughout the Manitoba Advanced House not only for their R-12 center-of-glass insulating value but also for their low-E coatings on three surfaces. The energy-efficient features include a spacer to prevent heat-transfer from exterior to interior, heat mirror film that reflects radiant heat to the exterior and krypton gas for insulation.



of lumber are 8-ft. long 2x8s," said Glenn Buchko, executive director of the Manitoba Home Builders Association, which acted as general contractor for the project. The 2x8s were in the garage-door headers.

The first-floor joists are open-web trusses made of 2x4s; the second-floor joists have finger-jointed cords and a plywood web. Why use two different trusses? The open-web joists allowed for large ducts and conduits; the closed-web joists use less material. Both types of truss "dramatically reduced our need for large-dimension lumber, thus lowering the demands we impose on our forests," said Buchko.

Water conservation is also a major factor in the Manitoba Advanced House. Water-efficient toilets, shower heads and faucets reduce water usage without sacrificing performance. Low-flush toilets use about 1.5 U. S. gallons per flush, compared with 3.5 gallons for conventional toilets.

Infrared sensors (Crane Canada Inc., 5850 Cote-de-Liesse Road, Montreal, Quebec H4T 1B2; 514-735-3592) on bathroom water faucets automatically turn water on and off when hands are removed from beneath the faucet.

Landscaping includes drought-resistant native plants, which are adapted to Manitoba's dry summers. These plants reduce watering requirements and provide summertime shade and a comfortable, attractive climate around the house.

There's even a system to collect and store rainwater from the roof and from the sump pit for use in watering the lawn and garden.

Windows for all seasons—The Manitoba Advanced House is oriented to maximize passive-solar heat gain—but with a difference. The program called for window treatments that would control summertime overheating. The most energy-efficient windows in Canada, Willmar's R Plus XII (drawing, above), were installed throughout (Willmar Windows, 485 Watt St., Winnipeg, Man. R2L 2A5; 204-668-8230). They're considered quadruple-glazed, though two of those glazings are actually Heat Mirror 88 film, which reflects radiant heat while it transmits 88% of the light, suspended between two panes of glass. The inner light has an additional soft low-E coating, and the air spaces are filled with krypton gas. A special spacer-bar system was developed to keep the edges of the lights warmer than conventional-window edges, and center-of-glass insulation values hit R-11.5. R Plus XII windows cost about one-third more than conventional double-glazed windows.

To prevent solar overheating in summer, all windows are equipped with removable solar screens, which block about 30% of solar radiation. That reduces the cooling load by more than one-third and, when combined with the house's ventilation system, also eliminates the need for air conditioning.

Heating and ventilating—On the mechanical side, a 94% efficient natural-gas water heater with a custom-built air handler (Mor-Flo Industries Inc., division of American Water Heater Group, P. O. Box 4056, Johnson City, Tenn. 37602; 615-283-8000) heats both the home (forced hot air) and the domestic hot water. The unit's high efficiency is achieved in part by circulating warm greywater, the wastewater from such things as washing machines and dishwashers, through a heat exchanger (drawing, facing page) to preheat water going to the boiler.

Indoor-air quality is maintained by a heat-recovery ventilator (HRV), which preheats incoming air. The modified Lifebreath 195 HRV (Nutech Energy Systems Inc., 511 McCormick Blvd., London, Ont. N5W4C8; 519457-1904) mixes fresh air with return air, and all air is then filtered through an 85% efficient bag filter to remove dust and fine particulate matter. The air then passes through an activated-charcoal filter to remove odors and chemicals before it is heated and distributed.

The home is divided into four heating zones—all forced hot air except for hot-water baseboard in the fourth bedroom, which I'll explain in a minute—allowing one area of the home to receive fresh, heated air, while another (unoccupied) area still can receive fresh, unheated air. To ensure high air quality and to prevent the chronic problem of mold growth in cold closets, return-air vents, which pull stale air from the room, are installed in all bedroom closets. The location of these vents improves overall air quality, too. "Clothing can be a significant source of indoor-air pollution because of chemicals used in dry cleaning," Proskiw noted. "Here, we're eliminating them at the source."

The fourth bedroom, on the main floor, can be used as a den, a hobby room or a smoking room. It has its own separate exhaust-air system, so any noxious odors or chemicals produced by hobbies or smoking are exhausted directly outside. For the same reason, this is the room heated with hot-water baseboards.

Great care was taken in selecting materials used inside the home to ensure good indoor-air quality. For instance, the technical requirements as issued by Energy, Mines and Resources required that products containing urea-formaldehyde-based resin glues, such as the chipboard used in the kitchen cabinets, be sealed to limit formaldehyde outgassing. Indoor air could not contain any more than 0.05 parts per million of formaldehyde.

Using less electricity—"There are two major factors affecting the energy performance of any

Drawings: Christopher Clapp

house—the structure itself and the people who live in it," said Hockman. In the Manitoba Advanced House, a Power Sentry power-usage indicator was installed above a desk in the kitchen to show present and cumulative use of electricity (Northwest Extension Inc., 15 Central Way #201, Kirkland, Wash. 98033; 206-828-9190). The power-usage indicator also presents data in dollars and cents.

In other installations, this type of information system, which makes homeowners aware of just how much electricity is being used at any moment, has resulted in an immediate 10% to 20% reduction in consumption. "It's an awareness thing," said Proskiw.

The appliances by General Electric are among the most energy-efficient models on the market. The clothes washer is rated at 74kwh per month, compared with conventional washers that can use 150kwh. The refrigerator is rated at 55kwh compared with similarly sized conventional units that can use as much as 85kwh per month.

Artificial lighting was considered important because Winnipeg receives only about eight hours of daylight per day during December. High-efficiency fluorescent and halogen lighting fixtures are used throughout most of the house. Less-efficient incandescent lighting is restricted to fixtures that are seldom used, such as closet lights, because the incandescent lights are a lot less expensive. The Manitoba Advanced House also makes extensive use of dimmers and automatic light switches to promote energy savings and to increase convenience.

In Winnipeg's cold winter climate, engine-block heaters and and vehicle-interior warmers keep cars from freezing up. Because these comfort devices use lots of electricity, an indoor timer automatically switches on the heaters about two hours before vehicles will be used.

Future repercussions—There are a multitude of features in the Manitoba Advanced House, many of them simple in concept. "All the features had to be as practical as possible, with the widest potential application," said Hockman. "This type of house will be aimed at the mainstream in the very near future."

The principles learned and demonstrated in the Manitoba Advanced House eventually could be transferred to the renovation industry. Because much of the technology incorporated in the Manitoba Advanced House is cutting-edge, it is, therefore, expensive. The lessons learned in Winnipeg, however, will help that technology develop further, and the cost of renovating existing homes will drop.

Although its monitoring systems made the Manitoba Advanced House about 25% more expensive than a conventionally constructed home, the house is truly a demonstration that energy-efficient, environmentally friendly, "green" houses are practical and ready to stand the test of the marketplace. □

Kip Park lives in Winnipeg, Manitoba, and he writes about housing, construction and energy-technology issues. Photo by the author except where noted.

An energy-efficient heating and ventilating system.

Using one-third the energy of a typical house built in 1975, the Manitoba Advanced House incorporates heat-capturing devices, energy-efficient appliances and multiple heating zones. Incoming water is warmed in a custom-built preheater that captures heat from dishwasher and laundry wastewater; the preheated water then goes to a highly efficient gas water heater and is distributed to the domestic hot water and the heating system. The ventilating system, required in the airtight Manitoba house, pulls outdoor air through a heat-recovery ventilator, which warms the air with the residual heat of stale air that's exhausting from the house. The warmed incoming air mixes with recirculated indoor air and is filtered twice, then sent to one of four separate heating/ventilating zones. All fan motors are more efficient than conventional fan motors.