CE 71

Energy Efficiency Building Envelope Retrofits for Your House

Homeowners are becoming increasingly interested in improving the energy efficiency of their house to reduce costs, improve comfort and help protect the environment. Many older Canadian houses are relatively drafty and lightly insulated, and this can result in higher heat losses and energy bills—even in those built more recently, between the 1950s and the 1980s. These houses likely use at least 25 per cent more space heating energy than houses built after 2010, because increased insulation and airtightness levels have been included in more recent building codes.

In Canada, space heating accounts for over 60 per cent of residential energy use and, therefore, makes up a good proportion of your overall energy bill. Fortunately, there are several options that you, as a homeowner, can consider for reducing heat loss, including adding, or retrofitting, insulation to your house. A well-insulated and well-sealed house needs less heating in the winter (and less cooling in the summer), protects you from increasing energy prices, uses resources more efficiently, has less environmental impact, and is more comfortable to live in.

Choosing how much insulation to add to your house can be confusing and will be influenced by the space heating energy savings you wish to achieve, the way your house is constructed, and your budget. This *About Your House* provides general guidance for achieving varying degrees of space heating energy savings by better insulating and air sealing your house.

Before planning an energy retrofit for your house, Canada Mortgage and Housing Corporation (CMHC) recommends that you hire a qualified residential energy service provider to undertake an EnerGuide audit. During the audit, the energy service provider will measure the existing airtightness of your house, identify air leaks that should be sealed, provide specific options for upgrading insulation, recommend door and window improvements, and suggest upgrades to your space heating system. This *About Your House* will look at airtightness, insulation and window/door replacement strategies.

IMPROVE AIRTIGHTNESS

Reducing unintentional air leakage (that is, air sealing) through the walls, ceilings and foundations of the house is one of the most cost-effective ways to improve its energy performance and comfort. This should be the first priority in any building envelope retrofit because air leakage can reduce the effectiveness of some types of insulation, and allows warm, conditioned air to escape to the outdoors or lets cold outdoor air infiltrate to the interior, causing the heating system to work harder. If left uncorrected for too long, air leaks can also cause moisture and indoor air quality problems.

The air barrier system

To know where, and how, to seal your house, you have to understand what makes up the "air barrier system." An air barrier system is composed of one or more materials that resist the movement of air through the walls, roof and foundation of your house. Most air barrier systems are made up of a combination of air-impervious materials such as polyethylene, spun-bonded polyolefin, polystyrene, oriented strand board and gypsum board, and—in the case of windows—glass. Ideally, the individual components are sealed together by gaskets, weatherstripping and sealants to form a continuous, draft-proof wrap around the house. However, in reality, there are often many unsealed joints in, and penetrations through, the air barrier systems in most houses, representing both a problem and an energy efficiency retrofit opportunity.

First, you have to find the leaks. While some leaks are easily detected, most leaks are found during a "blower door" test. This test is done as part of the EnerGuide audit, or can be done independently by a contractor. The blower door depressurizes your house causing outside air to leak in through cracks and openings, and the operator uses tools such as smoke pencils or thermographic equipment to locate these leaks. Common air leakage points include:

- ceiling pot light fixtures recessed into attic spaces;
- electrical boxes penetrating ceilings below attic spaces;
- wiring, plumbing and duct penetrations into the attic;
- exhaust fans located above bathroom ceilings in the attic space;
- window-wall joints (behind the finishing casings);
- operable windows;
- door weatherstripping;
- electrical boxes on exterior walls;
- floor-wall joints;
- first- and second-floor rim joist areas;
- foundation rim joist area; and
- foundation wall and floor electrical, plumbing and duct penetrations.

You may use many different approaches to sealing the various parts of the house. For instance, you may air seal leaky windows and doors with new gaskets and weatherstripping. You can seal small gaps around wiring with caulking, and larger gaps with spray foam. You can also install airtight gaskets under the cover plates on electrical switch and outlet boxes, and airtight boxes constructed of polystyrene board insulation over exhaust fans in attic spaces. You should consult an air leakage control specialist for the most effective methods.

KNOW YOUR INSULATION OPTIONS

Insulating materials, such as fibreglass and mineral wool batts, cellulose, expanded and extruded polystyrene, and spray foams are commonplace in houses. Each can provide a thermal barrier in the building envelope to slow heat loss. The thermal resistance of insulating materials is indicated by their RSI-value (or their imperial equivalent R-value). The higher the RSI-value, the more resistant the insulation is to heat flow. For instance, closed-cell, medium-density polyurethane foam has almost twice as much thermal resistance as fibreglass batt insulation. This can be an important consideration where there is limited space to add insulation.

It is also important to know that, even though there may be insulation in the walls or roof of your house, it may not be performing as well as it should be. Parts of the house structure (for example, wood

framing, metal components and concrete foundations) that are exposed to both the interior and exterior can provide a direct path for heat to flow around any insulation in the wall, roof or foundation, thereby reducing the insulation's overall effectiveness. This is called "thermal bridging." When adding insulation to your house, try to cover these thermal bridges as much as possible with the newly installed insulation to reduce heat loss. Choose the type of insulation that provides the thermal resistance you require, is suitable for its location in the building envelope, and fits within the available space.[1]

Determine whether to insulate on the inside or outside. Insulation can be retrofitted from the exterior or the interior. Your choice will largely depend on:

- the house's interior and exterior finishes and the ease with which they can be removed and restored;
- the layout and construction of the house and the ease with which it can be altered;
- property line setback requirements that may restrict the thickening of the walls;
- other renovation work that should be done at the same time;
- whether the house will be occupied during the renovation, and your tolerance for mess and disruption; and
- the level of energy savings you wish to achieve.

An interior retrofit offers several advantages: the work can be done year-round; it doesn't affect or require the removal of exterior cladding; and it doesn't reduce distances to property lines, which may require special permission from your local building department. If you plan to do a major renovation that will affect the interior finishes, an interior insulation retrofit will likely make the most sense. Also, if you are only considering room-specific renovations (for example, performing kitchen and/or bathroom renovations, or finishing a basement), you should take this opportunity to air seal and add insulation in those areas.

However, it is often easier and less disruptive, to add insulation and a new air barrier system from the exterior. In effect, an exterior insulation retrofit can provide a continuous, airtight, blanket of insulation around the house. The main advantages of an exterior retrofit are that it doesn't affect interior finishes; it doesn't reduce room sizes; and you can continue to live in the house while the work is completed outside. The continuous insulation and air barrier systems help keep the house structure at a more uniform temperature, which improves its durability and performance. An exterior retrofit also provides an opportunity to improve the appearance of the house.

DETERMINE HOW MUCH INSULATION TO ADD AND WHERE

Once you have considered your budget and your house's original construction, you can now decide how much insulation to add, depending on your energy-saving objectives. Table 1 provides general guidance for the amount of insulation to add to the roof/attic, walls, foundation and basement floor, as well as for window and door upgrades, to achieve up to 10-per-cent, 25-per-cent and 75-per-cent space heating energy savings. The number of areas that must be included in the retrofit project, and the amount of insulation to be added, increase with each improvement in targeted space heating energy savings.

Note that, no matter what level of energy savings you wish to achieve, all retrofit options require reducing

[1] Refer to the *About Your House* fact sheet entitled *Insulating Your House* for the RSI-values (or R-values) of common insulation materials (product no. 62039).

air leakage by 30 per cent or more. Houses built between the 1950s and the 1980s have measured airtightness values generally averaging above 6.0 air changes per hour (ACH_{50}). The air change rate is a measure of how many times per hour a volume of air, equal to the volume of air in the house, leaks through the building envelope at an applied air pressure difference of 50 pascals. If, for example, your house has a measured airtightness level of 6 ACH_{50} (as determined by the blower door test) before you start the renovation, the measured airtightness of the house post-retrofit should be 4.2 ACH_{50} or lower.

To achieve a 10-per-cent space heating energy savings, you can choose any one of three options:

- Air seal the house and add an additional RSI-3.52 (R-20) insulation to the existing insulation in the attic.
- Air seal the house and add an additional RSI-1.76 (R-10) insulation to the existing insulation in the basement walls.
- Air seal the house and add an additional RSI-1.76 (R-10) insulation to the existing insulation in the above-grade walls.

To achieve space heating energy savings of 25 per cent or better, you could choose to replace all the windows and doors with ENERGY STAR® units and improve the airtightness of your house at the same time. Alternatively, you could reduce air leakage by 30 per cent and add RSI-3.52 (R-20) insulation to roof/attic and RSI-2.64 (R-15) insulation to above- and below-grade walls.

Table 1 Retrofit options for different levels of heating energy savings

Targeted Space Heating Energy Savings	Retrofit Measures to Achieve Targeted Space Heating Savings					
	Improve Airtightness by at Least 30%	Add Insulation to Roof and Attic	Add Insulation to Below-Grade Walls	Add Insulation to Above-Grade Walls	Replace Windows and Doors	Add Insulation to Basement Floor
10%	✔	RSI-3.52 (R-20)				
	✔		RSI-1.76 (R-10)			
	✔			RSI-1.76 (R-10)		
25%	✔	RSI-3.52 (R-20)	RSI-2.64 (R-15)	RSI-2.64 (R-15)		
	✔				ENERGY STAR®	
>75%	✔*	On top of roof: RSI-7 (R-40)** Over existing attic insulation: RSI-10.6 (R-60)	RSI-2.64 (R-15)	RSI-5.28 (R-30)	RSI-1.04 (R-6) or more	R-1.76 (R-10)

* Note: Air leakage should be no higher than 1 ACH_{50} for space heating energy savings greater than 75 per cent.

** This is considered to be the highest insulation value that can reasonably be added on top of the roof sheathing.

A word of caution

Building envelope energy efficiency retrofits can have unintended consequences if consideration is not given to assessing the condition of the house for pre-existing problems and anticipating the possible effects of the retrofit work on indoor air quality, building envelope durability, heating appliance performance or other possible performance issues.

Pre-existing problems

Pre-existing problems should be corrected prior to undertaking an energy efficiency building envelope retrofit so that the problems do not worsen. Pre-existing problems include:

- 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; and
- the presence of hazardous materials such as asbestos, lead paint and rodent/bird waste.

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 could also lead to moisture problems. Odours from previously unnoticed sources (such as pets or stored items) may become more apparent and more objectionable. Therefore, energy-efficient mechanical ventilation should also be included in any house 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. Consult a qualified mechanical ventilation contractor and your EnerGuide service provider for more information.

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 a chimney-vented furnace, water heater and fireplace 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.

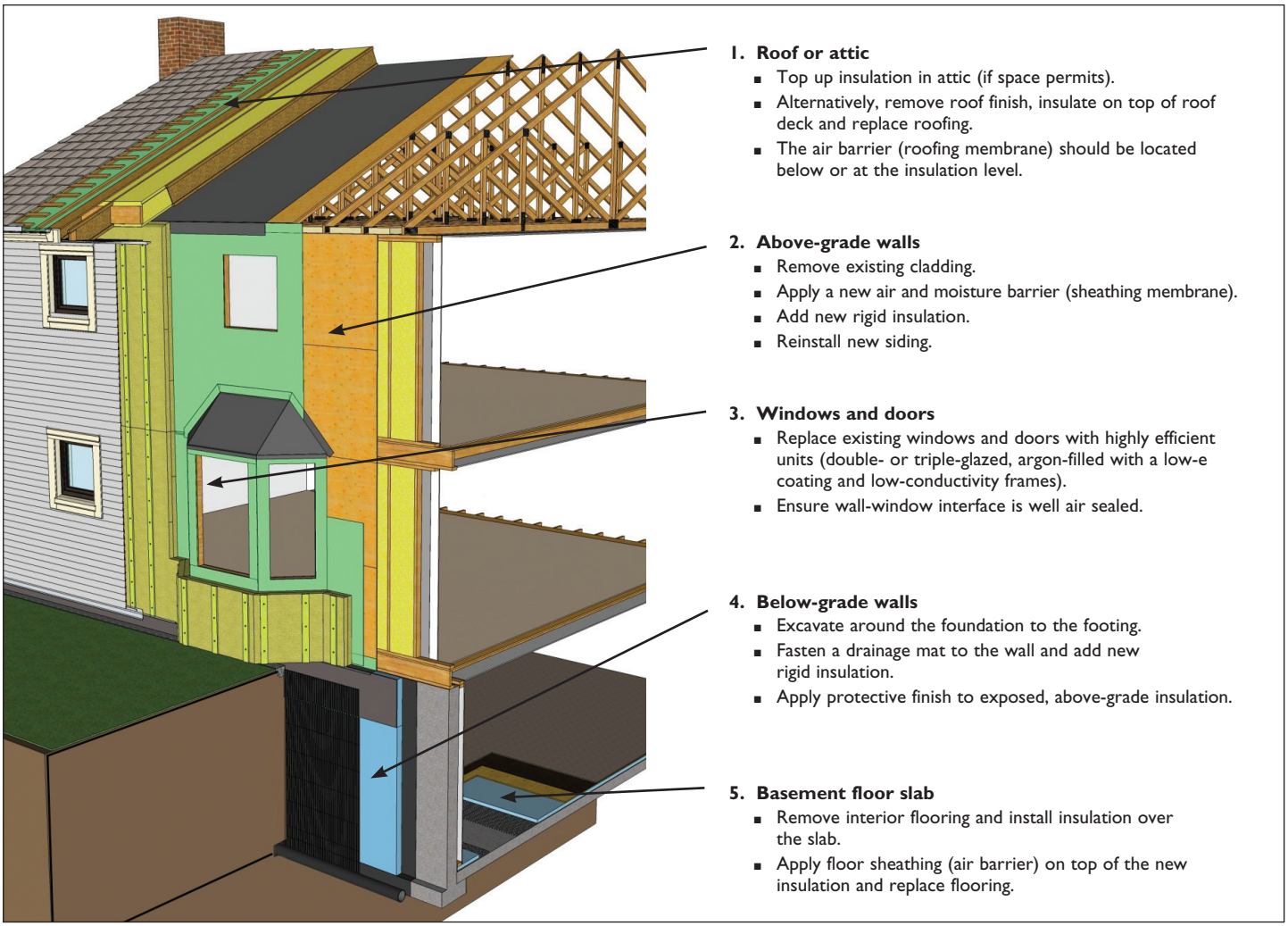

Figure 1 Exterior insulation retrofit: post-retrofit section through roof, walls and floors

Finally, space heating energy savings of 75 per cent or better require a more comprehensive approach involving all locations in the building envelope and using insulation with significantly higher RSI-values (R-values) at each of these locations. In addition to air sealing the house, you should add insulation to the roof/attic, above- and below-grade walls, and basement floor.

Note that the insulation retrofits and targeted energy savings are illustrative examples only, intended to show the scope of improvements that may be necessary to attain energy savings in the ranges indicated for a typical house built between the 1950s and the 1980s.

The choice of insulation needed to achieve any given level of energy savings will depend on your location and the characteristics of your house. Other combinations of insulation levels and locations may also be possible. Explore the options with your EnerGuide advisor.

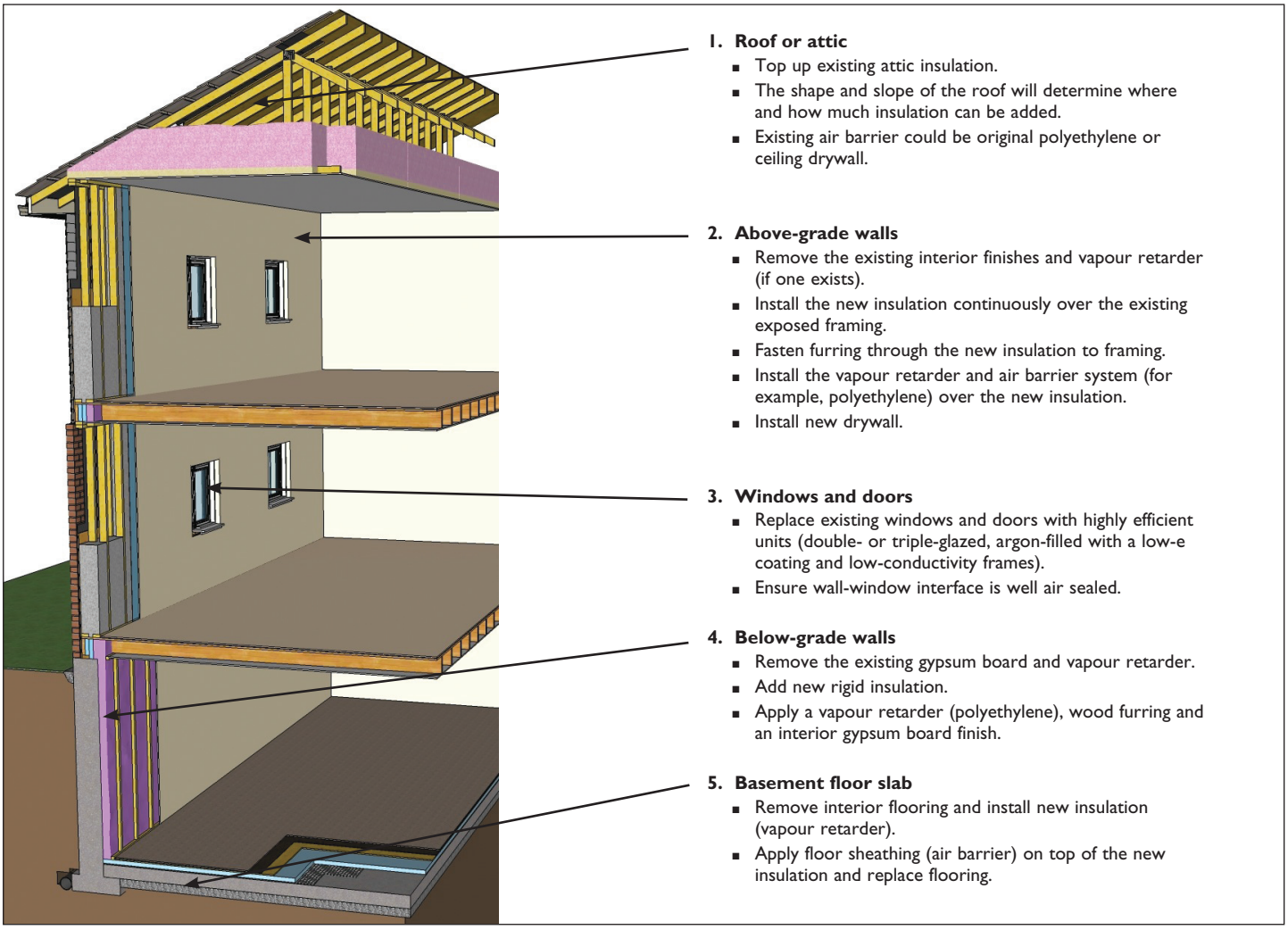

Figure 2 Interior insulation retrofit approach: post-retrofit section

Figures 1 and 2 illustrate possible exterior and interior approaches to retrofitting existing houses to improve insulation and airtightness.

Pay particular attention to the following areas where insulation may be minimal or lacking:

- **Overhangs and exposed floors**—Insulate and make airtight exposed floors that have either ground or exterior space below them. For example, this may occur at a bay window, at an overhanging floor or for a room over a garage.
- **Attached garage walls**—Insulate the wall between the interior space and the garage to the full height of the wall, and to the same thermal resistance (RSI-value, or R-value) as exterior walls.

CONTAIN THE COSTS

The best time to insulate and air seal the building envelope of your house is when you are planning other renovations that need to be done anyway. This includes fixing particular problems, such as water leaks, improving comfort or updating exterior finishes to enhance the house's appearance. You may consider doing a major renovation to update interior finishes and mechanical and electrical systems, and to improve interior space use. When such work is undertaken, it's a great opportunity to add insulation and to air seal, because the associated incremental costs may be more affordable. If renovation work is undertaken and energy efficiency measures are not included, this may be a significant lost opportunity.

An improved building envelope provides other benefits. Fewer drafts and cold spots, and less exterior noise, will improve the quality of the living space. A newly renovated, comfortable, energy-efficient house may have a higher resale value than its draftier neighbours. And finally, fewer greenhouse gas emissions associated with reduced space heating is part of the global solution to address climate change.

SUMMARY

Retrofitting the building envelope for space heating energy savings can provide significant savings on energy bills and a more comfortable house to live in. A well-insulated house will help to protect you against future energy cost increases and can contribute towards the overall value of your home.

Remember that improving airtightness is the most cost-effective measure and is necessary to maximize the benefits of adding insulation; you should insulate and air seal as much as possible given your circumstances. Even a modest improvement to a drafty, poorly insulated building is better than no improvement at all.

To find more *About Your House* fact sheets and other housing-related information products, visit our website at www.cmhc.ca. You can also reach us by telephone at 1-800-668-2642 or by fax at 1-800-245-9274.

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