Net-Zero Energy Housing

WHAT IS A NET-ZERO ENERGY HOUSE?

A net-zero energy (NZE) house is designed and built to reduce household energy needs to a minimum and includes on-site[1] renewable energy systems, so that the house may produce as much energy as it consumes on a yearly basis. An NZE home is not necessarily an "energy autonomous" house or "off-grid" house, as it can be connected to the electricity grid, so that it can supply electricity to the grid when it is producing more than it needs and draw from the grid when household demands exceed the amount of electricity produced on site. Taken over the year, the energy supplied to the grid balances the energy drawn from the grid, thus achieving net- zero annual energy consumption.

Though the design and construction of NZE homes tend to focus on energy efficiency and renewable energy generation, they may also include technologies and practices that enhance indoor air quality and comfort, reduce environmental impact, conserve natural resources and improve affordability.

Inspiration – the Minto ecohome EQuilibrium™ Housing project

Figure 1 NZE homes integrate energy efficiency and conservation with renewable energy systems.

WHY NET-ZERO ENERGY HOUSING?

NZE housing provides a way to significantly reduce energy-related costs and protect against future energy cost increases. NZE houses also tend to be more resilient in that they can continue to offer shelter during power failures, as they need so little energy to operate and stay warm. NZE homes also reduce the impact of housing on the natural environment by reducing energy-related pollutant

Housing accounts for 17 per cent of secondary energy use in Canada and 16 per cent of the country's greenhouse gas (GHG) emissions.

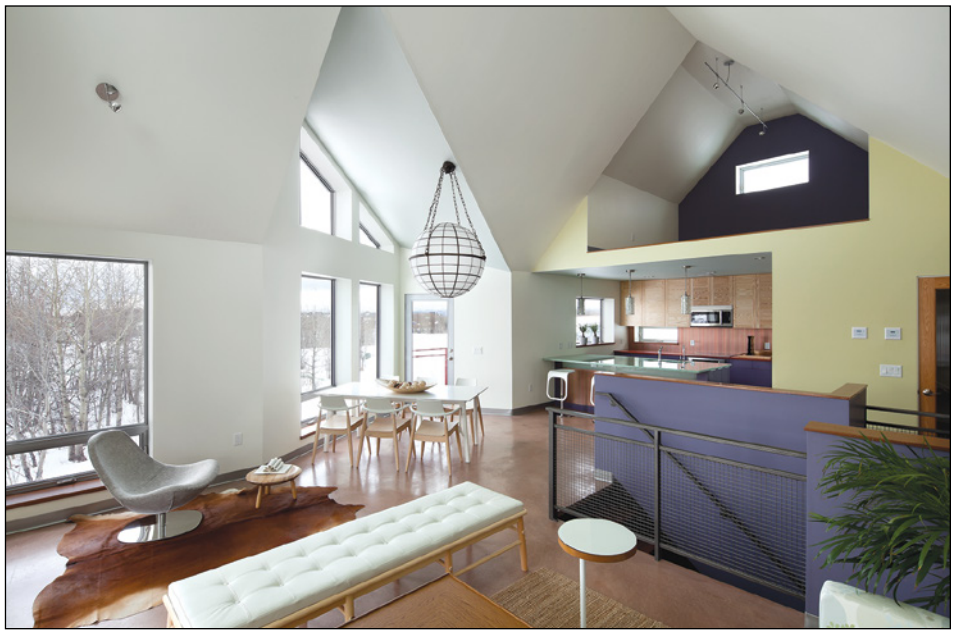
(Source: NRCan, Energy Use Data Handbook, August 2006; Secondary Energy Use and GHG Emissions, Residential Sector, 2004.)

[1] Some definitions of NZE homes include off-site renewable energy sources.

emissions to the land, water and air that contribute to climate change. Another advantage is that, to meet NZE levels of performance, houses have to be well designed and well built.

In addition, all of the features that make an NZE home possible can also provide a very comfortable, quiet and healthy indoor environment with plenty of natural lighting.

Communities of NZE houses offer the potential to reduce the size and cost of the energy, water and sewer infrastructure that serve them. This can help to control the costs of building new infrastructure and to extend the life of existing services.



EchoHaven EQuilibrium™ Housing project

Figure 2 NZE homes also offer bright and comfortable indoor living environments.

ACHIEVING NET-ZERO ENERGY

The CMHC EQuilibrium™ Sustainable Housing Demonstration Initiative launched the first series of NZE sustainable housing projects built across Canada. Eleven projects were constructed between 2007 and 2012, opened to public and industry audiences, and then monitored for performance during occupancy, providing a wealth of information on how to achieve net-zero energy in Canadian housing. For more information, see **www.cmhc.ca/equilibriumhousing.**

In order to create a net-zero energy home, there are three basic elements or steps to consider when designing and building the house:

1. Reduce the home's energy requirements.
2. Include renewable energy systems to provide the amount of energy required to operate the home.
3. Operate the home efficiently.

Reduce the energy requirements

NZE homes focus first on significantly reducing a home's energy consumption. This is achieved through the integration of a wide range of design strategies, technologies, products and techniques:

- Significant quantities of insulation will reduce heat loss in the winter and heat gain in the summer (see table 1). Insulation should be provided all around the building envelope (beneath the slab, in all walls and in the roof), and special attention should be given to eliminate any thermal bridges that can conduct heat through the building envelope.
- A robust continuous air barrier will reduce heat loss and heat gain due to air leakage into and out of the house. The effectiveness of the air barrier should be tested with a depressurization ("blower door") airtightness test.
- The orientation of the home on its building site and the selection and placement of the windows should allow the house to take full advantage of the sun's free heat and

light, as this can significantly reduce energy requirements and improve indoor esthetics.

- The provision of measures such as roof overhangs, shading devices and natural vegetation will prevent overheating inside the home and increasing cooling-related energy use and costs.
- The installation of energy-efficient mechanical ventilation will help maintain a healthy indoor living environment through the provision of a continual exchange of stale indoor air with fresh outside air.
- The use of heat recovery ventilation systems and drainwater heat recovery systems will recover energy otherwise wasted from outgoing exhaust air and from wastewater, respectively.
- All space heating, cooling and water heating equipment, as well as appliances and lighting fixtures, must be properly designed and installed, given the low energy needs of the house. ENERGY STAR® ratings can provide guidance for choosing the most energy-efficient products.

Table 1 Insulation levels that may be found in an NZE home

Area	Net-zero energy home insulation levels (effective RSI- / R-value)
Attic	RSI-11 / R-60 +
Above-grade walls	RSI-7 / R-40 +
Below-grade walls	RSI-3.5 / R-20 +
Basement slab	RSI-2 / R-10 +
Windows	Triple- or quadruple-pane windows, low-e film, argon gas, insulated spacer, casements

Produce the required energy

Once the energy needs have been reduced with energy-efficient technologies and practices, it is time to consider renewable energy options to meet what energy demands remain. The most common option is a rooftop photovoltaic (PV) system to provide electricity.

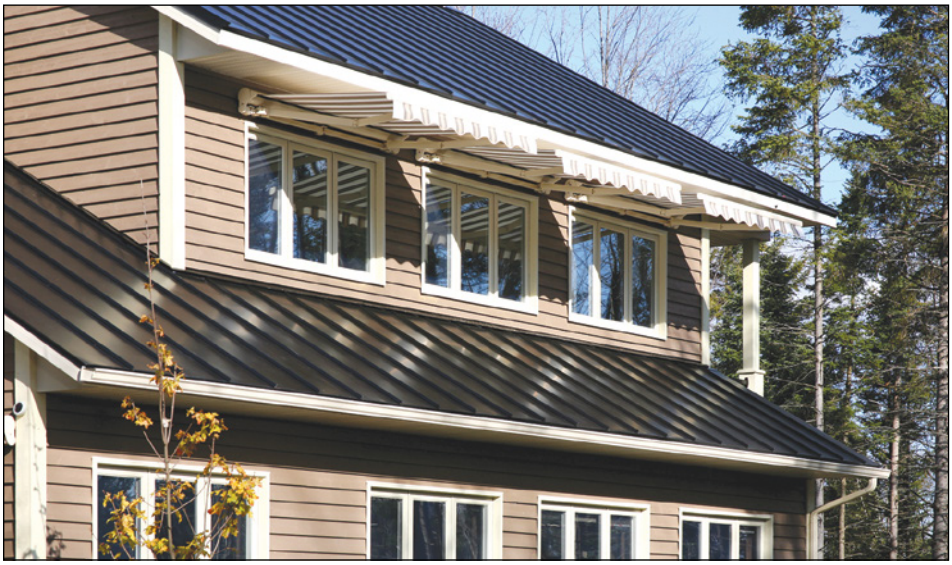
How airtight should an NZE house be?

The airtightness level of a house can have a large impact on heating and cooling energy use, related costs and comfort. Leaky houses also tend to suffer more from moisture problems. Therefore, to achieve NZE levels of performance, it is important the house is as well sealed as possible.

The airtightness of houses is usually expressed in air changes per hour (ACH) at an indoor-outdoor pressure difference of 50 pascals (Pa). The airtightness of a house can be measured with specialized equipment commonly known as a "blower door." For an NZE home, the targeted air change rate may be 1.0 ACH or less. In comparison, a typical code-built home would test at 2.5 to 3.5 air changes per hour or higher.

Riverdale Netzero EQuilibrium™ Housing project

Figure 3 NZE homes feature airtight wall assemblies that can hold high quantities of insulation.



EcoTerra EQuilibrium™ Housing project

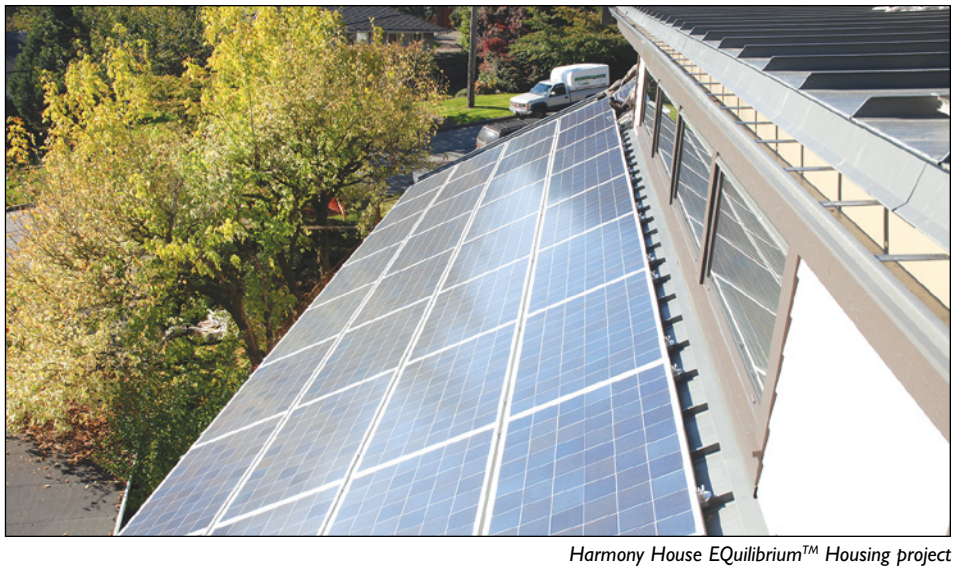
Figure 4 NZE homes are positioned on their sites to maximize solar energy gains and also have features such as awnings and overhangs to protect against overheating.

By ensuring the electricity demands of the house are reduced as much as possible in step 1, the size, and hence cost, of the PV system needed to meet the energy needs can also be reduced. Experience has shown that PV systems work reliably and require little ongoing maintenance. Homeowners should be aware that PV electricity production can be reduced by existing, or future, shading from trees or neighbouring buildings. The annual electricity production from PV systems can be estimated, so the costs and benefits are well understood before the systems are purchased. Many NZE homes constructed in Canada have PV systems of up to 10 kilowatts.

Other renewable energy sources include rooftop solar thermal panels, which produce hot water, as well as wind and water turbines, which generate electricity.

For NZE houses connected to the grid, the PV system is usually connected in such a way that it can deliver electricity back to the grid. While this arrangement does not offer a power source during blackouts, it is simpler to install and maintain than a system that uses energy storage in batteries. Another advantage is that the home is still connected to the electrical grid, thereby ensuring a reliable and continuous supply of electricity, regardless of how much electricity the on-site PV system is generating.

Some jurisdictions provide the opportunity for the homeowner to sell the produced energy to the electricity grid for a fixed price over a specific period of time. Certain utilities allow the PV-generated electricity to be credited on the electricity bill. It is important to note that NZE homes that are connected to gas and electricity utilities will incur fixed system metering, connection and distribution charges—regardless of how much energy the house may consume. In such cases, it will not be possible to reduce the energy bills to zero.



Harmony House EQuilibrium™ Housing project

Figure 5 NZE homes have photovoltaic systems to produce renewable energy on site.

Some NZE systems may store electricity generated on site to be used to directly power the home, and possibly also an electric vehicle. Energy stored in batteries can provide the home with power during blackouts. Battery storage of excess energy allows power to be drawn first from the stored energy and then from the grid, as required, allowing homeowners to take advantage of time-of-use electricity rates. However, a battery storage system is more complex and expensive to install and maintain, and requires dedicated space within the home.

Operate the home efficiently

While the home location, design and systems can go a long way toward determining whether a home can approach NZE consumption, NZE levels of performance can only be achieved by reducing the amount of energy used to run the house and making the most efficient use of the energy actually consumed. Even a house equipped with the latest technologies and built using best practices will fail to achieve NZE performance if its occupants do not pay attention to how they use energy.

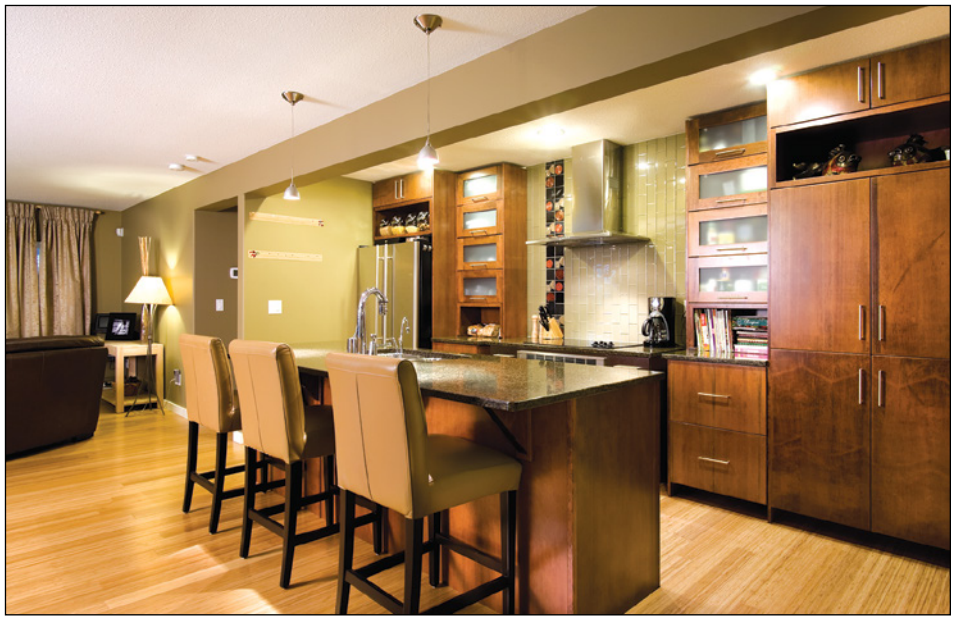
This includes temperature settings for space heating and hot water and the number of electronics, appliances, entertainment centres and other energy-using devices that are plugged in and used. Even the way lights and hot water are used will impact annual energy use and the ability to meet NZE objectives.

Future-proofing a house

The first costs of NZE can sometimes be discouraging. However, there are steps that can be taken to make a low-energy house "NZE-ready," so that the features needed to achieve NZE performance can be added cost-effectively at a later date. For instance, wiring and piping conduits and roof reinforcement can be included in a new home construction project today, with a view to adding rooftop solar energy panels in the future.

In an NZE home, the energy required for appliances and other things plugged into electrical outlets can be more than half of the total energy requirements of the home. Even with a low-energy design, an NZE home may still require an average of 21GJ (5 kW) to simply cook, wash, bathe and operate lights, computers, TVs and video game consoles. Heating the home requires the most energy in a code-built home, while occupant base loads (operation of lights, electronics, appliances, etc.) can require the most in an NZE home.

Some NZE homes install a display or "dashboard" to provide occupants with real-time information on their home's energy consumption and energy production. They can then check how their home is performing in regard to balancing energy use with energy generation and then choose to make changes in order to reduce energy consumption.



Avalon Discovery 3 EQuilibrium™ Housing project

Figure 6 NZE homes feature high-efficiency lighting, appliances and electronics to reduce electricity base loads.

NZE: NOT JUST FOR NEW HOMES

While NZE homes are often associated with modern, new home construction projects, the NZE design and construction principles can be applied to existing homes, as well. Obviously, it is far easier to build NZE features, such as increased insulation levels, superior airtightness, and efficient heating, appliance and lighting systems into new homes than into existing ones.

Now House EQuilibrium™ Housing project

Figure 7 Existing houses can be retrofitted to approach near NZE performance.

Existing homes pose challenges, as they have fixed solar orientation, structure and floor plans. It can also be very difficult to find the space in existing homes to add insulation and install the continuous air barrier system needed to reduce air leakage to a minimum. Despite these challenges, some renovators have applied NZE principles to renovation projects and have managed to ensure a significant reduction in net household energy use.

SUMMARY

NZE housing is a reality today and can offer a wide range of benefits and advantages, including the following:

- Low utility bills—save money on energy costs all year round and be protected from future energy price increases.
- More comfortable living space—enjoy better indoor air quality, stable temperatures, more natural light, and isolation from outdoor noise sources.
- A greener choice for the environment—minimize the household's greenhouse gas emissions and ecological footprint, conserve resources and reduce pollution.
- A better future—help make sure that future generations of Canadians have better housing choices, clean air to breathe, clean water to drink, and a safe, healthy world to live in.

To find more *About Your House* fact sheets and other housing-related information products, visit our website at www.cmhc.ca.

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