# Consumer Guide to **High Performance Homes**

BC HOUSING

# Contents




BC Housing extends its thanks to FPInnovations who co-funded this project, and to the representatives of many organizations involved in the residential construction industry in British Columbia, including builders, consumers, utilities, research and government organizations, which provided valuable input in the development of this guide.

Faced with rising energy costs, a greater concern for the environment and an increased focus on the comfort and health of their families, homebuyers are looking for homes that are more comfortable, healthier, energy efficient, environmentally friendly—and less expensive to operate.

## INCREASING OPTIONS

At their core, high performance homes use less energy, while keeping occupants comfortable and healthy. As the demand for these homes increases, so do the available options – from different performance labels (e.g. LEED, ENERGY STAR, R-2000, Passive House, BUILT GREEN®, EQuilibrium™,[1]) to a variety of emerging technologies (including solar panels, heat pumps, LEDs, etc.) – all of which can be overwhelming.

On the bright side, despite the expanding number of choices, the most cost-effective way to increase housing performance has remained unchanged over the decades:

- maximize the performance of the building envelope by adding more insulation,
- pay attention to details to increase the airtightness, and
- add a heat recovery ventilation system to improve indoor air quality.

This guide assists consumers in making informed decisions.

Focusing on the building envelope and ventilation at the time of construction makes sense, as it is difficult to make changes to these systems in the future. On the other hand, as energy-efficient technologies such as LED lighting become available and more affordable, they can be purchased and added relatively easily to the home.

This guide assists consumers in making informed decisions, whether they are in the market to buy a newly built home, or are looking to hire an architect, designer or custom homebuilder to build a custom high performance house.


Although this guide focuses on new construction, a number of the guidelines presented here can be applied to existing homes. Note that deep energy retrofits can be done on existing homes to such an extent that they become high performance homes. A good source for information on air sealing and insulation retrofits can be found in the BC Housing-published *Best Practices for Air Sealing and Insulation Retrofits for Single Family Homes*. *The 1000 Home Challenge website* provides resources for homeowners considering deep energy retrofits, as well as a series of North American case studies.

[1] EQuilibrium™ Sustainable Housing Demonstration Initiative, launched in 2006 by Canada Mortgage and Housing Corporation (CMHC), led to the construction of 11 very high performing homes in Canada (two in B.C.).

## WHAT ARE THE BENEFITS?

There are many benefits to living in a high-performance home. These can include:

**Lower energy bills**—lower energy consumption reduces your operating costs and helps provide protection from future increases in energy prices.

**Healthier living**—better air quality by design, including mechanical ventilation and the use of materials and finishes with lower amounts of volatile organic compounds (VOCs), helps provide a healthier indoor environment.

**Greater comfort**—an energy-efficient building envelope will make you feel more comfortable at equivalent indoor temperatures due to reduced drafts and temperature variations in the home.

**Reduced pollution and CO2 emissions**—reduced energy use can significantly lower greenhouse gas (GHG) emissions.

**Natural light**—making effective use of daylight can provide a more pleasing indoor environment while reducing your electricity bill.

**Increased resale value**—many homebuyers are looking for energy-efficient homes, which can typically be sold more quickly and for more money than conventional homes.

**Reduced noise levels**—increased insulation levels and better windows can reduce sound transmission from outside.

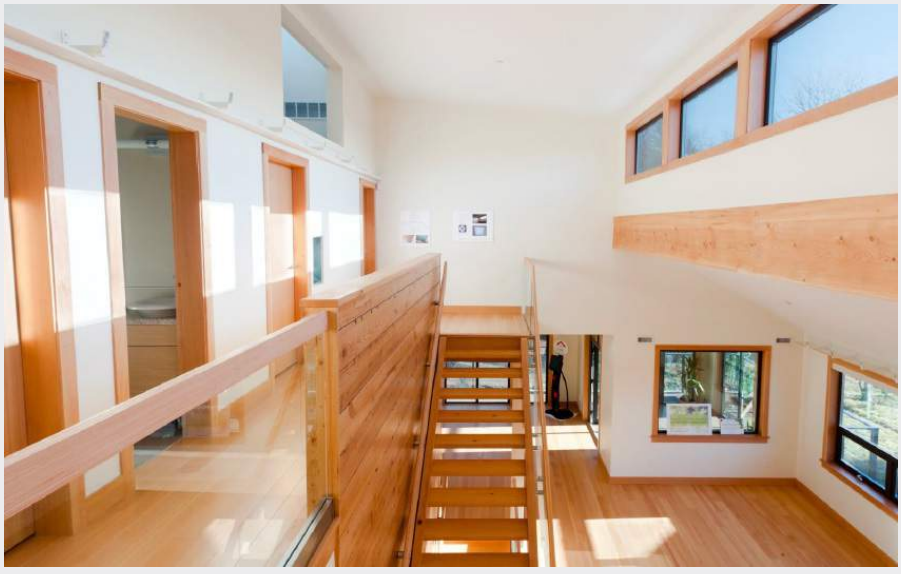
**Higher resilience**—super insulation combined with passive solar design can maintain comfortable indoor temperatures longer than conventional homes during power outages.

A federal government study concluded that 94 per cent of R-2000 home occupants found a significant improvement in indoor air quality compared with their previous home, and over half of occupants reported general health improvements.

*"The temperature is always perfect. The air is always perfect in terms of humidity. The air feels fresh but good. That first thing, level of comfort, is like incredible. We are most impressed with this."*

EQUILIBRIUM™ HOMEOWNER

Despite the significant downturn in U.S. housing in 2009, the "green" building market continued to grow despite negative market conditions[2].



[2] McKinsey & Company, 2009. *Pathways to a Low-Carbon Economy – Version 2 of the Global Greenhouse Gas Abatement Cost Curve.*

"This house fits my lifestyle. I am very happy about being here. The difference between the EQuilibrium™ house and my previous residence, which was a one-bedroom apartment with 400 sq. ft., (is) my utility bills in the EQuilibrium™ house are less than that of a one-bedroom apartment. My bills are stunningly low. Anywhere from half to a third of what I was originally paying."

EQUILIBRIUM™ HOMEOWNER

## WHAT DOES IT COST?

High performance homes typically cost more to build than conventional houses, but the higher purchase price is offset, at least in part, by lower energy consumption costs. What's more, high performance homes are often of higher quality and more comfortable to live in. Making housing more energy efficient has also been shown to be one of the lowest cost opportunities to contribute to energy and climate change goals.

## FIRST PRIORITY: BUILDING ENVELOPE

R-value represents the capacity of a building component to resist heat flow. The higher the R-value, the greater the insulating power.

A lesson learned from various high performance home projects is that it is best to focus on simplicity. While adding more insulation to walls is relatively easy to design, build and maintain, many consumers looking to buy a high performance home first think of technologies such as ground-source heat pumps or solar domestic hot water systems. However, it can be challenging to properly commission and achieve high energy performance using these more complex technologies. Many of CMHC's EQuilibrium™ housing projects found that not only is it difficult to get more complex systems to perform as expected, but they can also be difficult and more costly to operate and maintain over time.

Focusing on the building envelope not only leads to high energy savings, but it is also an easy way to improve comfort and reduce noise levels. Unlike other systems that get changed over the life of a building, such as furnaces, major changes to the building envelope are more difficult and costly to make after the home is constructed. Therefore, it is more cost effective to do as much as possible to insulate and make the home airtight during construction.

### Insulation Levels

The minimum levels of insulation that builders are required to include in new homes are set as minimum R-values by code (see sidebar). The BC Building Code sets the minimum effective insulation levels at between R-15.8 and R-21.9, with requirements varying based on climate and whether or not heat recovery ventilators are used. The Vancouver Building Bylaw (VBBL) has required R-22 effective insulation since January 1, 2015.

Determining the right amount of insulation for your high performance home will depend on a number of factors, including the budget, local climate, and elements specific to your building. Good guidance can be found in a recent study[3] conducted by Natural Resources Canada (NRCan) that examined the most cost-effective insulation values to use to achieve net-zero energy consumption. The results indicate an optimal range of R-0 to R-10 under the slab, R-24 in basement walls, R-30 to R-40 for main walls, and R-60 to R-80 in the roof, with the low end of the range suitable for warmer coastal climates, and the higher end of the range for colder interior and northern regions of the province.

G. Proskiw, A. Parekh. 2010. *Optimization of Net Zero Energy Houses*, Presented at the Second Building Enclosure Science & Technology Conference. Portland, OR.

Due to these higher insulation levels, walls and ceilings will be thicker than usual. Wall thicknesses range from 254 mm (10") to 457 mm (18"). Open ceiling thicknesses range from 406 mm (16") to 610 mm (24"). This has an impact on floor areas and building heights, and needs to be accounted for in the design stage to ensure compliance with local bylaws. Some municipalities have regulations on allowable lot setbacks, house footprints and height that make allowances for greater insulation levels, whereas other municipalities do not take insulation thickness into consideration.

BC Housing has published guides assisting builders and designers in building energy-efficient walls.

Higher R-values can be achieved in many ways, and the different solutions can be evaluated based on thermal and moisture control, durability, buildability, material use and cost. Some emerging solutions include:

- applying additional insulation to the exterior of a standard wall,
- building a double-stud wall system, with two stud walls separated with an insulation-filled space, and
- using structural insulated panels (SIPs).

The key is to pick a wall system that is appropriate for your climate, that your builder has experience with, and that meets your needs.

More information on energy-efficient wall options can be found in the BC Housing-published *Illustrated Guide – R22+ Effective Walls in Wood-Frame Construction in British Columbia,* and in FPInnovations' *Guide for Designing Energy-Efficient Building Enclosures for Wood-Frame Multi-Unit Residential Buildings in Marine to Cold Climate Zones in North America* or its guide *Pathways to High Performance Homes in British Columbia*. These guides assist builders and designers in not only building energy-efficient walls, but to do it in a way that will not compromise durability, which is very important when it comes to super-insulated walls.

## Windows

When it comes to windows, size, type and location can make a big difference. In a high performance home the windows would typically be triple-glazed. The NRCan cost-effectiveness study found that although a good triple-glazed window is desirable, it does not have to be the most expensive window available.

*"Triple-glazed windows keep out the noise and the warmth in. It is very comfortable."*

EQUILIBRIUM™ HOMEOWNER

There are a variety of windows on the market with different performance levels. Good windows will be rated to have low heat loss (low U-value of around 1.2 W/m²K [0.21 Btu/h·ft²·F] or less), and a range of possible solar heat gain coefficients (SHGC). The optimal SHGC will depend on a number of factors, including shading, orientation, and the amount of windows in the house.

A house designer should look at the impact of different window options in terms of both energy and comfort. The more windows in the home, the higher the risk of overheating. Proper attention to windows and shading can help maximize passive solar heating in the winter while avoiding overheating in the summer. Windows facing south should typically have overhangs that shade the windows when the sun is high in the summer, and allow sunlight in during the winter when the sun is lower in the sky. East and west facing windows may need external shading to limit overheating.

## AIRTIGHT BUILDING, MECHANICAL VENTILATION AND INDOOR QUALITY

All buildings lose heat from the unintentional airflow through wall penetrations, such as leaks around doors and windows and through other small cracks and openings. With current air-sealing requirements in the BC Building Code (BCBC), it is expected that new homes in the province will have air leakage in the range of 2.5 to 3.5 air changes per hour (ACH) when pressurised at 50 Pa by a blower door fan, whereas a very airtight house can have 0.5 ACH or less. A good target for a high performance home is a measured airtightness of less than 1.5 ACH at 50 Pa.

Making houses more airtight is a relatively inexpensive measure that can generate big energy savings. The key is to ensure a continuous air barrier. This barrier can be a combination of several materials, as long as it provides an unbroken barrier between conditioned space (indoors) and unconditioned space (outdoors, attic, crawlspace, and attached garage).

House undergoing a blower door test. Test provides a measured air leakage rate and can help identify areas in the building envelope that need to be addressed to improve airtightness.

In older homes, air leakage unintentionally helps bring fresh outdoor air into the house. If a house is made airtight, mechanical ventilation must be installed to ensure that there is adequate fresh air inside to maintain good indoor air quality. Mechanical ventilation provides superior indoor air quality compared to air infiltration through doors, windows and other openings. With the use of a heat recovery ventilator (HRV) or energy recovery ventilator (ERV), heat from the exhaust air is recovered by preheating the incoming fresh air. Windows can still be opened, but they will not necessarily improve indoor air quality, and will often lead to increased heating and cooling costs.

To ensure the removal of indoor pollutants and the supply of fresh outdoor air, an HRV/ERV should be operated at low speed continuously year-round, especially in airtight homes. High-speed operation is often needed when cooking or using the bathroom, or when there are extra people in the house. For more information on how to operate and maintain an HRV/ERV system, consult BC Housing's *Maintenance Matters – Maintaining Your Heat Recovery Ventilation System*.


More information about HRVs and ERVs can be found in BC Housing's *Heat Recovery Ventilation Guide for Houses*.

## SPACE HEATING AND COOLING

Builders of high performance homes that have a highly insulated and airtight building envelope need to design space-heating systems (and cooling if required) to match the substantially reduced energy loads. Not taking into account the reduced load can lead to inefficient operation, premature wear and tear, and a missed opportunity to save money from buying a smaller heating system and associated ducting. Those relying on old rules of thumb to design a heating and cooling system run the risk that it will not be able to perform as desired. The heating demand can be reduced to such a degree that options not typically thought of as energy efficient become acceptable because they can be sized small enough to meet the small demand. Ask your builder or designer how the heating and cooling systems match with the reduced demands of a high performance home.

## OTHER ENERGY LOADS

After having maximized the performance of the building envelope and invested in a heat recovery ventilator, a number of choices can be made to further reduce energy consumption. These include choosing energy-efficient lighting, appliances, electronics, etc., as well as house design options such as energy-efficient hot water heaters and drainwater heat recovery systems to recapture energy going down the drain in showers. Energy-efficient appliances and electronics do not always cost more than similar choices. Buyers should take the time to verify their rated energy consumption and factor that in the purchase decision. Most of the major appliances in Canada need to be sold with an EnerGuide[4] label that provides their energy consumption rating. For electronics and other appliances, look for ENERGY STAR certified products, which are typically in the top 15 to 30 per cent of their class in terms of energy performance.

## RENEWABLE ENERGY GENERATION

If you have reduced energy consumption to a minimum and are still interested in lowering your energy footprint further, consider adding renewable energy technologies. Rooftop solar technologies should be considered in the roof design stage, as the slope, orientation and area should be configured with these technologies in mind. The optimum slope and orientation is affected by local climate, latitude, topographic features, vegetation and the particular application. While optimal slopes and orientations for particular types of systems exist, some flexibility is possible without incurring large penalties.

Natural Resources Canada has developed *Solar Ready Guidelines* that provide design considerations and modifications to inform builders.

Care should be taken not to shade roof-mounted solar equipment (e.g., photovoltaic modules and solar thermal water-heating panels) or areas of the roof reserved for future solar installations. A simple rule of thumb is that any potential shading structure, like a chimney, should be at least twice as far away from the solar equipment as the structure is tall. Sun charts and digital tools are available to assess how obstructions such as trees, buildings, or chimneys will shade the system at various times of the year. Natural Resources Canada has developed *Solar Ready Guidelines*[5] that provide design considerations and modifications builders can make to new attached and detached homes in preparation for the installation of a future solar system.

[4] Consult Natural Resources Canada's guide: *Choosing and Using Appliances with EnerGuide* for more information. Available online at: www.nrcan.gc.ca.

[5] Natural Resource Canada, 2013. *Solar Ready Guidelines for solar domestic hot water and photovoltaic systems*. Available online at: www.nrcan.gc.ca.

## OTHER POSSIBLE FEATURES

Many other features can contribute to indoor health, resource conservation, and to the protection of the local environment. They are worth investigating.

Although this guide focuses heavily on energy efficiency features, there are many other features that can contribute to indoor health, resource conservation, and to the protection of the local environment. These are not covered in depth in this guide, but are worth investigating.

There are many sources of information on these design aspects. A good source are building program labels and rating systems that consider factors beyond energy efficiency. For example, the LEED for Homes Rating System guidance documents [6] outline many design strategies that can help make your home more sustainable, such as water conservation features, selecting materials that emit little to no volatile organic compounds (VOC), and/or selecting materials that are more environmentally friendly.

## QUESTIONS TO ASK WHEN BUYING A HIGH PERFORMANCE HOME

If you hope to buy a high performance home, it is vital to connect with a builder or designer who understands your needs and has the skills to meet them. You cannot just add some green products to a house and expect it to perform well; how the parts work together matters. Knowledgeable builders and designers educate their customers.

The cornerstone of a high performance house is the whole-house systems approach. What this means is that a knowledgeable builder or designer considers all the components and how they interact when building your home: the design, the location, and the materials that will be used, so that the house conserves energy, is healthier, is comfortable, and causes less stress on the environment.

### The following are some questions to ask the builder or designer:

- Do you affix a third-party verified performance label to the home?
- How do your insulation levels compare to minimum code requirements?
- Has the airtightness of the house been tested and what level did it achieve?
- Do your homes include a heat or energy recovery ventilation (HRV/ERV) system that was designed and installed by a qualified contractor?
- Do you follow best practices to help extend the durability of your homes?
- What other elements are included in the home to help improve its performance?

It is equally important that design professionals and builders ask you questions as you explain your needs and desires. If they do not understand what you really want, you will likely not get what you desire.

[6] LEED Canada for Homes 2009 Rating System can be consulted to see example sustainable design features: www.cagbc.org/cagbcdocs/LEED_Canada_for_Homes_2009_RS+addendum_EN.pdf

## KEY POINTS TO REMEMBER

- High performance homes cost more to build but offer many benefits, including greater comfort and healthier living, with some or all of the upfront costs recovered through lower utility bills.
- Airtight, highly insulated building envelopes are central to high performance homes. Costs can be recovered by savings associated with buying a smaller heating system, and in lower heating costs.
- The use of heat recovery ventilators is a typical feature of high performance homes to ensure adequate fresh air in all rooms.
- Insulation levels are difficult to change after the home is constructed, thus investing in a more energy-efficient building envelope will provide a lasting legacy for the home.

Homebuyers are increasingly looking for homes that are comfortable, healthier, energy efficient, environmentally friendly — and less expensive to operate.

## FOR MORE INFORMATION

- EQuilibrium™ Housing homeowner quotes were taken from the CMHC publication: EQuilibrium Housing Homeowner/Occupant Qualitative Research Report.
- *City of Vancouver-Passive Design Toolkit-For Homes.* Light House Sustainable Building Centre and Dr. Guido Wimmers, 2009. Available at www.vancouver.ca.
- 2015. *Illustrated Guide – R22+ Effective Walls in Wood-Frame Construction in British Columbia.* Published by BC Housing. Available at www.bchousing.org.
- 2013. *Guide for Designing Energy-Efficient Building Enclosures for Wood-Frame Multi-Unit Residential Buildings in Marine to Cold Climate Zones in North America*. Published by FPInnovations. Available for download at https://fpinnovations.ca/Pages/index.aspx.
- 2014. *Pathways to High Performance Homes in British Columbia*. Published by FPInnovations. Available for download at https://fpinnovations.ca/Pages/index.aspx.
- Canadian Home Builders' Association Builders' Manual. Available for purchase at www.chba.ca/buildermanual.aspx.




BC HOUSING

Technical Research & Education

1701- 4555 Kingsway
Burnaby, BC V5H 4V8

Phone: 778 452 6454
Toll-free: 1 866 465 6873

www.bchousing.org
Email: technicalresearch@bchousing.org