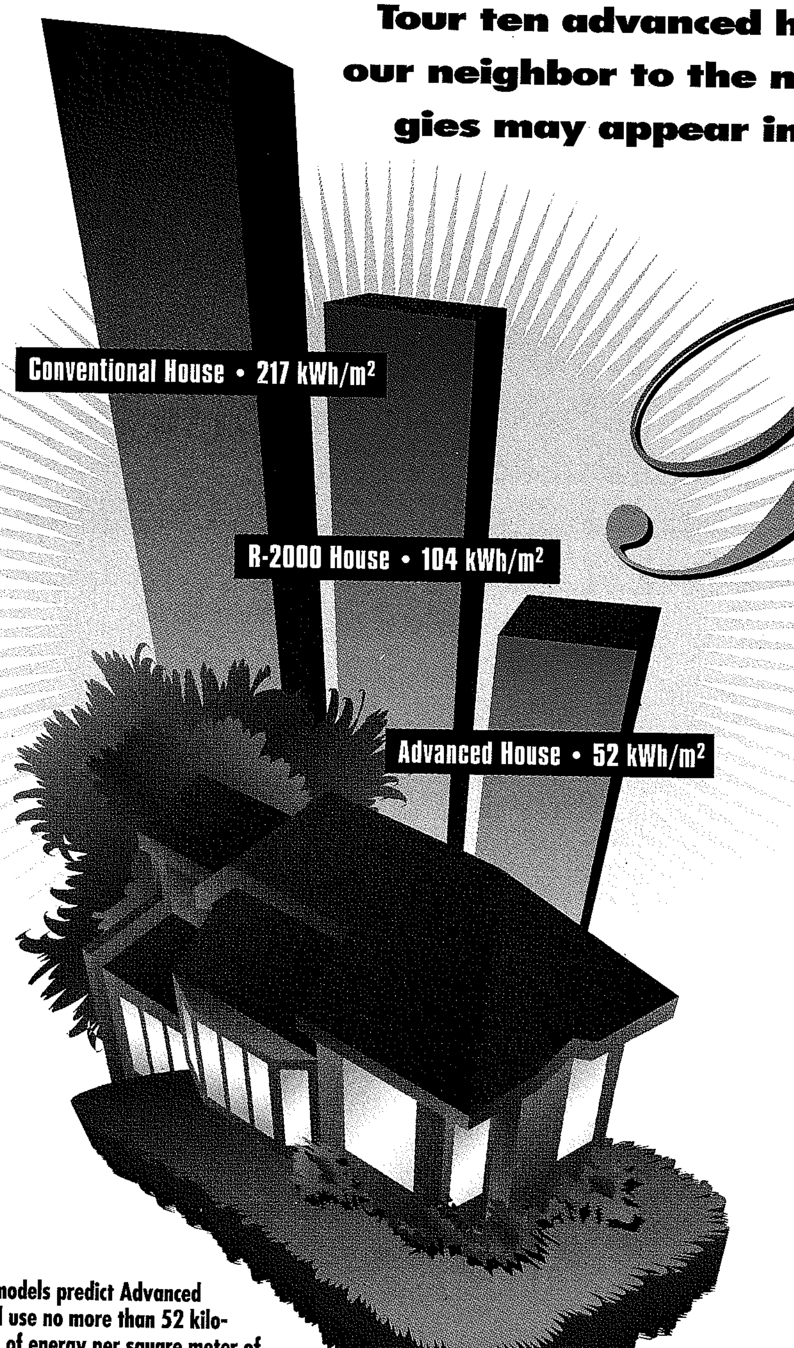
CANADA'S ADVANCED HOUSES

Tour ten advanced house designs from our neighbor to the north. Their technologies may appear in U.S. homes soon.

BY DAWN STOVER



Computer models predict Advanced Houses will use no more than 52 kilowatt-hours of energy per square meter of floor area, including basements. That's half the annual energy consumption of the average R-2000 house, and less than one-fourth that of the typical Canadian house built to code in the late 1970s.

Probably because of its cold climate, Canada is a world leader in energy-efficient housing. The United States is five to ten years behind its neighbor, most housing experts agree. So POPULAR SCIENCE went to Canada to learn about a group of state-of-the-art homes, dubbed Advanced Houses.

Ten Advanced Houses, winners of a nationwide competition, have been constructed across Canada. Entrants met stringent requirements: The houses will use half as much energy as those in the well-regarded R-2000 program that Canada has been pushing for a decade, and one-fourth the energy and half the water of conventional homes. Builders also focused on indoor air quality and resource-conserving materials choices.

These targets were met in different ways. "Each house is not the archetypical house of the future, but one set of solutions," explains Tim Mayo of Canada's energy department. Intended as benchmarks for the Canadian building industry, the houses are the proving ground for new technologies and products that should drive future housing development. Seven of eight windows that were prototyped for the project are now on the market, for example. "We're trying to push the mainstream industry as far as it can go, and then just a bit further," says Mayo. Looking at the group of Advanced Houses as a whole, it is easy to identify some emerging trends:

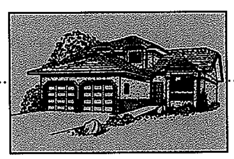
• Builders are using more engineered-wood products. Premanufactured truss walls comprised of inner

TOM WHITE

and outer wood studs separated by plywood webs or metal spacers were used in three houses, for example. This allows for wall cavities up to 12 inches deep, but uses only small-dimension lumber. Only three houses have a traditional 2x6 wall-framing system.

- Six houses are insulated with recycled materials such as cellulose, which is made from waste newsprint. Two houses use newer, high-density fiberglass batts that contain some recycled glass.
- Three houses feature quadruple-glazed windows with gas fills, non-metal spacers, and low-emissivity coatings that reflect heat but transmit visible light. Five houses have triple-glazed windows.
- The houses integrate space heating, cooling, ventilation, and water heating. Ground-source heat pumps provide heating and cooling in three houses. Another four use high-efficiency systems that integrate gas heating and domestic-hot-water requirements.
- Occupancy sensors control ventilation in seven houses.
- Renewable energy sources are gaining a foothold. Solar panels heat water for six houses; five of the six also have photovoltaic-powered pumps. Solar energy generates electricity for two houses; another one has wind power.
- All but two of the houses incorporate some type of home-automation system to control lighting, security, heating and cooling, and more.

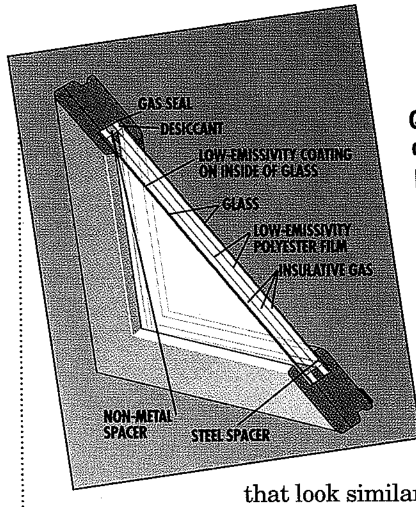
The Advanced Houses will be open to the public for a year, then sold, and finally monitored for a year under normal occupancy. Although the houses rely on a variety of experimental technology, they don't look out of place in neighborhoods of conventional homes. Each house's total project cost was about $700,000 to $800,000 (Canadian); much of the expense comes from designing and installing prototypes, which can be more costly than off-the-shelf products. The houses will sell for prices typical in their neighborhoods; the three that have already sold went for $185,000 to $250,000 (Canadian). Here are some innovative features a visitor might see on a quick tour of the houses.



BREATHING EASIER

Indoor air quality received special attention in the design of the Manitoba Advanced House in Winnipeg. The hobby room, which could also serve as a home office or smoker's room, has its own ventilation system. Other "healthy house" touches include a special bag filter to capture particles, floors made from natural cork, a basement floor sealed to prevent the entry of radon (a naturally occurring soil gas that may be implicated in some lung cancers), and return air vents located in the closets to remove dry-cleaning fumes and other pollutants.

Eyes on energy: This meter helps occupants watch electricity consumption.



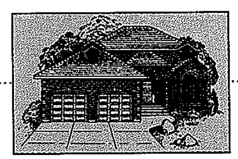
Quadruple-glazed windows have two glass panes and two layers of polyester film.

STEVE STANKIEWICZ

The Manitoba House needs no air conditioning. During the summer, overhangs help keep sunlight from penetrating windows. The windows also have clip-on solar screens that look similar to regular screens but reduce heat gain by about 30 percent.

Although temperatures in Winnipeg can drop to -40°F in the winter, the house's windows gain more energy than they lose—even on the colder north side. To find the best windows for the job, the team that built the house held a competition. The winner: quadruple-glazed Willmar windows with two Heat Mirror polyester films, an additional low-emissivity coating on the inner pane of glass, insulative spacer bars, and a gas fill that is 80 percent krypton and 20 percent argon. The windows have an insulative value of R-12, which is as good as some conventional walls, says project manager John Hockman of Appin Associates. Now on the market, they cost about 40 percent more than triple-glazed windows, which are standard in new Winnipeg homes.

Other details include a natural-gas refueling station next to the garage, an under-sink compost handler that is kept under negative air pressure to prevent odors from escaping, and an energy-use meter that helps reduce consumption by telling occupants how much electricity they're using in dollars.



SOMETHING NEW UNDER THE SUN

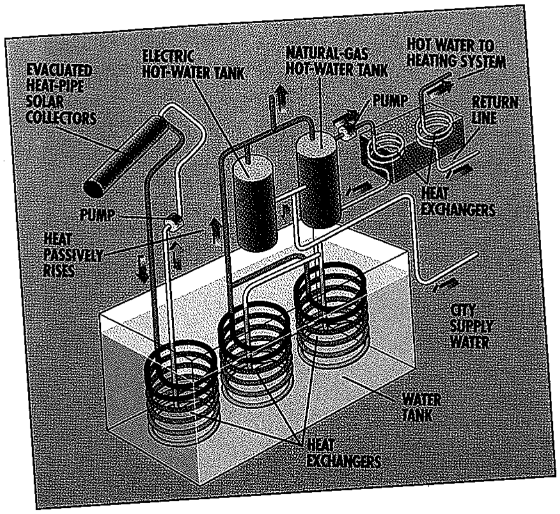
The four-bedroom Saskatchewan Advanced House in Saskatoon makes ample use of solar energy. A photovoltaic panel on the roof generates 1.9 kilowatts, about 10 percent of the electricity used in the house. The panel provides enough juice to run a Photocom refrigerator, which uses about one-third the electricity of an average fridge (typically the biggest energy gobbler in a house). The photovoltaics also power the heating and cooling systems. Surplus electricity is stored in batteries.

Evacuated heat-pipe solar collectors on the roof capture heat and transfer it to a 750-gallon insulated water-storage tank in the basement. From there, the heat passively rises into a pair of domestic hot-water tanks mounted on top of the storage tank. These two tanks provide hot water for the kitchen, bathrooms, and laundry. Via a heat exchanger, they also transfer heat to water circulating through a radiant-floor-heating system. The two hot-water tanks provide backup heat when the solar storage tank in the basement can't meet the demand. "This is a very simple system," claims designer John Carroll. "The three pumps are the only moving parts."

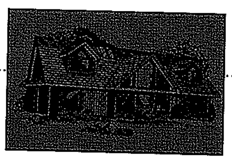
The Saskatchewan House also has radiant cooling, which, unlike conventional air conditioners, requires no CFCs, or chlorofluorocarbons. Water is pumped through 2,300 feet of tubing in the ceilings of the main and upstairs levels, where it picks up heat from aluminum collector plates. The water then flows through another 1,600 feet of tubing buried in the ground beneath the floor slab and in the backfill. Cooled to about 50°F by the soil, the water recirculates to the ceilings.

To conserve water, the backyard's concave shape channels the flow toward the grass to water the yard.

STEVE STANKIEWICZ



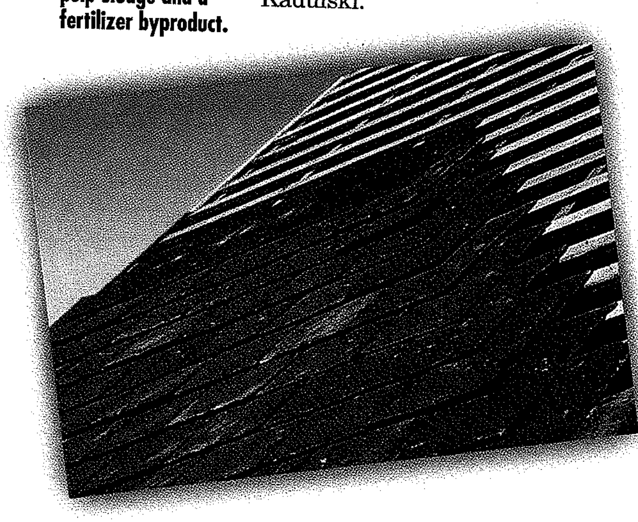
Stored in a large tank, heat (red arrows) captured by solar collectors rises into a pair of tanks that provide domestic hot water and radiant floor heating. (Blue arrows are cool fluids.)



PANELS: SOME ASSEMBLY REQUIRED

Located in the Vancouver suburb of Surrey, the British Columbia Advanced House uses a variety of prefabricated components. The second-floor walls and the roof are made from stress-skin panels, which are stronger than conventional double-stud walls, require less lumber, and can be mass-produced. "What we're really doing is moving the construction off site and into the factory, where there's better quality control and more efficient materials use," explains architect Richard Kadulski.

Prototype roof tiles look like slate but are made from paper pulp sludge and a fertilizer byproduct.



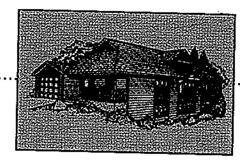
Each stress-skin panel has a layer of HCFC-blown polyurethane sandwiched between two sheets of plywood. Because they are manufactured using HCFCs (hydrochlorofluorocarbons) instead of CFCs, the panels are potentially less damaging to Earth's ozone layer.

Strolling around the house, an informed visitor can spot many recycled materials. The foundation and landscaping contain crushed glass, the rubber pavers are made from old tires, and the deck is recycled plastic. The roof tiles, developed by Vancouver-based C-Max Technologies, are particularly noteworthy. They look like slate, but are made from a fire-retardant weather-resistant combination of two waste products: pulp sludge produced by local mills, and a cementlike material made from a fertilizer byproduct.

Local inventors devised two other products. The Touch Tap in the shower allows occupants to preset the temperature and flow rate for each person in the house, says Kadulski. And the Ventex toilet, with a fan that vents odors from the bowl through a pipe to the outside, removes about 85 percent less air than a bathroom ceiling fan. Homeowners turn on another fan when they take a bath or shower.

Household waste goes into a tank buried under the front lawn, where microorganisms break down the solid materials. Only the liquids continue on to the city sewer system, reducing the need for municipal waste treatment.

The most sophisticated element of the house is its home-automation system. The house is prewired so that appliances can "talk" to each other. If the doorbell or telephone rings, for example, the vacuum cleaner automatically stops.



WASTE NOT, WANT NOT

The Waterloo Region Green Home, located an hour west of Toronto in Waterloo, Ontario, takes what some have called a "low-tech" approach to energy efficiency and environmental responsibility. "We consider that a compliment," says project manager John Kokko of Enermodal Engineering Ltd.

The project team used no CFCs in the house, and selected a variety of recycled materials including: siding made from sawdust, a steel roof made from junked cars, carpeting made from plastic soda bottles, and a refurbished bathtub and sink.

One of the team's goals was to virtually eliminate construction waste. "We never had a dumpster on site," says Stephen Carpenter of Enermodal. While builders typically send about 2.5 tons of waste to the landfill for every house they erect, the Waterloo team generated just two garbage bags

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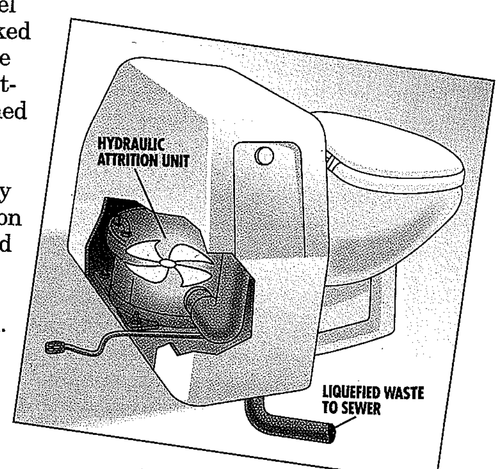
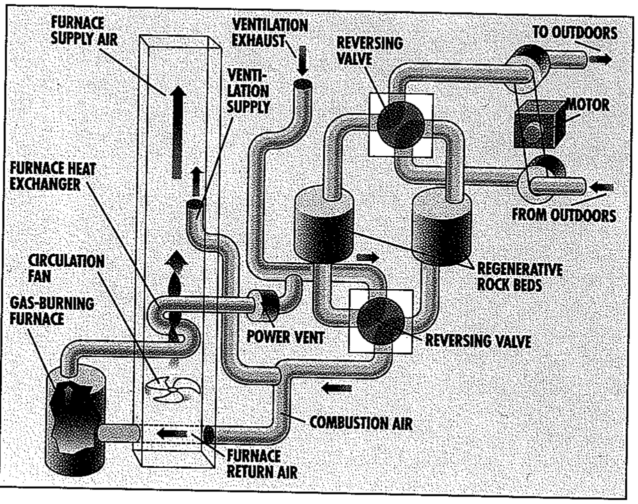


A liquefying toilet uses one-third as much water as other low-flush toilets.



STEVE STANKIEWICZ

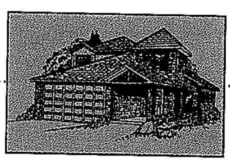
In this heat-recovery system, one rock bed is heated with furnace and ventilation exhaust, while a second rock bed heats incoming air. Every five minutes, valves switch the airflow to the two rock beds.

weighing about ten pounds apiece.

The team used only half the concrete that would be required for a poured-in-place foundation by adapting engineered concrete wall panels for the foundation. Flat on one side, the precast panels have steel reinforcing on the other, wafflelike side to give them the strength of a conventional foundation.

The house's heating system, developed with the Canadian Gas Research Institute, uses a conventional natural-gas furnace joined to a heat-recovery ventilator (HRV) with two briefcase-size containers of gravel. Furnace flue gases and ventilation exhaust from the bathrooms heat one set of rocks, while the second set of rocks heats incoming fresh air. Every five minutes, a pair of valves reverses the airflow to the two compartments, so the heated rocks are cooled, and the cooled rocks are heated. Because the rocks are cheaper than a stainless-steel heat exchanger, the furnace/HRV system could be manufactured less expensively than its competitors. It will be field-tested in 20 other Canadian houses this year.

One innovation Kokko and Carpenter can't resist pointing out is a "toilet with a twist." Made by Control Fluidics of Greenwich, Conn., the Fluidizer toilet contains a blenderlike device that liquefies solid waste and toilet paper. The patented toilet uses just two quarts of water for each flush; other low-flush toilets use one and a half gallons, and standard models use three gallons. The Fluidizer could become commercially available as early as June.



ALL TRUSSED UP AND READY TO GO

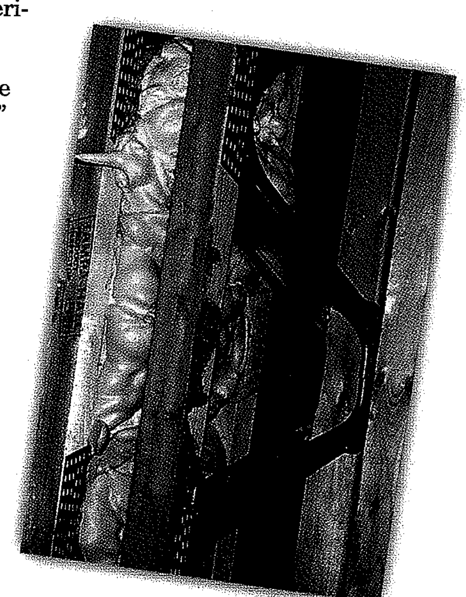
Metal-web trusses are premanufactured units commonly used in floors. "Stand that floor system on its side, and you've got a wall," says Paul Duffy, an engineer at Buchan, Lawton, Parent Ltd. in Toronto, and project manager of The Novel Environmental Advanced Technology Home, or NEAT Home, in Hamilton, Ontario.

Truss walls provide high levels of insulation without requiring increasingly scarce and expensive large-dimension lumber. "There's nothing bigger than a 2x5 in the whole house," says Duffy.

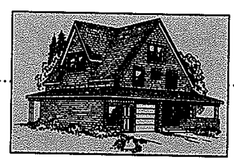
The NEAT Home's 11-inch-thick walls consist of 2x3 studs separated by a metal web. They're covered with insulative foam sheathing on the outside, and drywall on the inside. The wall cavities are filled with a poured-in-place non-CFC foam. "It expands up to 60 times its volume," says Duffy. Specially formulated for this project by Icynene Inc. of Mississauga, Ontario, the foam flows easily around the framing materials but does not build up enough pressure to force off the drywall or sheathing. It shrinks less than three percent as it dries, to prevent insulative gaps. Builders put scraps of excess foam into the attic before blowing recyled fiberglass insulation into place.

For the foundation, the project team adapted a technology commonly used in high-rise construction. "It's never been tried in a residential foundation application," says Duffy. To build the foundation walls, workers used tie rods to position rigid insulation and a fiberglass drainage layer between concrete forms. They then poured two layers of concrete to form a sandwich around the insulation. The outer concrete layer supports above-grade masonry finish, and the inside layer supports the house framing. There's no need for any exterior or interior finishing of the foundation walls. "When you strip the forms, you're done," says Duffy.

To accommodate changing family needs, the NEAT Home has an oversize garage door that allows the owner to add a roll-in suite to the house. This suite, which arrives on the site completed like a manufactured home, contains a bedroom, kitchenette, and bathroom. Plumbing and mechanical hookups on the garage wall ease installation.



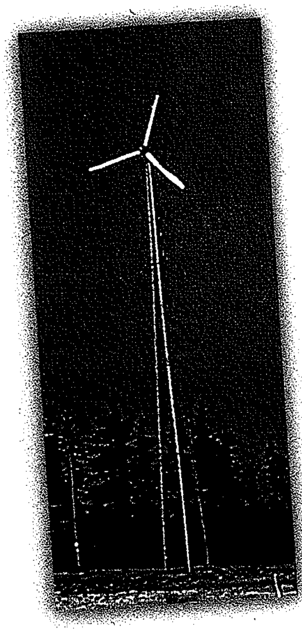
Lumber-saving truss walls are filled with poured-in-place foam insulation.



A CHILL WIND TURNS TO POWER

While the other Advanced Houses are located in suburban subdivisions, the P.E.I. Advanced House outside of Charlottetown on Prince Edward Island is in a rural setting. Architect Ole Hammarlund dubs it "the Advanced House of Green Gables."

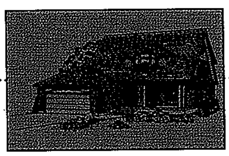
The first thing visitors will notice is a ten-kilowatt



windmill on an 80-foot tower. The house will draw power from the grid when there is no wind, and feed surplus electricity back into the grid. Maritime Electric will compensate the homeowners for any extra power that is produced. "We should be a net producer of electricity, so we'll be getting a check from the utility each month," says project manager Norm Finlayson. However, the utility buys electricity at a much lower rate (three cents per kilowatt-hour) than it charges (11 cents).

The plan calls for a green light on the tower to tell visitors when the windmill is producing power, and a red light that will indicate that power is being purchased from the grid. If there is a power outage in the utility's network, the windmill shuts down automatically. "We don't want to electrocute people working on the lines," explains Finlayson.

This ten-kilowatt windmill provides most of the electricity for a high-tech farmhouse.

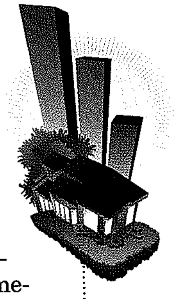


GOOD INSULATION, SMALL DUCTS

he well-insulated Innova House, located near Ottawa in Kanata, Ontario, requires only half the airflow rate needed to heat a conventional house. That enabled the project designers to install insulated air-distribution ducts that are only two inches in diameter. Not only are the flexible ducts narrower than normal ones, but they're also shorter: Because the house isn't drafty, the ducts deliver air along interior walls, reducing the heat losses that would occur in longer ducts carrying air to exterior walls.

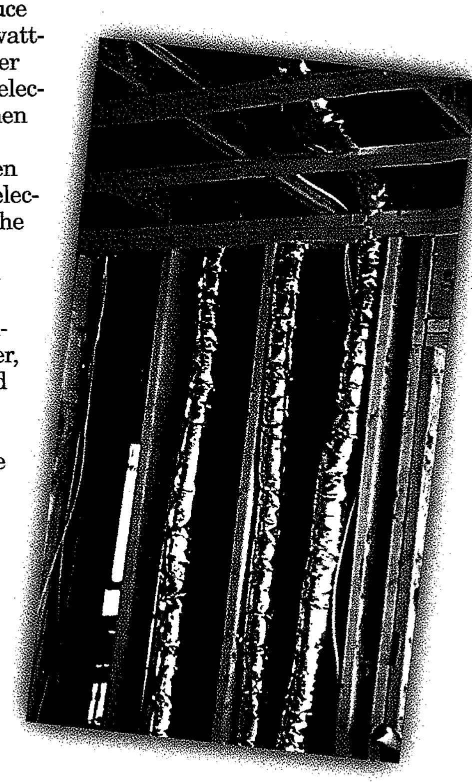
To reduce noise, the last yard of each duct is lined with sound-absorbing material. Also, the blower motor in the basement starts and stops gradually

The top of this natural-gas range is sealed with a glass ceramic surface to isolate combustion products from indoor air.



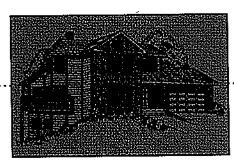
over a 90-second period. This not only conceals noise, it also conserves energy, because the blower only operates at top speed when the heating system's heat exchanger is at its warmest.

Photovoltaic panels on the roof of the Innova House will produce about 3,000 kilowatt-hours of electricity per year. The house draws electricity from the grid when the photovoltaics can't meet its demands. When there's a surplus, "the electricity flows back into the grid and goes to the neighbor's house," says project manager Bruce Gough of Energy Building Group Ltd. However, the local utility insisted on installing a special meter that won't run backward, so the house gets no credit for the electricity sent to the grid. (U.S. utilities, however, must purchase excess power produced by homes; price is set by each state's public utility commission.)



Small insulated air-distribution ducts are flexible and reduce heat losses.

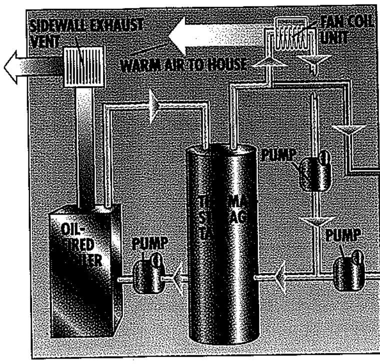
Natural gas fuels the heating system and appliances. The house has two prototype direct-vent appliances: a sealed-combustion gas range that is also found in three other Advanced Houses, and a direct-vent gas clothes dryer used in one other house. Developed by the Canadian Gas Research Institute, the range draws its combustion air from outdoors through the outer portion of a tube-within-a-tube pipe, and it vents its exhaust air through the inner tube. This setup prevents potentially toxic gas-combustion products like carbon monoxide from mixing with indoor air. Because the dryer doesn't use indoor air, it also doesn't depressurize the house the way most dryers do; depressurizing can draw air pollutants into a house. Gas is also used in an engine-driven heat pump, which provides cooling.



GARBAGE IN, ENERGY EFFICIENCY OUT

Natural gas is not available in Nova Scotia, and electricity is expensive. So the EnviroHome in Bedford, just north of Halifax, relies on oil heating.

Because the house is well insulated, even the smallest oil-fired boiler would only run for a few minutes at a time to heat the house. "As a consequence, the operating efficiency of the boiler would be very bad," says system designer Peter R. Meridew of CBLC Ltd.



TOM WHITE

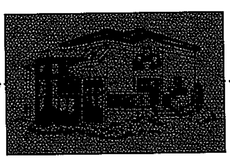
An oil-fired boiler heats water stored in a large tank, which takes care of the house's space- and water-heating needs.

To solve this problem, a boiler heats water stored in a tank insulated with more than two inches of urethane and a fiberglass jacket. Rather than react to indoor-air temperature changes, "All we've told the boiler to do is to take care of that tank," says Meridew. The system allows the tank temperature to drop substantially before activating the boiler, so the boiler remains on for at least ten minutes at a time—long enough to reach peak efficiency. After the boiler turns off, the control system circulates water for a few extra moments "to scavenge the last bit of heat still in the boiler," Meridew says.

The tank supplies heat for the warm-air distribution system and domestic hot-water tank; the latter is also heated by rooftop solar collectors. Existing energy-efficient homes heated by oil could be retrofitted with a similar system.

The EnviroHome's ventilation system uses carbon dioxide sensors to track house occupants. "Wherever there are people, there's carbon dioxide," says Meridew. At night, the carbon dioxide levels in the bedrooms rise. The automated system then opens the upstairs damper and closes the downstairs damper, Meridew explains. "If the people go to bed, why put fresh air downstairs?"

Like many of the other houses, the EnviroHome uses recycled materials—a total of ten tons. This includes fly ash in concrete, newsprint in insulation, sawdust in siding, and used firebrick in the fireplace. "We put a lot more garbage into our house than we took out," quips project coordinator Dale Eastman of Clayton Developments Ltd.



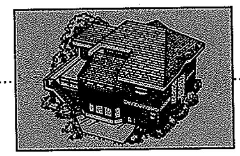
WRAPPING IT UP

Located in Montreal, Maison Performante (French for Advanced House) is one of three homes that use an external air barrier to make the building shell as airtight as possible. Conventional houses are typically sealed on the inside with polyethylene, but penetrations for electrical outlets and other fixtures can undermine performance.

Maison Performante instead relies on an internal vapor barrier and an external air barrier. The latter is made of air-barrier wrap sandwiched between two exterior layers of fiberboard sheathing to provide structural support. This Exterior Air System Element approach, developed by the Canada Mortgage and Housing Corporation, "has never before been tried in a Canadian home," says André Gagné of the Association Provinciale des Constructeurs d'Habitations du Québec, which built the house.

The house also has a unique heating and cooling system. Two 260-gallon cisterns under the garage collect rainwater funneled from the roof. In summer, the water is used to water plants, wash the car, and clean the patio. But in October, the homeowner shuts the valve, and the cisterns become solar storage tanks. Heat captured by solar collectors on the roof preheats domestic hot water; any surplus goes to the storage tanks. The tanks also receive the excess heat from a south-facing sunspace.

When the house needs heat, a mixture of water and antifreeze circulating through the closed loop of a ground-source heat pump extracts heat from the solar storage tanks. When the temperature of the water in the tanks falls below 39°F, the heat pump reverts to its conventional mode, extracting heat from the ground. If this system works well, it may be possible to eliminate the expensive ground coils in future installations, and use a small inexpensive electric or fossil-fuel-driven heating system to back up the heat-pump-and-cistern combination.



THINNER WALLS, JUST AS EFFICIENT

Maison Novtec in Montreal has thinner walls than any other Advanced House. "We used a first-of-its-kind insulation system," says Krishnan Gowri of the Society of Information and Research for the Construction Industry. The walls are only eight inches thick but have an insulative value of R-32. A regular stud wall with that insulative value is more than ten inches thick.

The builders construct a 2x4 load-bearing wall, and fill the cavities with thinner, high-density fiberglass batts containing up to 30 percent recycled glass. The wall exterior is then sheathed with two layers of CFC-free rigid extruded polystyrene insulation separated by plywood. Half-inch-thick clay bricks snap into grooves on a vacuum-formed plastic layer laminated to the outer layer of rigid insulation. Supplied by Celfortec of Valleyfield, Québec, and U.S. Brick of Owosso, Mich., the "outsulation" has previously only been used for cladding on commercial buildings.

"Outsulated" walls are finished with thin bricks that pop into a plastic form laminated to a layer of rigid insulation.

Maison Novtec relies on two ground-source heat pumps—connected in a series—for heating, cooling, and domestic hot water. One unit heats water, while the other heats air. Using separate compressors allows the heat pumps to be sized more closely to each application for greater efficiency, the designers claim. PS