Energy Efficiency Building Envelope Retrofits

- Exterior Retrofit for 1960s and 1970s Two-Storey Houses
- >75% Space Heating Energy Savings

Figure 1: Two-storey detached house

EXTERIOR RETROFIT

The building envelope can be retrofitted from either the exterior or the interior. The choice will largely depend on the house's interior and exterior finishes, layout and construction, lot line setback requirements, other renovation needs and whether or not the house will be occupied during the renovation. There are several advantages to insulating and air tightening from the exterior. An exterior retrofit covers cracks, holes and thermally conductive materials (called 'thermal bridges'); it allows you to detect and repair water entry problems; it doesn't affect interior finishes or reduce room sizes, it makes it easier to ensure the insulation and air-barrier system is continuous; it keeps the structure at a more uniform temperature; and it provides an opportunity to update the appearance of the house.

RETROFIT FOR ENERGY SAVINGS

One of the best ways to reduce the energy consumption of an existing house is to add insulation to the roof, walls and basement, upgrade windows and doors, and seal cracks, leaks and holes. These improvements, called "energy efficient building envelope retrofits," help to reduce heat losses in the winter and heat gains in the summer, and should result in lower energy bills, improved comfort and reduced outside noise intrusion.

This fact sheet provides guidance for exterior energy efficient building envelope retrofits to 1960s and 1970s two-storey houses that can reduce space heating energy consumption by 75 per cent or more. It describes the starting point (what you have now), air-sealing and insulation options to achieve the targeted energy savings, technical considerations to keep in mind in the planning of the retrofit project, and general precautions.

What You Have Now

The pre-retrofit construction of a 1960s or 1970s two-storey house will vary depending on its age and location and on whether any upgrades have already been completed. The building envelope of a typical 250-m^2 (2,691-sq.-ft.) house of this vintage with a finished basement will likely be clad with masonry, siding or stucco. Figure 2 illustrates common materials, insulation RSI-values (R-values), and assemblies for this type of building, subject to regional variations. Houses such as these are generally quite leaky with measured airtightness values averaging above 6.0 air changes per hour (ACH_{50}).

Houses built in the 1960s and 1970s also tend be lightly insulated. It is common to find attics with a single layer of insulation and walls with insulating values that are half that required in new homes. Basements usually have modest levels of insulation, if any at all. Fortunately, there are many opportunities to improve the energy efficiency of the building envelope. Insulation, air sealing and window technology have evolved significantly. For example, higher RSI-value (R-value) insulation is now available; low-emissivity coatings, gas fills and superior seals and spacers improve the thermal performance of windows considerably; and airtightness techniques are better understood.

To achieve over 75-per-cent space heating energy savings, air tightening and insulation values should be increased in all of the critical areas of the building envelope: roof or attic, above-grade walls, windows and doors, below-grade walls and basement floor slab. Figure 3 shows a general approach to retrofitting the same wall shown in figure 2—from the attic to the basement.

Canada

CMHC SCHL
HOME TO CANADIANS

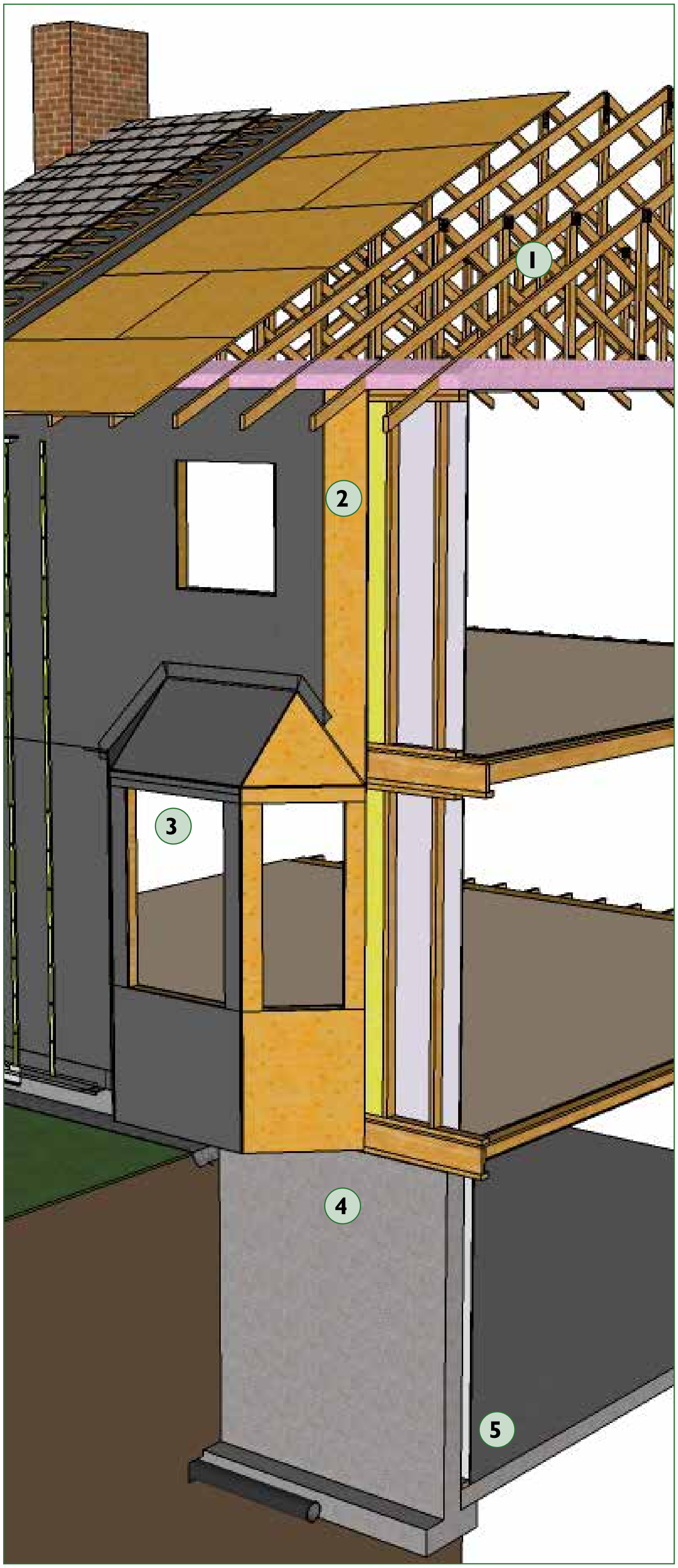


Figure 2: Pre-retrofit section through roof, walls, floors and basement

1. Roof and attic

- Fibreglass or cellulose insulation, providing a nominal RSI-4.5 – 5.5 (R-25 – 31).

2. Above-grade walls

- 38 mm x 89 mm (2" x 4") wood-frame walls. The stud cavity may contain fibreglass batt insulation, providing a nominal RSI-2.0 – 2.6 (R-11 – 15).

3. Windows and doors

- Single- or double-glazed with wood or vinyl frames.

4. Below-grade walls

- Concrete or concrete block, may be uninsulated or may have wood-frame walls filled with fibreglass batt insulation, providing a nominal RSI-1.1 – 2.2 (R-6 – 12).

5. Basement floor slab

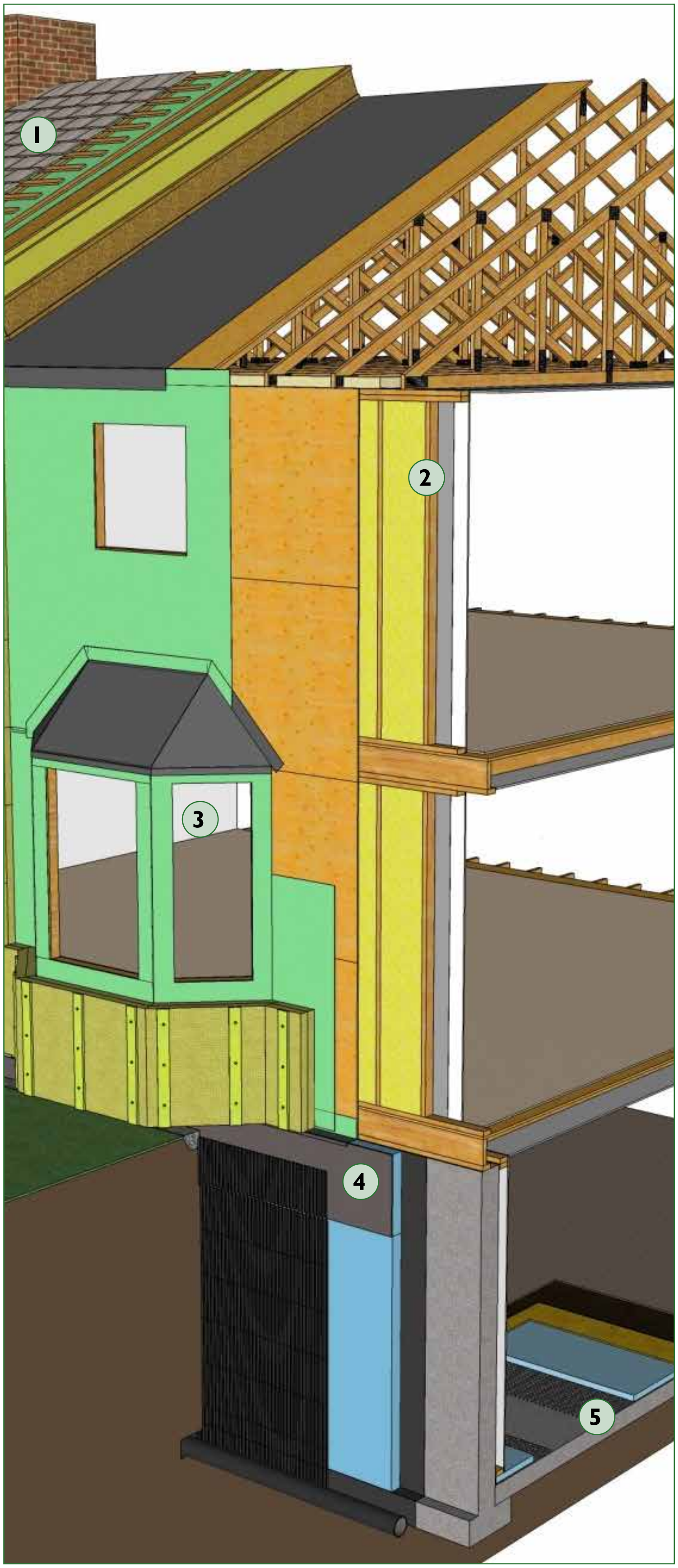


Figure 3: Post-retrofit section through roof, walls, floors and basement

1. Roof and attic

- Extend roof sheathing membrane/air barrier down and seal to wall air barrier (sheathing membrane).
- Install exterior I-joists and insulation, ensuring continuity of roof and wall insulation.
- Install new roof sheathing with strapping and ventilated drainage cavity.

2. Above-grade walls

- Install exterior insulation with vertical strapping and ventilated drainage cavity.

3. Windows and doors

- Replace windows with triple-glazed, low-e, low conductivity frames with insulated spacers.
- Install closed-cell spray foam between windows and doors, and rough openings.
- Install insulated doors.

4. Below-grade walls

- Ensure bituminous dampproofing covers foundation from grade to footing.
- Install extruded polystyrene (XPS) insulation and drainage mat.

5. Basement floor slab

- Install extruded polystyrene (XPS) insulation over existing floor slab.
- Install new sheathing and finished floor.

Before planning a retrofit for a specific house, CMHC recommends that a qualified residential energy service provider undertake an EnerGuide audit of the house. The audit should measure the airtightness of the pre-retrofit house, suggest upgrades to the heating system, and locate areas where air leaks should be sealed and insulation should be added. Audits and ratings can be obtained from service organizations licensed under Natural Resources Canada's EnerGuide program. For more information on finding a qualified service organization, visit http://oee.nrcan.gc.ca/residential/personal/16352.

BUILDING ENVELOPE RETROFIT MEASURES FOR SPACE HEATING ENERGY SAVINGS

Taken together, the following energy-efficient retrofit measures should result in space heating energy savings of 75 per cent or more:

- Improve the airtightness to 1.0 ACH_{50} or lower.
- Add insulation on top of the roof.
- Add insulation on the exterior of below-grade (basement) walls.
- Add insulation on the exterior of above-grade walls.
- Add insulation to the basement floor slab.
- Replace windows with best quality windows.

Improving airtightness by sealing cracks, holes and gaps in the building envelope is relatively inexpensive and has a big effect on reducing energy loss, making it the most cost-effective measure. In other words, it leads to the greatest savings of heating energy per dollar spent. Moreover, an airtight house gains the full benefit of all the other retrofit measures because air leakage can reduce the thermal resistance of some types of insulation. Because of this, all proposed retrofit options include increasing airtightness to 1.0 ACH_{50}. Improved airtightness reduces air leakage into the house and may require improved mechanical ventilation, such as that provided by a heat recovery ventilator, to maintain acceptable indoor air quality. The measures required to achieve this level of airtightness can be determined by an energy audit.

The suggested total effective RSI-values (R-values) to achieve space heating energy savings of 75 per cent or more are as follows: RSI-7.0 (R-40) in the roof or attic, RSI-3.5 (R-20) in the below-grade walls, RSI-7.0 (R-40) in the above-grade walls, RSI-1.8 (R-10) in the basement floor slab, and RSI-1.0 (R-6) in the windows. Assuming that the pre-retrofit house has similar insulation levels to those outlined in figure 2, the approximate amount of insulation that should be added to each of the building envelope locations is shown in table 1.

TECHNICAL CONSIDERATIONS

Roof and attic

Insulation

Insulating the roof/attic from the exterior makes the most sense when the existing roof is too shallow to accommodate a sufficient amount of insulation or when the roof should be replaced for other reasons. However, there are limits to the amount of insulation that can be added on the exterior. RSI-7.0 (R-40) is considered to be reasonable for this application. Note that the existing insulation in the attic ceiling will no longer contribute to the RSI-value (R-value).

Install an I-joist structure (or similar framing) on a new self-adhesive membrane over the existing roof sheathing, and fill the cavity between joists with fibreglass batt insulation to the effective RSI-values (R-values) outlined in table 1. The 'effective'

ACH_{50} Value	Retrofit Measures					Space Heating Energy Savings (approximate)
	Add Insulation on Top of Roof	Add Insulation to Exterior of Below-Grade Walls	Add Insulation to Exterior of Above-Grade Walls	Add Insulation to Basement Floor Slab	Replace Windows and Doors with Best Quality Windows and Doors	
1.0	RSI-7.0 (R-40)	RSI-3.5 (R-20)	RSI-7.0 (R-40)	RSI-1.8 (R-10)	RSI-1.0 (R-6)	>75%

Table 1: Suggested ACH_{50} and additional effective RSI-values (R-values) to achieve space heating energy savings of 75 per cent or more

insulation value accounts for the reduced insulation value of thermally conductive components in the assembly, such as trusses, rafters and studs, and is usually lower than the nominal value of the insulation itself. The original rafter or truss tails should be cut off, and a plywood or oriented strand board (OSB) sheathing nailed to the truss ends. This will make it easier to connect the wall insulation and air barrier with the roof insulation and air barrier.

Alternatively, in lieu of installing an I-joist system, a continuous layer of closed-cell polyisocyanurate foam insulation can be installed over the self-adhesive membrane and existing roof sheathing. A new exterior sheathing board, sheathing membrane and roof finish can then be installed over top of the closed-cell insulation. This retrofit may be advantageous if the weight of the I-truss framing on the existing roof is a structural concern.

Airtightness

The retrofitted roof involves the removal of the existing shingles and the installation of a self-adhered membrane (air and vapour barrier) on top the existing roof sheathing prior to installing new I-joists (see figure 4).

Alternatively, instead of installing a self-adhesive membrane, 50 mm (2 in.) of closed-cell spray foam insulation may be applied directly on top of the sheathing between the I-joists, before insulating with fibreglass batts.

In either case, ensure the air barrier is continuous at the roof-to-wall connection by sealing the roof air barrier (for example, the self-adhering membrane) to a component that is connected to the wall air barrier (for example, the wall sheathing membrane).

If there is an existing air barrier/vapour retarder in the ceiling, an opening should be made in the ceiling to allow conditioned air into the attic. Otherwise, moisture laden air could become trapped in the attic space (refer to Important Considerations, below).

Vapour retarder

In the retrofitted roof assembly, the self-adhesive sheathing membrane applied to the plywood sheathing (interior of the insulation) is the vapour retarder. To avoid moisture problems, it is important that the exterior water-resistive barrier is vapour-permeable.

In the alternative approach, the layer of closed-cell spray foam is vapour-impermeable and can function as the vapour retarder when placed on the warm (interior) side of the insulating layer.

Water penetration control

This assembly sheds all exterior moisture by gravity drainage over shingled materials. The top side of the sheathing is drained and ventilated by constructing a 10-mm (3/8-in.) to 64-mm (2½-in.) strapped cavity (to support wood or asphalt-fibreglass shingles, roof tiles, or metal roofing). During the retrofit, pay careful attention to the condition of the existing roof sheathing and the attic space. If there are indications of moisture penetration (water staining, mold or wood rot), further investigation and repair will be required.

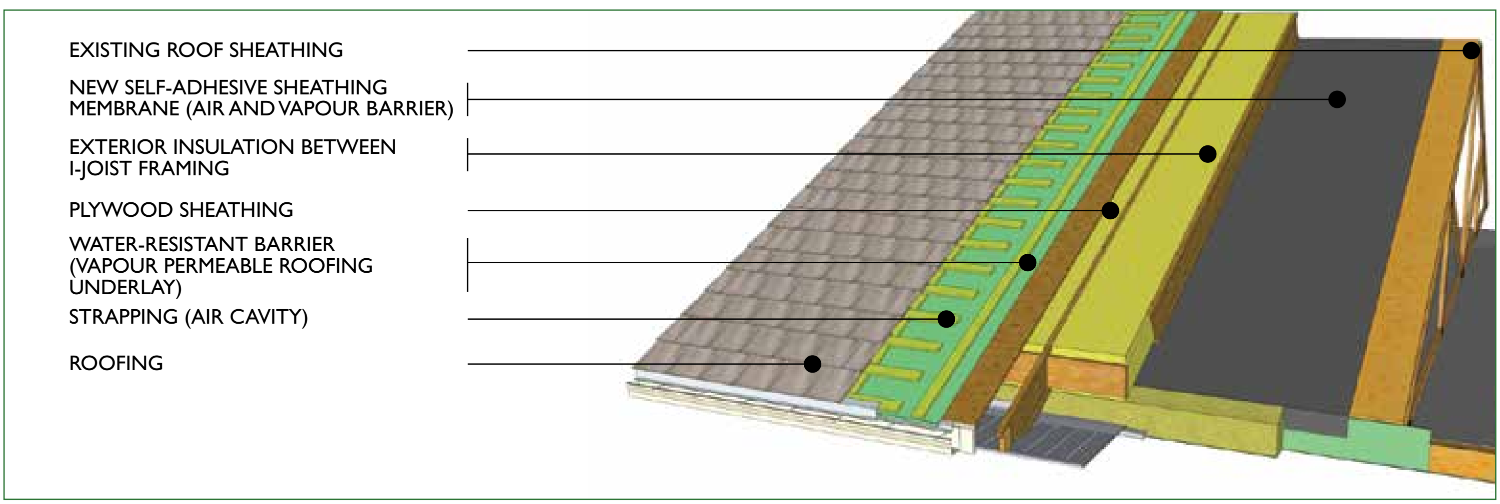


Figure 4: Section through roof

Important considerations

The installation of a new exterior insulated roof assembly makes the existing attic space now part of the interior space. By extending and sealing the wall air barrier to the new roof air barrier, the soffit venting (if it existed) will be eliminated. Vents in the roof and gables should be removed, and their openings covered over with sheathing. The new roof and wall air barriers must extend over the original vent openings to ensure a continuous air seal. In addition, the new wall insulation must extend over the gable ends and connect to the roof insulation.

The attic space must be ventilated when it is part of the interior space. The attic hatch should be removed and replaced with a decorative grate to allow conditioned air from below to rise to the attic, and at least one return air duct for the house space heating system should be extended into the attic to draw the attic air back to the furnace and induce air circulation. In houses with no ducted heating systems, a fan should be installed in the ceiling between the conditioned attic and the space below to circulate the air.

Above-grade walls

Insulation

To retrofit above-grade walls from the exterior, rigid mineral-wool insulation is attached to the outside of the sheathing in two layers, with joints staggered and overlapped (see figure 5). The insulation is attached with screws through vertical strapping on the exterior of the insulation. The added insulation must be sufficient to produce the effective RSI-value (R-value) in table 1. New cladding is installed outside of the exterior insulation and attached to the vertical strapping. Refer to table 1 for suggested insulation values.

Airtightness

Airtightness is achieved by installing an air barrier, typically the sheathing membrane sandwiched between the sheathing board and the insulation. Proper detailing is required at all joints and penetrations in the sheathing membrane to ensure air-barrier continuity. Connect all components of the wall air barrier with the air barriers in the roof and below-grade assemblies and at all interfaces and joints throughout the house (such as windows, floor projections, etc.).

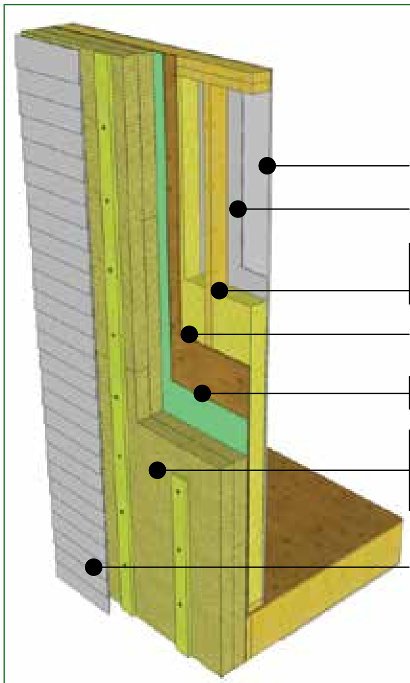


Figure 5: Section through above-grade wall

Vapour retarder

The existing polyethylene on the interior of the wall assembly acts as the primary vapour retarder. Alternatively, vapour-retarder paint, in combination with sealant at joints and penetrations, may provide adequate vapour control.

Water penetration control

The cladding acts as the assembly's primary water shedding surface, while the sheathing membrane acts as a water-resistive barrier. Alternatively, an unsealed layer of vapour permeable sheathing membrane (water-resistive barrier) can be installed between the insulation and the furring to intercept any water that gets past the cladding. Ensure that there is a vented air space between the cladding and wall sheathing to enable the wall to dry[1].

Pay careful attention to the condition of the exterior sheathing. If there are indications of moisture penetration (water staining, mold or wood rot), further investigation and repair will be required.

[1] A drained and vented rainscreen wall with an air space between the cladding and sheathing is recommended.

Important considerations

Mineral-wool insulation is shown in this retrofit approach, since it is sufficiently rigid to support the furring strips and cladding and is vapour-permeable to allow drying. Foam insulation, such as XPS, may also be used for this retrofit; however, the vapour-impermeable characteristics of the foam can restrict drying. Therefore, greater care must be taken to reduce and control the indoor relative humidity and minimize the amount of exterior moisture that reaches the sheathing membrane. To encourage drying to the exterior, the air-barrier membrane should be vapour permeable, the joints between the foam should be left open (unsealed) and a vented drainage space (that is, rainscreen) should be provided between the insulation and the cladding.

Windows and doors

Insulation

Doors with insulated cores and energy-efficient windows having either double, or preferably, triple glazing, and low-conductivity frames (vinyl or fibreglass) can provide significant energy savings to existing homes. The windows should have low-e coating(s), argon-gas fill and low-conductivity insulating glass edge spacers that can be customized depending on performance needs. For instance, a low-e coating applied to the inside surface of the outside pane will reflect much of the sun's energy back to the exterior, thereby reducing helpful solar heat gains in the winter. If the coating is applied to the outside surface of the inside pane, this will allow more of the sun's energy into the house and will also help reflect internal heat back into the house to reduce the space heating requirements. Look for windows with overall thermal resistance values in accordance with levels shown in table 1 or better.

Replacing architecturally significant doors may not be desirable, but poorly insulated doors can cause a significant loss of energy in a well-insulated house, particularly in cold climates. If replacing the doors, look for doors with insulated cores and thermal resistance values greater than RSI-1.0 (R-5.7). Consider installing storm doors outside the existing exterior doors to reduce heat loss in winter. During summer months, the storm door vent should be open to allow the heated air between the doors to escape to the exterior, thereby preventing damage to the door components due to excess heat buildup.

Where possible, consider exterior shading devices, such as roof overhangs and awnings, to limit solar heat gain on south-, east- and west-facing windows during the summer. For south-facing windows, as a rule of thumb, the awning or overhang should extend out a distance equal to one-third of the window height to provide shading.

Airtightness

It is important to provide an airtight interface between the windows/doors and the walls. This can be accomplished by installing a backer rod and sealant, or spray foam insulation, in the gap between the rough opening and the window or door (see figure 6). Operable windows (such as awning, sliding, casement, tilt-turn, or single- or double-hung windows) are prone to leakage over time; gaskets, caulking, tapes, seals and weatherstripping break down with continued use. Consider selecting windows with low air-leakage characteristics and durable seals and gaskets.

Vapour retarder

The windows and doors can act as vapour retarders, provided that the connections between the windows/doors and walls are airtight.

Water penetration control

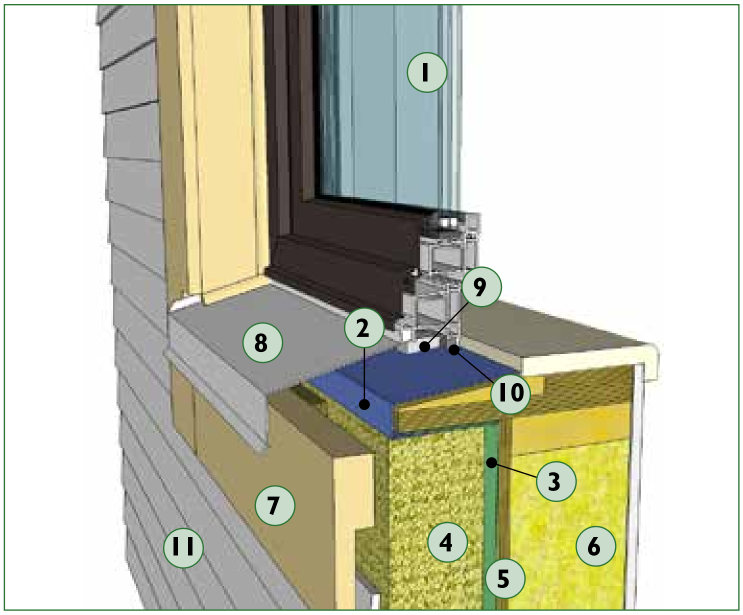
It is important to provide good sealing and water shedding where the window/door sits in the wall. Provide a waterproof "sill dam" underneath the window and slope it outwards to the exterior of the wall. Ensure the sill water barrier is effectively sealed to the window frame and the water barriers in the existing or retrofitted wall assembly.

Choose windows with appropriate water penetration resistance. This is particularly important for houses in exposed locations or climates with high wind and rain loads.

Important considerations

It is important to carefully seal the window to the wall in order to achieve a continuous air and water barrier. Many different approaches are possible depending on the window type, the wall assembly, and the position of the window within the rough opening[2].

[2] Refer to CMHC's *Design, Selection and Commissioning of Window Installations*.



1. TRIPLE-GLAZED WINDOW WITH LOW-CONDUCTIVITY FRAME
2. FOIL-FACED, SELF-ADHERED MEMBRANE
3. SHEATHING MEMBRANE (AIR AND WATER BARRIER)
4. EXTERIOR INSULATION
5. EXISTING SHEATHING
6. EXISTING STUD CAVITY WITH GLASS FIBRE (BATT) INSULATION
7. EXTERIOR WOOD TRIM
8. SILL FLASHING COMPLETE WITH END DAMS
9. WINDOW SHIMS
10. BACKER ROD AND SEALANT, OR SPRAY FOAM (NOT SHOWN), TO CONNECT WALL AIR BARRIER TO WINDOW
11. CLADDING (ANY TYPE)

Figure 6: Window installed to outside of wall

Exterior retrofits to improve the thermal performance of the building envelope will result in a thicker wall assembly. This means the window can be installed in one of three positions: in line with the exterior surface, in line with the interior surface, or in the middle of the rough opening as shown in figure 6. Installing the window in line with the interior wall will help to reduce the potential for condensation on the glass as it is in a warmer location but may require deep sill flashings and window trims on the exterior. This reduces window exposure to wind-driven rain but relies more on flashings to deflect water. Installing the window in the middle of the wall, as shown, requires less exterior flashing and trim, and provides space for an interior window sill.

Below-grade walls

Insulation

Insulation can be applied on the exterior of the foundation wall to the full height of the below-grade wall, extending above the joist space to the above-grade wall (see figure 7). In this exterior retrofit, the below-grade walls are excavated, and XPS or mineral-wool insulation is installed at the exterior of the concrete foundation wall (in sufficient thickness to meet thermal requirements outlined in table 1).

Alternatively, closed-cell spray foam insulation can be installed in place of XPS or mineral-wool insulation.

Airtightness

The existing concrete wall acts as the air barrier.

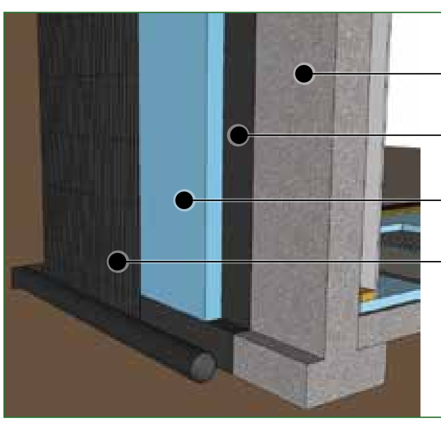


Figure 7: Section through below-grade wall

Vapour retarder

The existing concrete wall acts as the vapour control for the assembly. If there is existing insulation on the inside of the concrete foundation wall, there should also be a sheet of polyethylene on the inside surface of the insulation to act as the vapour retarder.

Water penetration control

This retrofit strategy incorporates a drainage mat on the outer face of the insulation to shed the majority of ground water. Dampproofing is applied on the exterior surface of the concrete foundation wall to provide water penetration control. If it is discovered that the existing foundation appears to have drainage or leakage problems, further investigation and repairs should be completed.

Important considerations

Ensure the insulation, air barrier and water barrier are continuous, and fitted and sealed together where the below-grade wall meets the above-grade wall.

Basement floor slab

Insulation

To improve energy efficiency in new home construction, insulation may be installed below the slab. However, in the energy retrofit of existing basement concrete slabs, one must insulate the slab from the interior. This is done by removing the interior flooring (if the basement floor is finished) and installing XPS board insulation (in sufficient thickness to meet the thermal requirements outlined in table 1). Tape all joints, and install floor sheathing and finished flooring above the insulation (see figure 8). Insulation thickness may be limited by the amount of floor-to-ceiling height available in the basement. Consider using insulation with a high RSI-value (R-value) per unit thickness to minimize the floor-to-ceiling height reduction.

Airtightness

An air barrier is required on the interior side of the insulation to prevent warm interior air from contacting the cold concrete slab. This can be achieved by taping the joints of the XPS insulation, and by connecting the floor air barrier with the wall air barrier (that is, the concrete wall). A continuous and effective basement air barrier should also reduce infiltration of soil gases (moisture, radon) into the occupied spaces.

Vapour retarder

XPS insulation is an adequate vapour retarder; therefore, an additional vapour control layer is not required.

Water penetration control

The existing foundation and slab assembly serves as the water control layer. When undertaking this retrofit, look for signs of water ingress through, or moisture problems on, the existing floor slab. Any existing water ingress or moisture problems will require further investigation and repair.

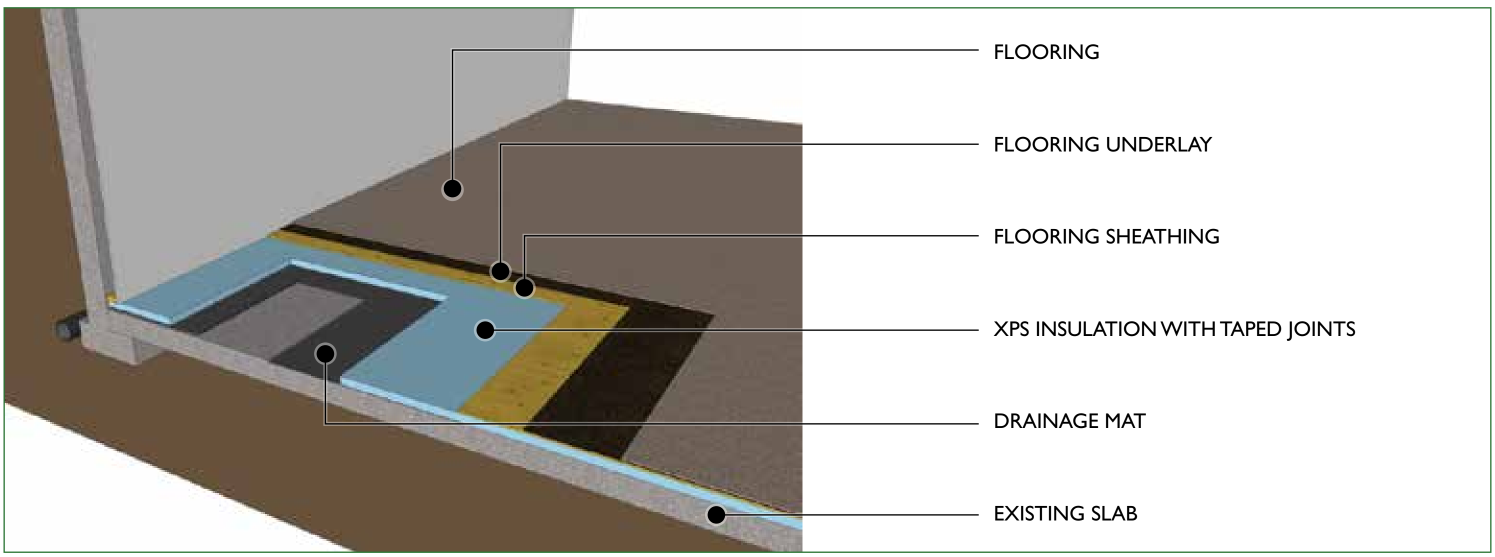


Figure 8: Retrofit to basement floor slab

ADDITIONAL DETAILS

A 1960s or 1970s two-storey house may have other areas where insulation should be installed, or that may require more attention to air sealing. Some common areas are shown below.

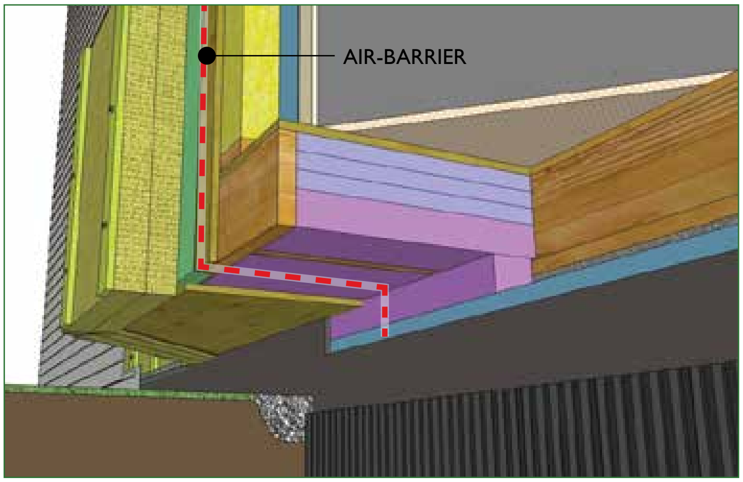


Figure 9: Section through exposed projecting floor

Exposed floors

Floors at the ground level or upper storeys that have either ground or exterior space below them should be insulated. For example, this may occur at a bay window (see figure 9).

Closed-cell spray foam and XPS insulation can be installed between the floor joists at exposed floor locations. Install several layers of XPS insulation first, to reduce the thickness of spray foam that is required.

In the air-barrier continuity line, use spray foam to extend airtightness from the top of the foundation wall to the exterior rim joist of the exposed floor. Ensure the wall sheathing membrane extends and seals to the underside of the wood framing in the projecting wall, connecting to the spray foam insulation.

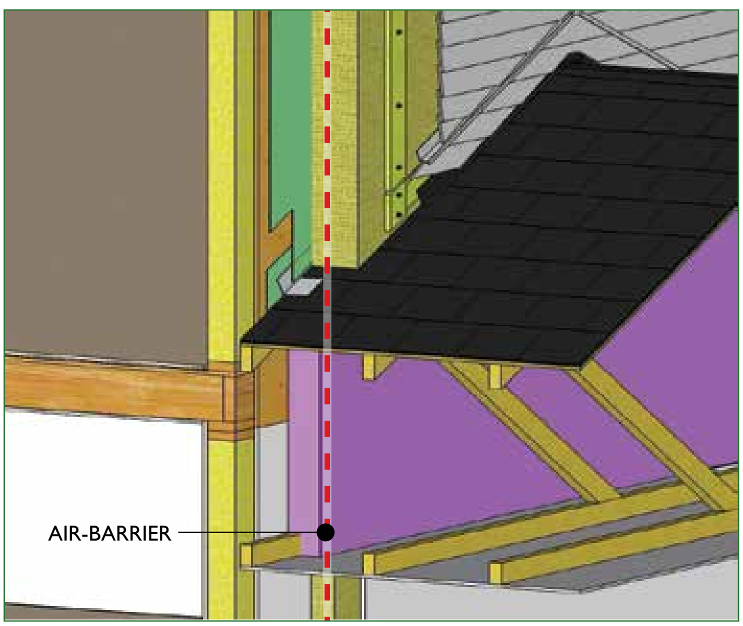


Figure 10: Section through garage roof at insulated wall

Garage wall

Because the garage is unconditioned space, the wall between the interior space and the garage must be well insulated. This can be achieved by installing mineral-wool, XPS or spray foam insulation on the exterior wall. Spray foam insulation is recommended for the exterior wall space within the garage attic, because of its ease of installation in tight spaces and the complexity of the surfaces to be insulated (see figure 10).

In the air-barrier continuity line, ensure the airtightness plane in the exterior wall retrofit assembly above the garage roof is continuous with the retrofitted wall assembly below the garage roof. One way to achieve airtightness is to seal the existing roof underlay to the plywood sheathing on the wall, that is, install a roofing membrane strip onto the roof underlay, and seal the sheathing membrane to the roofing membrane.

ENERGY SAVINGS

Heating energy consumption can be significantly reduced when high insulation values are used, thermal bridging is minimized and airtightness is improved. Specific retrofit costs, energy savings and payback periods depend on many factors, including the location, design and construction of the existing house, and the level of retrofit done. Because of this, it is important to look at costs and savings on a case-by-case basis.

The graph below (see figure 11) shows annual heating energy consumption for a typical two-storey house in various Canadian climates with various levels of enclosure performance (all with the same mid-efficiency mechanical equipment). If a highly energy-efficient building envelope retrofit is completed, space heating energy consumption could be reduced by more than 75 per cent, depending on the existing construction and the level of enclosure retrofit performed.

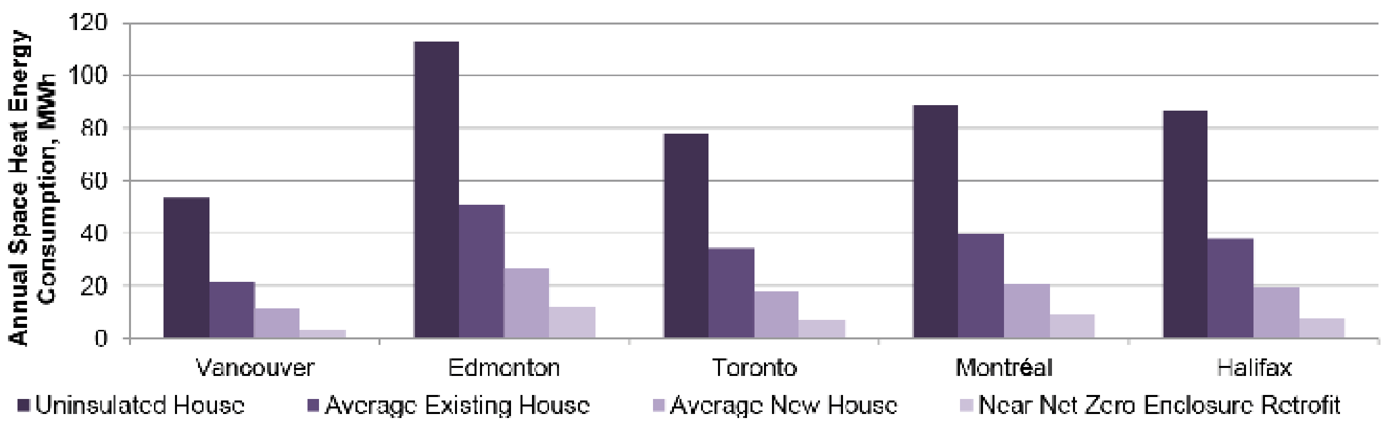


Figure 11: Annual space heat energy consumption of houses with various insulation and airtightness levels in different locations across Canada

A WORD OF CAUTION

Assess the condition of the house for pre-existing problems and anticipate the possible effects of the retrofit work on indoor air quality, building envelope durability, heating appliance performance or other possible performance issues, in order to avoid unintended consequences of a building envelope energy-efficiency retrofit.

Pre-existing problems: The house may have moisture problems (high humidity, water leaks, dampness, mold, etc.) in the roof, walls, floors or foundation; indoor air quality problems (stale air, lingering odours, soil gas, pollutant emissions from household products, etc.); radon or other soil gases; structural sags, cracks and deflections; or the presence of hazardous materials such as asbestos, lead paint and rodent/bird waste. Pre-existing problems should be corrected prior to undertaking an energy-efficient building envelope retrofit so that the problems do not worsen.

Ventilation: A highly energy-efficient building envelope retrofit will provide a more airtight house, which is important for reducing energy consumption. However, this will also result in less incidental ventilation, which would otherwise be provided by a leaky enclosure. This can cause the air in the retrofitted house to seem stale and odours to linger longer. Odours from previously unnoticed sources (such as hobbies, pets or stored items) may become more apparent and more objectionable. Therefore, energy-efficient mechanical ventilation should also be included in any home energy retrofit strategy. This can be accomplished by adding a heat recovery ventilator (HRV) or an energy recovery ventilator (ERV). This ventilation should improve occupant health and comfort.

Building envelope durability: Installing additional insulation can increase the risk of moisture to the building envelope if inside and outside sources of moisture are not controlled.

Heating appliance performance: Reducing heat losses through the envelope may result in the existing furnace or boiler being oversized for the house. Oversized heating equipment does not operate efficiently as it tends to cycle on and off more frequently. Reducing air leaks in a house with chimney-vented furnaces, water heaters and fireplaces can reduce the amount of air needed for safe and efficient operation.

Consult with a qualified energy service provider, building professional, home inspector or contractor before the retrofit to better understand, and plan for, pre-existing conditions and possible unintended consequences of the retrofit project. Often, corrective measures can be planned that not only prevent problems but also add value to the overall project. For more information on retrofit and renovation considerations, visit CMHC's website at www.cmhc.ca.

REFERENCES

RDH Building Engineering, research report, *Near Net Zero Energy Retrofits for Houses*, CMHC, 2012.

Building Enclosure Design Guide – Wood-Frame Multi-Unit Residential Buildings
http://www.hpo.bc.ca/building-enclosure-design-guide

Renovating for Energy Savings – Case Studies: available online at http://www.cmhc.ca/en/co/renoho/reensa/index.cfm

Printed in Canada
Produced by CMHC 01-05-13

67791