

ADVANCED HOUSES PROGRAM



Technical Requirements for Advanced Houses

Shared Vision, Shared Challenges

The Advanced Houses Program is challenging Canada's home building industry to look to the future.

The challenge is daunting. Without a concerted attack on environmental issues and energy consumption, the world we hand over to our children could be an uninviting place to live.

In the housing sector, CANMET, the research and development arm of Energy, Mines and Resources Canada, is working in partnership with the Canadian Home Builders' Association to champion the design and construction of more environmentally appropriate, energy-efficient housing. The Advanced Houses Program, an initiative under Canada's Green Plan to reduce global warming, provides industry with the opportunity to develop and field test new products and technologies.

Under the Advanced Houses Program, ten prototype homes, all winners of a national design competition, are being constructed across Canada. Thanks to an impressive array of new ideas, concepts and product prototypes, each home is pushing the limits of building technology to meet the program's rigorous technical requirements. Each Advanced House is designed to minimize its impact on the external environment by consuming less than one-quarter the energy and one-half the water of a conventional Canadian home and has a significantly better level of comfort and indoor air quality.

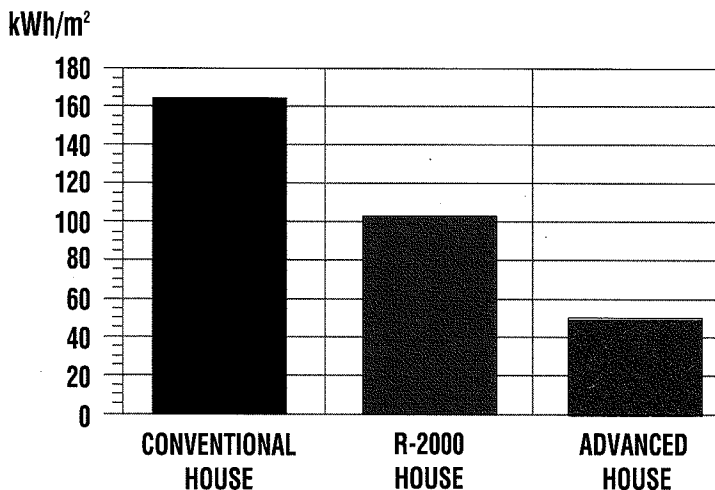
The Advanced Houses Program builds on the success of the R-2000 Program, which is based on performance-based energy targets for space heating and hot water heating—leaving designers and builders free to apply their own creative solutions to meet the targets.

The Advanced Houses Technical Requirements follow the same successful approach, but go far beyond the R-2000 requirements. Advanced Houses have to meet stringent performance-based requirements in the following three categories:

- total purchased energy
- indoor comfort and health
- environmental features

The Advanced Houses Program is ensuring that Canada retains its position as the world leader in environmentally appropriate and energy-efficient housing.

Average Annual Energy Consumption



ADVANCED HOUSES PROGRAM

Purchased Energy

The Total Purchased Energy Requirement of an Advanced House is set at 50% of the energy used by an equivalent R-2000 house. To achieve this, the Advanced Houses Program has established individual performance targets for the following energy consuming categories in the home:

- space heating
- space cooling
- domestic hot water
- appliances and fans
- lighting
- outdoor electricity and peak loads

To permit the designers greater freedom in meeting the overall energy target, trade-offs are allowed between the categories as long as the total value meets the purchased energy requirement. Because the requirements specify purchased energy, Advanced House design teams were able to take advantage of renewable energy and heat-recovery strategies.

Space Heating

The Space Heating Target uses the energy budget formula developed for the R-2000 Program and cuts it in half. This formula takes into consideration the type of fuel, the local heating degree days, and the volume of the house. A building surface-area-to-volume factor has been added to correct a bias in the R-2000 space heating calculation that favours larger houses. An occupant factor has also been included to encourage the construction of moderate-sized houses.

The Advanced Houses must meet the same stringent air tightness target as R-2000 houses — 1.5 ACH at 50 Pa. Advanced Houses receive a performance credit for achieving greater air tightness levels.

Advanced Houses use a variety of new technologies and prototype products to reduce energy demands for space heating, including:

- advanced framing and foundation techniques
- higher density insulation materials

- high-performance window assemblies
- window glazings selected by orientation
- higher efficiency space heating appliances
- utilizing renewable energy, including passive solar and ground-source heating (ground-source heat pumps)

Space Cooling

Although Canadian houses have a relatively low cooling load, consumer demand for a comfortable indoor environment year-round is leading to increased requests for summer cooling.

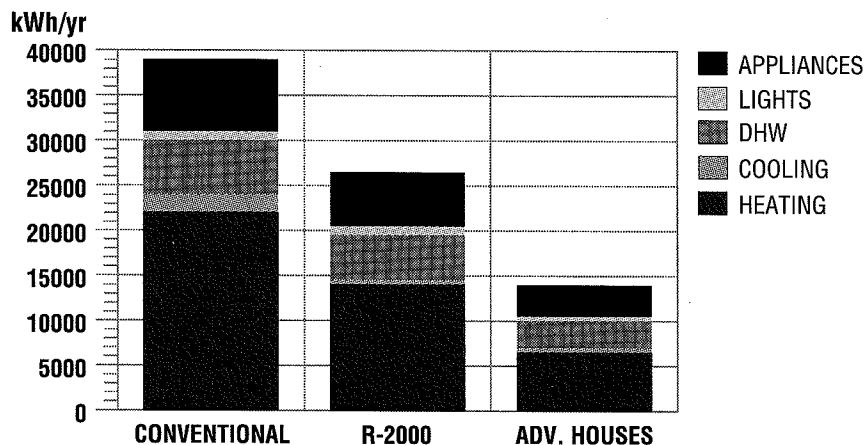
The Cooling Energy Target is a 50% reduction in cooling energy consumption compared with the central air conditioning requirements of a conventional house built after 1985. The house temperature used for calculating the required cooling energy is 25°C and must not exceed 27°C at the outdoor July 2.5% design conditions.

Consumer demand for a comfortable indoor environment year-round is leading to increased requests for summer cooling.

The Advanced House design teams have chosen a number of innovative approaches to meet the cooling energy target including:

- free ground cooling (no compressors)
- free night-time cooling
- radiant cooling panels
- shading window screens
- evaporative cooling
- natural gas and ground-source heat pumps

Typical Total Annual Energy Consumption



Note the basic difference between the conventional and R-2000 houses is in the energy consumed for space heating, while Advanced Houses incorporate a reduction in all categories of energy consumption.

ADVANCED HOUSES PROGRAM

Domestic Hot Water

The Domestic Hot Water (DHW) Heating Target is a 50% reduction in hot water energy consumption compared to the R-2000 target. An occupancy factor has also been added.

These stringent requirements are justified by the potential for reducing DHW energy consumption through the variety of energy conserving strategies and pre-heat technologies emerging on the market. These include:

- increased insulation on water heaters and piping
- new generation solar water heaters supplying 45%-75% of average household needs
- integrated, higher efficiency natural gas space and water heating appliances with annual efficiencies up to 94%
- integrated ground-source heat pumps with a coefficient of performance (COP) approaching 3.5

Appliances

Establishing energy targets for appliances, fans, and lighting represents a significant departure from the original R-2000 energy performance target. General Electric Canada and Camco are the official suppliers of appliances, fan motors, lighting, and other products for the Program.

The Appliance and Fan Energy Target is set at 3,838 kWh per year — a 50% reduction in the energy consumed by R-2000 homes. This ambitious target encourages Advanced Houses to explore the significant energy-saving potential in these areas.

For appliances, the Advanced Houses teams are incorporating:

- energy efficient 'white goods' (refrigerator, stove, washer, etc.)
- more gas appliances, including prototype sealed-combustion stoves and clothes dryers

Fans

More and more, fans are being run continuously in mechanical ventilation systems and for better indoor air quality and in forced-air heating systems for more even temperatures. The energy these fans consume can be substantial.

The energy these fans consume can be substantial.

To promote the use of more energy efficient fan motors, their electrical power consumption in Advanced Houses has been set at:

- 1.2 W/(L/s) of air flow capacity for houses without a forced-air heating system, and
- 0.75 W/(L/s) of air flow capacity for houses with a forced-air heating system.

To meet these requirements, Advanced Houses are using emerging technologies such as:

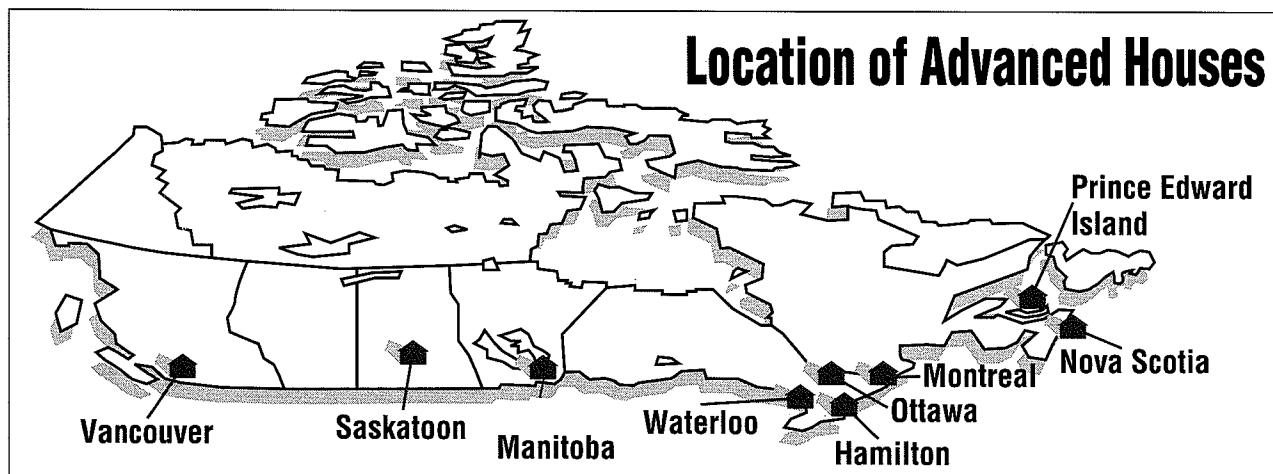
- more efficient fan motors, such as brushless DC motors — the motor of choice in the new generation of Heat Recovery Ventilators
- electronically commutated motors (ECMs) for forced-air systems
- photovoltaics to power fans, pumps and some appliances

Lighting

Lighting accounts for approximately 2% (1,000 kWh/yr) of the electrical needs of a conventional household. Although this may seem trivial, it has a significant impact on peak electric utility loads.

The Lighting Energy Target is set at a maximum of 8W/m²—an estimated 60% reduction in lighting compared to a conventional house. To ensure that adequate lighting levels are provided, a minimum lighting output of 40 lumens/Watt is also required.

The lighting performance target is being met through a combination of the following technologies:



ADVANCED HOUSES PROGRAM

- compact fluorescent lights
- high-efficiency ballasts for fluorescent fixtures
- specular (shiny) reflectors
- improved dimming technologies
- improved phosphors and bulbs

Lighting accounts for approximately 2% (1,000 kWh/yr) of the electrical needs of a conventional household.

Peak Load

The energy performance targets significantly reduce the base and peak energy demands of the Advanced Houses. To further restrict peak load demands, the peak electrical requirement of houses heated with electric resistance heating is limited to 115% of the design heat loss.

The Outdoor Electrical Usage Target is set at 183 kWh/yr to address peak loads associated with automobile block heaters and outside lighting and electrical appliances.

Most Advanced Houses include home automation systems to control peak energy loads and optimize energy system operation. As an added selling feature, the automation systems can enhance the indoor air quality, thermal comfort, and personal security in the home.

HOT2000 Computer Program

CANMET's HOT2000 computer simulation program is used to evaluate the performance of each house built under the R-2000 Program.

HOT2000 was also used by the Advanced House teams to identify

optimal solutions to meeting the individual and overall energy targets for their houses. Through the use of this computer tool, the teams were able to evaluate alternative mechanical systems, modify insulation values and optimize window glazings and orientations at the early design stages.

The feedback gained from monitoring the Advanced Houses will play an important role in the ongoing improvement of HOT2000.

Indoor Comfort and Health

Most Canadians spend more than two-thirds of their day in the home. For this reason, one of the prime goals of the Advanced Houses Program is to demonstrate that housing can be energy-efficient without compromising the quality of the indoor environment. The Advanced Houses Technical Requirements include targets for ventilation, materials emissions and comfort.

One of the prime goals of the Advanced Houses Program is to demonstrate that housing can be energy-efficient without compromising the quality of the indoor environment.

Ventilation

Ventilation systems must be designed and installed according to a recently adopted national standard, CSA F326

"Residential Mechanical Ventilation Requirements". Items covered under the Standard are:

- a minimum whole-house ventilation capacity of 0.3 air changes per hour
- system capabilities to exhaust contaminants
- minimum rates for room-by-room ventilation

In addition, only induced-draft or sealed-combustion equipment is permitted.

Materials Emissions

A number of compounds, including formaldehyde and other volatile organic compounds (VOCs), are known to cause adverse health effects. A successful strategy for good indoor air quality requires careful selection of materials and finishes in addition to continuous ventilation.

Advanced Houses must meet limits established in the Exposure Guidelines (1987) for Residential Indoor Air Quality as developed by the Federal-Provincial Advisory Committee on Residential Indoor Air Quality.

To help meet this level of indoor air quality, the teams selected low off-gassing materials and reduced formaldehyde emissions by eliminating particleboard or by sealing exposed surfaces with special sealers.

A successful strategy for good indoor air quality requires careful selection of materials and finishes in addition to continuous ventilation.

ADVANCED HOUSES PROGRAM

Comfort

Primarily for comfort, Advanced Houses have to achieve three further goals:

- eliminate cold drafts
- limit noise from mechanical equipment
- maintain humidity levels of at least 30% RH

Environmental Features

In many urban areas today, municipal water and sewer systems are being stretched to the limit and landfill sites are rapidly filling up. Researchers and scientists are reporting almost daily about the consequences of the green house effect and the depletion of the ozone layer in the upper atmosphere.

The Advanced Houses Program has included a series of environmental targets in the Technical Requirements. The use of eco-friendly products and materials with recycled content is encouraged, while products and technologies using ozone-destroying CFCs are severely restricted.

Water Usage

In a conventional home, each person consumes approximately 300 litres of water per day.

The overall Water Consumption Target for the Advanced Houses is set at 50% of that consumed in conventional houses. To achieve this goal, specific requirements have been set:

- toilets: maximum 7 litres per flush
- shower heads: maximum 10 L/min
- sink faucets: must have aerators
- washing machines: low water consumption

In a conventional home, each person consumes approximately 300 litres of water per day.

To meet these goals, some Advanced Houses are installing water-conserving toilets with as low as 3 litres per flush, and others are incorporating composting toilets which use virtually no water at all. Some Advanced Houses are featuring rain-water cisterns and drought-resistant landscaping to further reduce the consumption of municipally treated water.

How Advanced Houses Are Meeting the Technical Requirements

Reducing Heating Energy

- advanced framing and insulation materials
- high-performance windows
- air-tight construction
- ground-source heat pumps
- high efficiency equipment

Reducing Cooling Energy

- CFC-free ground cooling
- ground-source heat pumps

Reducing Domestic Hot Water Energy

- grey-water heat recovery
- solar DHW
- exhaust heat recovery

Lighting and Appliances

- natural gas stoves and clothes dryers
- photovoltaics and wind power
- home automation systems

Indoor Health and Comfort

- room-by-room ventilation
- demand-controlled ventilation
- low-toxicity materials
- sealers on exposed particleboard
- sealed-combustion equipment

Reducing Construction Waste

- waste management plan
- recycled materials
- prefabricated components
- reduced waste to landfill

Reducing Water Usage

- 7 litre/flush toilets
- 10 litre/minute shower heads
- faucet aerators
- rain-water cisterns
- drought-resistant landscaping

Reducing Domestic Waste

- in-house recycling centres
 - outdoor composters
-

ADVANCED HOUSES PROGRAM

Waste Management and Recycling

During the building of a conventional house, approximately 2.5 tonnes of waste construction material are dumped in a landfill site. In addition, it is estimated that the average residence generates one tonne of domestic garbage annually.

Advanced Houses are required to minimize the environmental impact of housing on the waste stream by providing:

- a waste management plan for reducing and diverting construction waste
- a 10 litre-compost storage facility in or near the kitchen
- facilities to store recyclable materials, including paper, metal and glass
- an outdoor 150-litre compost bin

One ambitious Advanced House team is recycling all of its construction waste—nothing is being sent to a landfill site.

Chlorofluorocarbons

CFCs are widely used in building materials and equipment, including refrigerators and air conditioners and as blowing agents in many foam insulation products.

The Advanced Houses Program limits the use of technologies and products to those with an ozone depletion factor of 0.05 or less. Because of the state of current technology, this requirement does not yet apply to refrigerators and freezers.

Wood-Burning Appliances

Traditional wood-burning appliances, such as open fireplaces, are energy inefficient and pollute the outdoor environment.

To encourage the use of advanced wood burning technologies, wood-burning appliances must meet specific requirements for:

- high combustion efficiency
- minimizing outdoor pollution

Monitoring

An important aspect of the Advanced Houses Program is to determine whether the homes did, in fact, meet the Technical Requirements. Each home is being monitored for a minimum of one year to collect data on:

- energy consumption of systems and subsystems
- efficiency of mechanical systems, including heat pumps, integrated heating/hot water systems, ventilation systems
- occupant reactions to mechanical systems, appliances and lighting technologies
- quality of indoor environment, including measurement of parameters such as carbon dioxide, formaldehyde and humidity
- occupant reactions to environmental features

The goals of the monitoring program are two-fold; first, to evaluate the performance of emerging technologies and new products, and second, to assess how well the Advanced Houses meet the Technical Requirements.

The results of the monitoring program will provide valuable feedback to fine tune and further improve the innovative products and technologies. Monitoring will also provide key information to identify which energy targets and environmental features of the Technical Requirements could be incorporated into an upgraded and expanded R-2000 Program.

Energy efficiency and environmental responsibility—more than just buzz words, they signify the new global reality.

Through the Advanced Houses Program, teams of builders, architects, engineers, manufacturers, and all the other participants in the Canadian home building industry have taken up the challenge to build the best housing in the world.

Energy efficiency and environmental responsibility—more than just buzz words, they signify the new global reality.

The Canadian Centre for Mineral and Energy Technology (CANMET) is the research and development arm of Natural Resources Canada.

CANMET Buildings Group works in support of the federal government's energy and environmental initiatives with programs in five key areas:

- Advanced Houses Program
- C-2000 Commercial Buildings Program
- Building Systems Program
- Passive Solar and Window Program
- Indoor Environment Program

For more information on these activities, contact:

Buildings Group, CANMET
Natural Resources Canada
580 Booth Street
Ottawa, Ontario K1A 0E4



CANMET

