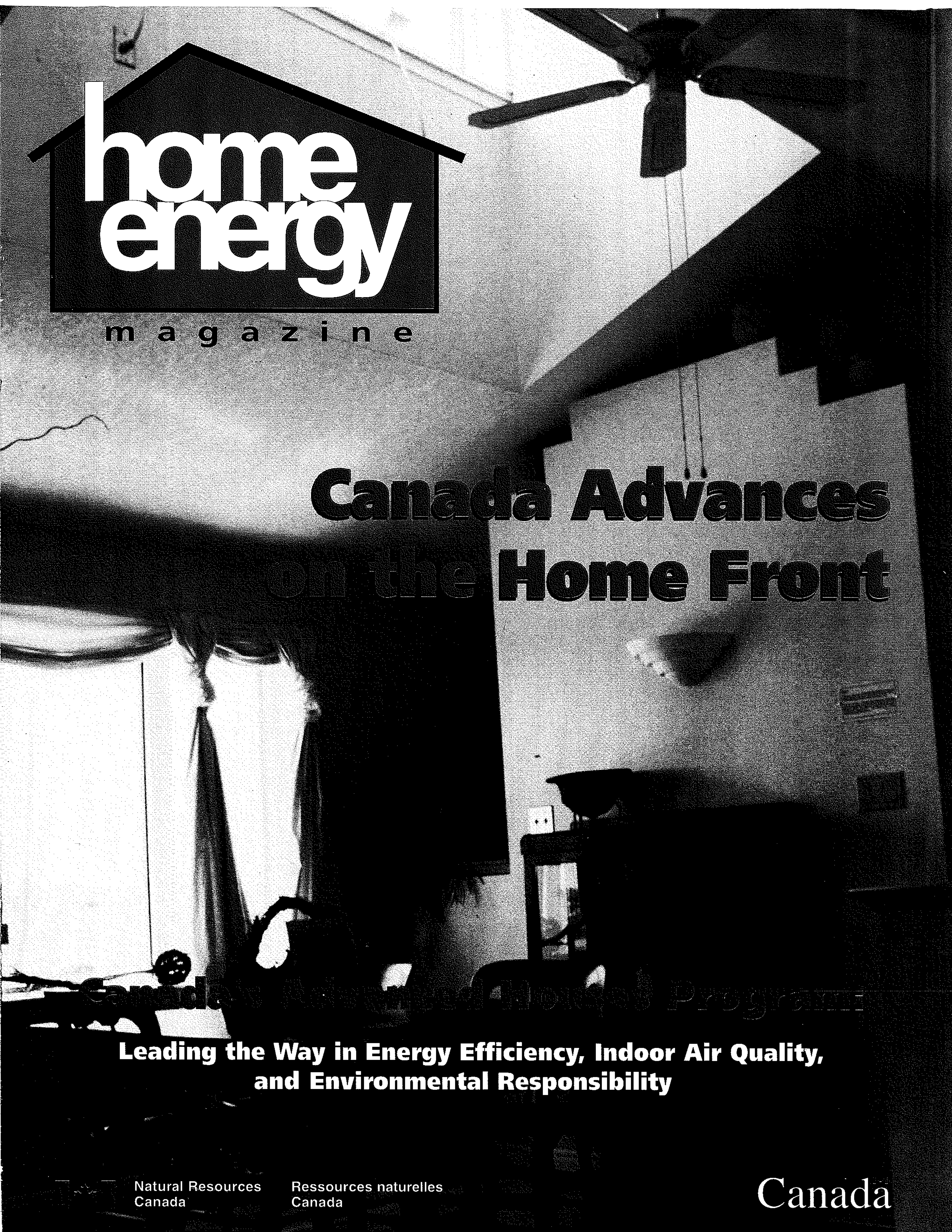
home energy magazine



Canada Advances on the Home Front

Canada's Advanced Houses Program

Leading the Way in Energy Efficiency, Indoor Air Quality, and Environmental Responsibility

Natural Resources Canada
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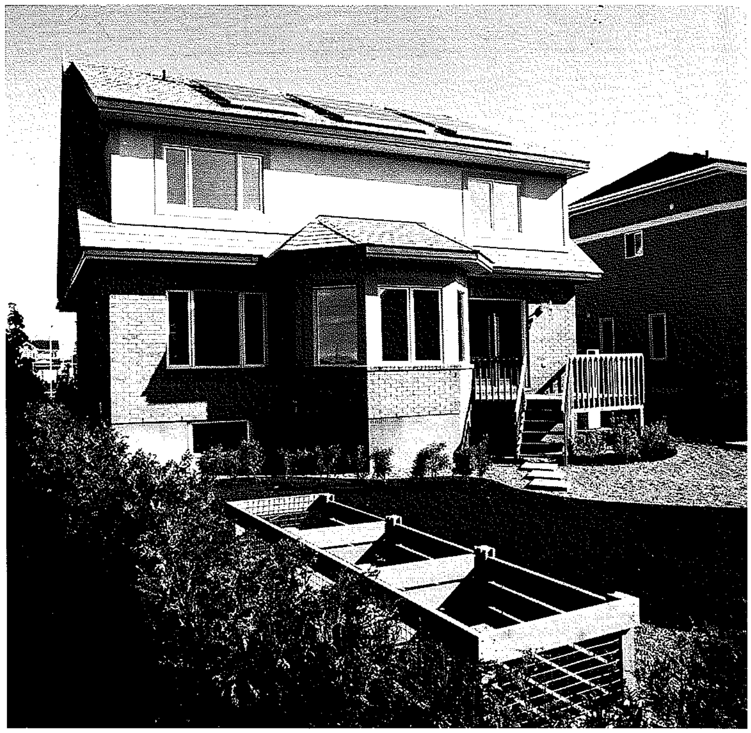
Canada

ADVANCED HOUSES: THE CANADIAN EXPERIENCE

by
Tim Mayo
and Robin Sinha



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Canada's Advanced Houses are more energy efficient, have better indoor air quality, and use even fewer resources than houses built to R-2000 standards.

The goal of Canada's Advanced Houses program was to build houses that are far more energy efficient, environmentally benign, and healthy for occupants than typical Canadian houses. Energy and indoor air quality (IAQ) monitoring has shown that, for the most part, the houses have met this goal.

Natural Resources Canada (NRCan) launched the Advanced Houses program in 1991. They used the same performance-based approach as for R-2000 (see "Canada's R-2000 Standards Get Tougher," *HE* May/June '95, p. 8), but expanded beyond space and water heating to cover total purchased energy, material selection for indoor air quality, and environmental features.

NRCan selected the 10 house proposals out of 31 plans entered by design teams that included architects, designers, engineers, builders, renovators, manufacturers, suppliers, utilities, and provincial and municipal officials. NRCan funded about one quarter of the total project costs. Each project also received cash, services, labor, and goods from manufacturers, suppliers, trade organizations, consultants, gas and electric utilities, municipalities, and government agencies.

The winners were chosen in early 1992, and all were under construction later that year. During 1993, they were open to the public for a mandatory one-year demonstration period; most were also open to industry tours during construction. The Advanced Houses were then sold and, once occupied, were monitored for at least one year to evaluate their performance.

The Design Guidelines

NRCan set the total purchased energy requirement at half the energy used by a typical R-2000 house, or about one-third of the energy used by a conventional new house. There were individual targets for space heating, cooling, water heating, lighting, and appliances (including motors for fans and pumps), although trade-offs were permitted between categories. The Advanced Houses had to meet minimum requirements for airtightness, ventilation rates, and lighting energy per floor area. Because the houses were field demonstrations, all lighting and appliances had to be supplied, which is unusual in the industry.

All houses were required to include room-by-room ventilation, compliance with guidelines for exposure to pollu-

In addition to the sustainable building materials that Canadian Advanced Houses emphasize, the Innova House in Kanata, Ontario, features solar panels and passive solar orientation. Visible in the foreground are compost bins—part of the overall sustainable design.

ADVANCED HOUSES PROGRAM, NATURAL RESOURCES CANADA

This Advanced House had a low enough heating load that it could use small-diameter ducts. These ducts have less surface area for conduction losses, but require more fan power to push the air through.

tants, noise limits from mechanical equipment, and humidity control. They were to cut water consumption in half, use federally labelled EcoLogo products and recycled materials, build in indoor recycling facilities, and have a construction waste management plan. Except in refrigerators, no chlorofluorocarbons (CFCs) were allowed.

Monitored Results: Energy Use

In August 1995, five of the Advanced Houses were selected for detailed monitoring. The Nova Scotia EnviroHome, the Waterloo Green Home, the Manitoba Advanced House, and the Saskatchewan Advanced House each had a full year of monitoring data. In addition, NRCan extrapolated yearly energy usage from six months of data for the Ottawa Innova House.

Overall Energy Performance

The houses were evaluated based on purchased (site) energy, converted to equivalent kWh. There was no calculation of energy use at the power plant for electricity usage, although many designers took source energy into account when choosing equipment for the houses. The typical Canadian house consumes an estimated 50–63 kBtu/ft^2 of floor area (160–200 kWh/m^2) per year. The target for the Advanced Houses was 17 kBtu/ft^2 (52 kWh/m^2); actual monitored total energy use was 25 kBtu/ft^2 (81 kWh/m^2) per year—one-third less than expected of an R-2000 house and a 50%–60% reduction from conventional houses (see Figure 1).

The energy consumption of each house was normalized to account for climate (heating degree days, °C). Annual energy intensity ranged from a low of about 2.4 Btu/ft^2/HDD°F (13.8 Wh/m^2/HDD°C) in Manitoba to a high of 3.7 Btu/ft^2/HDD°F (21.1 Wh/m^2/HDD°C) in Nova Scotia.

Distribution of Energy Usage

Although some of the Advanced Houses used electricity for heating, the five houses in this study all used gas or oil. Approximately 70% of the purchased energy usage was fossil fuel (used for space heating, domestic hot water, and gas appliances). All but the Nova Scotia house had a gas stove and clothes dryer.

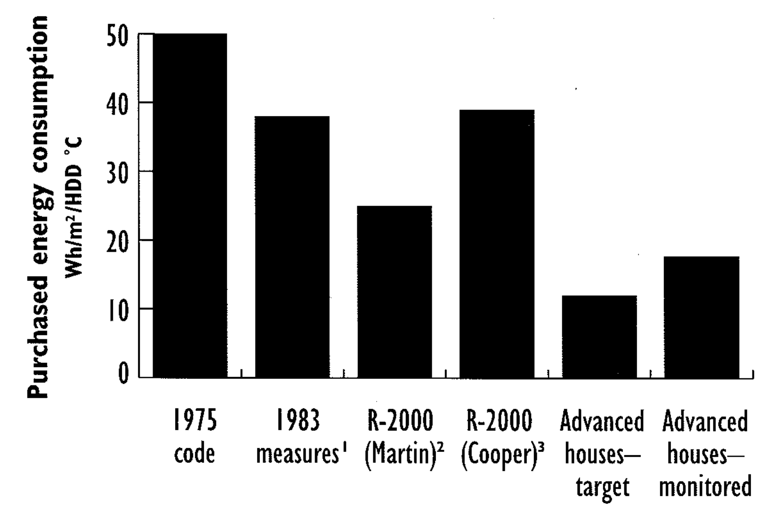
Approximately one-quarter of the space- and water-heating energy was used for domestic hot water. About 13% of the total purchased energy was consumed by fans and pumps. All the Advanced Houses used a forced-air fan delivery system for space heating, cooling, and ventilation.

Figure 2 shows the energy used by electric appliances and lighting. This usage was about 19 kWh per day, close to that observed in R-2000 houses and 75% greater than the Advanced Houses target of 11 kWh/day. Lighting in particular used significantly more energy (almost twice) than budgeted for in the program.

One reason for this is probably that homeowners are using more appliances and lighting than they used to. Also, although the Advanced House builders installed efficient fixed lighting, clothes dryers, and refrigerators, homeowners added lights and other appliances. For instance, the Saskatchewan Advanced House met the target for refrigerator usage with a photovoltaic-powered refrigerator, but the occupants installed a large new refrigerator when they moved in!

Heating Loads

The Advanced Houses were successful at lowering the heating load (see Figure 3). High-performance windows made the largest contribution to the reductions in above-grade heat loss. Higher wall insulation levels and lower ventilation rates also helped. The houses typically average about 0.3 air



[1]1983 Measures refers to houses built to insulation levels recommended by the Canadian National Research Council in 1983. It is a good indicator of standard houses built today.

[2]R-2000 (Martin) shows measured energy use from a study of houses built from 1983 to 1986, which was used as the reference point for the energy use of R-2000 houses (the goal for Advanced Houses was set at 50% of the energy use of these houses).

[3]R-2000 (Cooper) shows results from a study of houses built from 1986 to 1988. The greater energy use compared to the earlier R-2000 houses is attributed to increased usage of appliances and lighting in homes. The homes in this sample were also somewhat more expensive than typical.

SOURCE: ADVANCED HOUSES PROGRAM, NATURAL RESOURCES CANADA

KATHERINE FALK

Figure 1. Purchased energy comparisons, normalized for floor area and climate.

changes per hour (ACH) compared with about 0.5 ACH monitored for the benchmark older R-2000 houses. (New R-2000 houses also have an air change rate of about 0.3 ACH.)

Insulating the center of the floor slab achieved relatively little reduction in heat loss through the foundations. Most R-2000 houses already insulate foundation walls and at least floor slab perimeters.

Energy Supply

NRCan examined how purchased energy and passive solar are utilized in the Advanced Houses and how they compare with R-2000 houses. Energy is required from the space-heating appliance only when heat from lights and appliances and passive solar are insufficient to keep the house at the thermostat setpoint. Passive solar contributions were calculated by subtracting the heat contributions of lights, appliances, and space heaters from the overall heat load of the house.

There was a small reduction from the R-2000 average in the utilization of free heat from lights and appliances, in keeping with the modest reduction in purchased energy for these end uses. More surprising is that the passive solar contribution was less than in R-2000 houses, although the houses incorporated passive solar design. A likely explanation is that in the shoulder seasons when passive solar energy is most available for offsetting space heating, free heat from lights and appliances was more than sufficient to match the very low heat load of the house. Thus there was little opportunity to utilize passive solar, except in colder periods when free heat cannot contribute enough to offset the heat load, and these months (typically December and January) have the fewest sun hours.

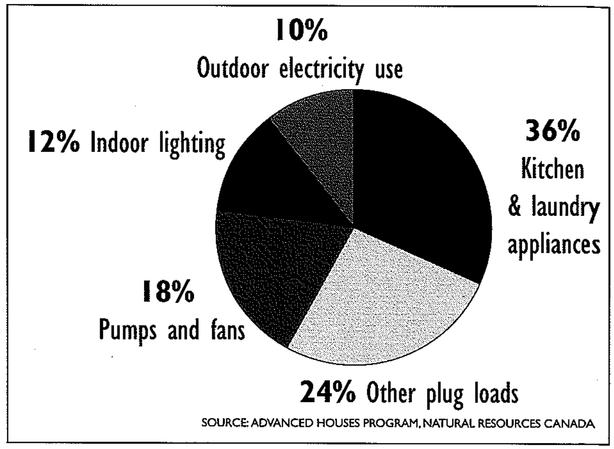


Figure 2. Distribution of electrical consumption in the Advanced Houses. Note: Kitchen and laundry appliances include refrigerator/freezer, dishwasher, clothes washer, and the electrical consumption of the gas stove and dryer.

Monitored Results: Indoor Air Quality

Selecting materials to comply with the indoor air quality requirements was difficult for Advanced Houses, because little product-specific information was available. (There are now several publications providing this information in Canada.) Problem materials include manufactured wood products with urea-formaldehyde resins, floor coverings, and wet-application products such as paints and adhesives. Solutions ranged from using solid-wood cabinets to sealing or encapsulating exposed particleboard to prevent off-gassing. Floor finishes tended to be prefinished hardwoods, ceramic tiles, and carpeting green-labeled by the Carpet Research Institute. All houses used water-based paints with low volatile organic compound (VOC) emissions; none used recycled paint indoors, due to uncertainty as to the chemicals it might contain. Several houses used air filtering systems.

Formaldehyde

Most houses had measured formaldehyde levels below the Canadian Department of Health and Welfare's target level of 0.05 parts per million (ppm). A couple of higher readings were attributed to furniture brought in by new occupants or used for the open house period.

Nonetheless, all of the results were at or below Health and Welfare's recommended action level of 0.1 ppm. Additional measurements under occupied conditions will provide a clearer picture of the actual levels of formaldehyde homeowners will be exposed to over the long term, and how occupants contribute to formaldehyde levels.

Total Volatile Organic Compounds

Although there is no Canadian standard for total volatile organic compounds (TVOC), the European Community has established an acceptable threshold of 5.6 μg/ft³ (0.2 mg/m³), which is generally being used by researchers in Canada. Measurements from the Advanced Houses show a wide variation in levels from a minimum of 1.1 μg/ft³ (0.04 mg/m³) to a high of 19.8 μg/ft³ (0.7 mg/m³). TVOC levels in the Ottawa Innova house increased from 4.2 μg/ft³ (0.15 mg/m³) shortly after construction to 11 μg/ft³ (0.4 mg/m³) after the occupants moved

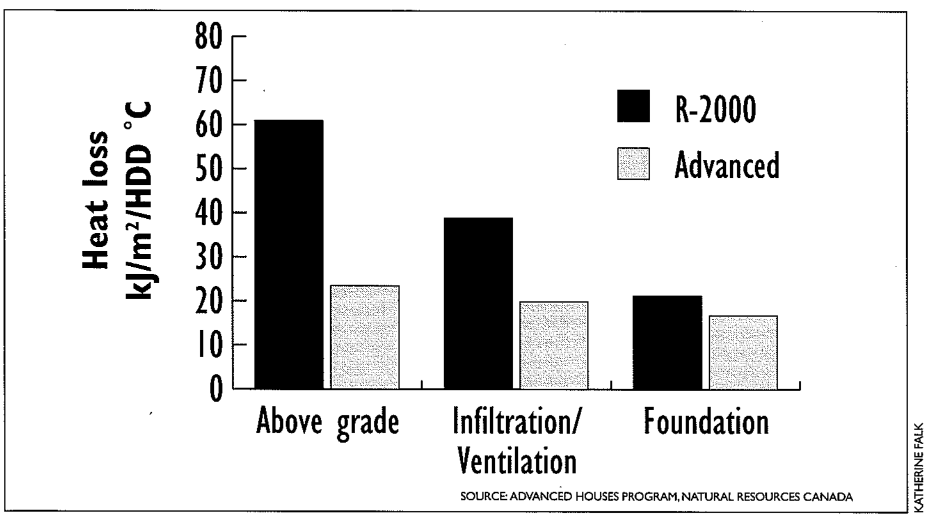


Figure 3. Comparison of measured heat loss. High-performance windows and better wall insulation significantly reduced above-grade heat loss in the Advanced Houses. Under-slab foundation insulation had only a small effect.

ADVANCED HOUSES PROGRAM, NATURAL RESOURCES CANADA

Engineered framing is a feature of the Waterloo Advanced House (Green Home). These engineered I-joists require less material than standard joists, and can be made with wood scraps or lower quality wood.

ADVANCED HOUSES PROGRAM, NATURAL RESOURCES CANADA

The Hamilton Advanced House used open-web truss systems for both the floor and the walls. An open-web truss uses less wood and reduces thermal bridging. Icynene foam works well for insulating these cavities because it expands to fill the space in a controlled fashion.

in. This shows how much occupants affect indoor air quality in houses. Nonetheless, the air is significantly better than that of conventional houses, due to better ventilation.

How They Did It

Advanced House designers focused on five major areas:

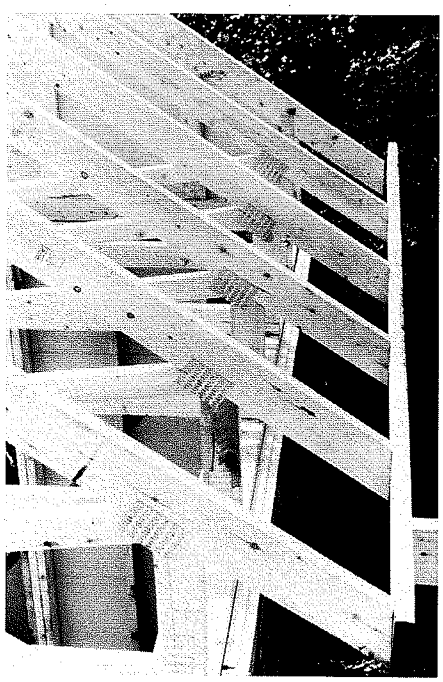
- Designing the house as a system.
- Upgrading the building envelope.
- Integrating the mechanical systems.
- Selecting materials and finishes to ensure better indoor air quality.
- Providing environmental features.

Whole-House Approach

The major lesson of the Advanced Houses is that an integrated design approach is required. The "house as a system" concept promoted by R-2000 is even more appropriate in Advanced Houses. Because energy loads have been drastically reduced, the old rules of thumb no longer apply. Simply downsizing equipment is unlikely to be the most cost-effective solution. With more efficient envelopes, different approaches to heating and cooling can be considered—different energy sources, different equipment, and different distribution.

A whole-house approach also goes beyond energy. For example, high-performance windows resist condensation, reducing the potential for peeling paint, wood rot, and mold growth. Their warmer interior surfaces make occupants feel more comfortable and eliminate the need for heating outlets beneath the windows.

In two Advanced Houses, designers reported that the savings in ductwork offset the increased cost of the high-performance windows. Good windows and small heat loads mean air-flow volumes can be lower. The 2-inch-diameter, high-velocity ductwork used in the Ottawa Advanced House was originally intended to provide fresh-air ventilation, but it has the capacity to meet the reduced heating and cooling loads.



ADVANCED HOUSES PROGRAM, NATURAL RESOURCES CANADA

This roof is built featuring a "raised heel" (also known as a "high heel") roof truss, which allows builders to insulate fully right up to the edge of the attic cavity.

However, small-diameter ducts mean higher-velocity air and a higher pressure drop across the fan, requiring more fan power. Observers did notice higher fan energy usage in this house (although the efficient electrically commutated motor [ECM] lessened this impact). The ducts did not prove to be particularly noisy, another concern with smaller diameter ducts.

Building Envelope

While upgraded envelopes and increased airtightness are typical of R-2000 houses, engineered framing and high-performance windows stand out as Advanced House features. The houses used a variety of strategies to provide the thicker walls needed to allow more insulation. The Hamilton Advanced House used standard open-web floor trusses on end as walls; others used manufactured I-beams; and one used a prototype double stud connected with metal pins.

Engineered wall framing technologies have significant potential. The slightly higher cost of a 2 x 6 I-stud or an open-web truss should be largely offset by savings from reduced warpage, twisting, and shrinking (resulting in reduced callbacks to repair popped wallboard screws). The open-web truss nearly eliminates thermal bridging through the web. Also, engineered studs require less material and can be made with wood scraps or lower-quality trees.

Insulating the open-web truss walls with loose fill can be difficult. In one house, the installers needed to put cardboard blocking between the cavities so that they could blow in cellulose to a high enough density. However, Icynene sprayed-in foam used in another house worked well in the open-web truss wall.

Insulation levels in these houses are above conventional practice but are not excessive—typically R-30–R-45 walls and R-50–R-60 ceilings. Every Advanced House provided full insulation under its basement floor. The most common insulating material was wet-spray cellulose, blown in place with a latex binder to prevent later settling.

Canadian building codes now distinguish between vapor diffusion retarders and air barriers. All Advanced Houses bettered the airtightness requirement of 1.5 ACH at 50 Pascals (Pa) with a variety of techniques; their success was largely a result of careful installation.

The trend appears to be toward exterior air barriers, which eliminate many of the problems associated with penetrations through interior air barriers. Two new exterior air barrier systems have recently entered the market—a polyethylene-laminated fiberboard with joints taped on site and a gasketed styrene foam insulation board developed by the Maison Novtec Advanced House.

All ten Advanced Houses used high-performance windows featuring various combinations of multiple glazings, low-e coatings, gas fills, insulating spacers, and low-conductivity frames. The design teams used the Canadian Window Energy Rating standard to guide the selection of their windows, including selection of windows by orientation in some houses. The rating is a heat balance for the product—solar gains in, minus heat loss and air leakage out—and is measured in watts per square meter of total window area. Windows in the Advanced Houses have Energy Ratings (ER) as high as +12 for fixed models and +4 for opening models, compared to about -15 to -30 for a conventional double-glazed window.

Integrated Mechanical Systems

Combining heating, cooling, hot-water, and ventilation systems is another trend, with ventilation the prime design consideration. All but one Advanced House used a water-based system, transferring the heating and cooling through fan coils into the forced-air ductwork.

COURTESY OF ENERMODAL ENGINEERING

The direct-vent natural gas fireplace in Canada's Green Home features spark ignition and fan-assisted heat delivery. The track lighting visible above demonstrates the overall lighting strategy of the house; spot lights illuminate specific areas rather than the entire room.

Still, no completely integrated package is yet available. Current practice is to assemble off-the-shelf components and combine their operation and control. All ten Advanced Houses used heat recovery ventilators (HRVs) and installed the ventilation system according to Canadian Standards Association (CSA) standard F326 "Residential Mechanical Ventilation," with fresh air supplied to living rooms and bedrooms and stale air exhausted from bathrooms and the kitchen (see "Mechanical Ventilation for the Home," *HE* Mar/Apr '96, p. 13).

Unfortunately, the Advanced Houses did not avoid installation problems. Although HRVs themselves have efficiencies in the 70%–80% range when tested to the CSA standard in the labs, many systems were observed to be imbalanced, resulting in reduced system efficiencies in the field.

The British Columbia Advanced House featured a sealed-combustion, condensing natural-gas hot-water heater, with remote fan-coil units providing space heating through the forced-air duct system. These combination space and domestic hot water (DHW) products have a rated efficiency of better than 90%.

The midefficiency natural-gas furnace/HRV combination unit in the Waterloo Green Home is a prototype by the Canadian Gas Research Institute. Production prototypes are now being field-tested, and the product should be commercially available in 1996. The combined efficiency is expected to be 85%.

The oil-fired combination system in the Nova Scotia Advanced House addressed the issue of short-cycling and the resulting inefficiency of typical oil systems in low-energy houses. The low-mass boiler heats the water in a 60-gallon water tank, permitting a longer firing time for peak efficiency. The water tank feeds a separate DHW tank and two fan coils to provide forced-air space heating for two zones. Steady-state efficiency is predicted to be 80%–85%.

Several houses used electrically commutated motors in variable-speed blowers. ECMs maintain a high efficiency over their entire range of speeds and hold air flow steady at specified levels regardless of changes in static pressure. In a typical furnace installation, they can save almost 60% of electricity consumption.

Appliances

Some of the Advanced House builders went beyond currently available technologies and installed prototype appliances not yet on the market. A prototype sealed-combustion direct-vent gas stove, designed by the Canadian Gas Research Institute, was installed in sev-

Advanced Houses of the World

Ecolonia in the Netherlands, Lotissement Solaire Aurore in France, Wädenswil and Brunnadern Zero Heating Energy Buildings in Switzerland, and Egebjerggård III and Tubberupvænge II in Denmark—these are a few of the Advanced Houses of the World, houses that go far beyond the norm when it comes to energy conservation, concern for the environment, good indoor air quality, and sustainable use of resources. They incorporate new technologies and advanced designs that give us a glimpse into the future of housing.

The International Energy Agency's Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) features 25 such houses in 13 countries in *Learning from Experiences with Advanced Houses of the World.* While the projects are similar in many respects, the focus varies slightly from country to country.

Some countries, such as the United States, tend to pay the most attention to reducing operating costs. The three U.S. houses featured—the Idaho Energy Conservation Technology House, the Energy Smart Home in Pensacola, Florida; and Optimar: The Energy Answer Home in Mulberry, Florida—all showcase superinsulation and ground source heat pumps.

Other countries, including the Netherlands, are making a concerted effort to reduce greenhouse gas emissions, using strict building standards, taxes, and research programs. Ecolonia and Scheidam—communities that feature energy-efficient houses, green spaces, and measures to encourage public transit—are part of the Dutch program, which has resulted in the construction of thousands of low-energy houses.

Increasing comfort is a big part of Japan's R-2000 program (modeled after the Canadian R-2000). The energy efficiency of the R-2000 houses means that Japanese residents can keep the house warm for more hours in the day and keep more rooms heated all winter.

In Switzerland, the biggest impetus for advanced housing is to reduce foreign energy imports. As a result, standard Swiss houses are as energy efficient as the most efficient houses in many other countries. Switzerland has built 30 advanced houses for its Pilot and Demonstration Program.

In Norway, the public is very concerned about environmental conservation, leading to a strong emphasis on sustainable housing. About 36% of the country's national research and development budget is spent on conservation activities. Norway's demonstration projects include the IEA Task XIII: Advanced Solar Low Energy Buildings, which use only 17% of the energy of a typical new Norwegian house.

Canada is leading the way in building houses out of sustainable materials that create a healthy indoor environment. The Canadian Advanced Houses program encouraged building with recycled products and avoiding CFCs. The Canadian Mortgage and Housing Corporation has been promoting good indoor air quality since its Healthy House competition in 1991.

So what makes an Advanced House? CADDET chose houses that incorporated techniques like superinsulation, ventilation with heat recovery, passive solar design, airtight construction, high-performance windows, transparent insulation, high-performance heating systems, solar domestic hot water systems, integrated mechanical systems, high-efficiency lighting, energy-efficient appliances, photovoltaics, and ecological management strategies.

Incomparable Houses?

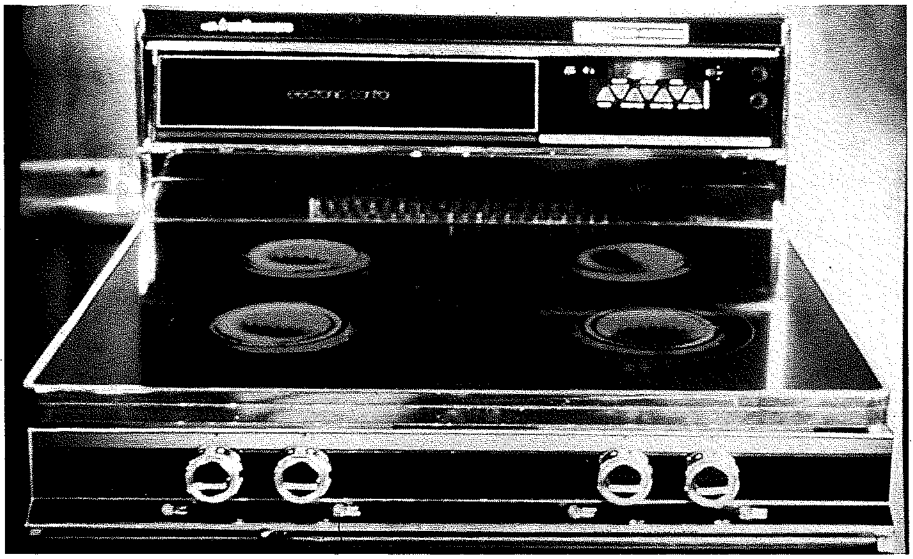
But actually comparing the energy used in the various Advanced Houses is difficult. According to German scientist Sabine Busching, it is nearly impossible to use the data collected from houses in different countries to get an accurate comparison of their energy performance. Busching is involved in an effort to create a standard set of measurements, and manner of expressing them, that will facilitate international comparison of houses. She explains the problem in this way:

> How do you prefer your heat loss coefficient—U.S.-style (Btu/h°F), Japanese-style (kcal/m²hK) or German-style (W/m²K)? Being a German, I have a hard time thinking in terms of the first two units. Luckily, we can use conversion factors to translate one to another. But some units are much more difficult to convert.
>
> Take Heating Degree Days (HDD), for example. Moscow, Idaho, has 3,600 HDD, using a base of 65°F (18°C) over a heating period of seven months (the period used by CADDET for the Advanced House comparison). Hamburg, Germany has 3,837 HDD based on 20°C (68°F) with a very different definition of the heating period (the Germans use an eight-month heating period, but days with an average outside temperature of 15°C [59°F] or more don't count at all). You can't use a single conversion factor for these—in fact, you would need all the original weather data to figure it out.
>
> Even if this problem were solved, difficulties remain. One involves comparing energy in the form of electricity to that from natural gas or oil. CADDET compared the Advanced Houses based on site (purchased) energy. Thus the Heidenheim House in Germany shows an annual purchased space heating energy use of 59 kWh/m² (one of the 'highest' of the Advanced Houses), while the Idaho House had only 25 kWh/m² of space heating energy use.
>
> But the motivating factor for the Heidenheim house was to reduce carbon dioxide (CO_2) emissions. Heidenheim has a gas boiler with heat recovery; Idaho, an electric ground source heat pump with electric resistance backup heating. If the electricity comes from a fossil fuel power plant, an evaluation of the two houses based on kg/m² of CO_2 would show a switch of ranking.
>
> For all these reasons, we need to improve the technique for comparing the energy efficiency of buildings. We need an international agreement about format and minimum data collection for monitored Advanced Houses. Besides general indicators (such as heating energy consumption, the efficiency of the mechanical systems, number of occupants, and floor area), evaluation and comparison of the houses should use indicators that respect the targets (like CO_2 reduction) that the projects aimed at.*

Learning from Experiences with Advanced Houses of the World is available for $49 postpaid. Make cheques payable to the Receiver General of Canada and send to: Publications, Buildings Group, CANMET Energy Technology Centre, Natural Resources Canada, 580 Booth St., Ottawa, Canada K1A 0E4.

—Jeanne Byrne

*Interview with Sabine Busching, Professor, University of Art–Hamburg, Department of Architecture, July 1996.



ADVANCED HOUSES PROGRAM, NATURAL RESOURCES CANADA

This prototype gas stove in the Waterloo Green Home features direct venting and sealed combustion.

eral Advanced Houses. Two houses also used a prototype sealed-combustion direct-vent gas clothes dryer.

Some houses also used home automation systems to help reduce peak loads. Two homes used the Consumer Electronics Bus (CEBus), which shifts operation of high-usage electrical appliances to off-peak times and monitors the performance of some mechanical equipment.

Environmental Features

The major environmental features of Advanced Houses are reduced water consumption, reduced construction waste, use of recycled materials, and provision of recycling and composting facilities.

Water consumption. Total water consumption appears to have been cut by more than half, and hot water consumption showed a small reduction. Cold-water consumption was reduced substantially indoors with low-flush toilets, and outdoors with a combination of drought-resistant landscaping and rainwater cisterns.

Construction waste management. Construction waste management made a significant reduction in the 2.7 tons (2.5 tonnes) of waste that a typical new house sends to landfill. One house reported no construction waste—except for two green garbage bags, it was all recycled or reused. The Nova Scotia Advanced House reported that of the 7,536 lb of construction waste it produced, only 2,467 lb was sent to landfill. The rest was either reused or recycled. The Nova Scotia Advanced House also calculated the amount of recycled materials used in its construction—a total of over 20,000 lb.

One innovation was the use of crushed, recycled glass mixed with gravel for foundation drainage. Laboratory testing of a sample from the Manitoba Advanced House showed that a half-and-half mixture of gravel and crushed glass outperformed all other types of drainage material.

Advanced House builders also learned that they have a strong influence on how "green" the occupants can be. In addition to their own efforts during construction, builders provided a range of recycling facilities, including in-house storage for paper, glass, and plastics; kitchen compost storage; and outdoor composters.

Industry awareness and acceptance of the benefits of innovative green technologies is strong, and public response has been good. Several builders of Advanced Houses have added environmental features or are offering environmental upgrade packages to all their houses.

Incremental Costs

It is difficult to determine the extra cost for the energy and environmental features in the Advanced Houses. Some of the equipment was prototypical and not commercially available. Because they were demonstration models, the houses showed several solutions rather than the single most cost-effective one. Many products were donated, so their true installed costs are not known. In other cases, features were added for market appeal.

The Waterloo Green Home's builders estimated the construction costs (excluding land and builder profit) for a similar conventional house with the same market appeal features—upgraded interior finishes, hardwood flooring, appliances, and landscaping—at about $125,000 Can ($93,700 US). The actual construction costs for the Waterloo Green Home were $147,600 ($110,700 US), due to the additional energy, environmental, and IAQ features.

The Advanced Houses have shown that significant reductions in energy consumption are possible, improved indoor air quality and comfort can be achieved, and that both builders and homeowners can contribute to reducing the impact of housing on the environment. The program is now promoting the adoption of technologies used in these houses (such as high-performance windows, integrated mechanical systems, and energy-efficient motors) in the existing housing market and new multifamily housing.

The Advanced Houses Program offers one- and two-day seminars on the program and the technologies used. Contact Tim Mayo at (613)996-3089.

Tim Mayo is manager and Robin Sinha is project manager of the Advanced Houses Program for Natural Resources Canada.

FOR MORE INFORMATION...

The Advanced Houses Program has numerous fact-sheets and technical reports on the design and performance of ten demonstration Advanced Houses, technology assessments, and indoor air quality issues.

For a copy of our Publications List, including related activities such as the R-2000 Program for energy-efficient houses and the C-2000 Program for energy-efficient high-rise buildings, contact:

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