IMPROVING THE BUILDING ENVELOPE

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Gary has served on a number of codes and standards committees including: Part 9 Committees of both the National Building Code of Canada and the Manitoba Building Code, ASTM E3158-18 Standard Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building and CGSB 149.10 "Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method".

Gary has a Bachelor's degree in Mechanical Engineering (Manitoba) and a Masters of Engineering in Building Science (Concordia). He has authored over 20 peer-reviewed papers as well as hundreds of technical reports for clients.

Introduction

As Canada takes steps to reduce our greenhouse gas emissions, homeowners are seeing a variety of information providing them with advice on what to do. The bottom line is that Canada is moving towards reducing our dependence on fossil fuels by improving the thermal efficiency of their homes and taking advantage of new heat pump technologies running on electricity.

The messages that Canadians are seeing are primarily focused on 2 options:

- Improving the thermal efficiency of the building envelope (the envelope includes the roof/attic, walls, windows & doors, and the basement), and,
- Switching from an oil, natural gas or propane furnace, to a heat pump.

Both are encouraged, but this document will present a case for doing them in a specific order so homeowners get the greatest benefit at the lowest cost.

The Existing Housing Stock in Canada

There are approximately **11 million existing houses in Canada** ranging in age from recent builds to those well over a hundred years old. Compared to contemporary building code requirements for energy efficiency, **most of these are poorly insulated, lacking in airtightness and are equipped with inefficient heating and cooling systems.** With escalating energy costs, these homes are increasingly expensive to operate and only provide their occupants with a less-than-optimum indoor environment.

The Case for Upgrading Wall Performance

The building envelope consists of the components that separate and protect the indoors from the outdoors. For the purposes of this article we will focus only on walls, but the same logic can be applied to roofs/attics and to basements.

Many Existing Houses Have Poorly Insulated Walls

In many older houses the exterior walls are often poorly insulated – typically with R-12 or less. In contrast, newer homes typically have almost twice as much wall insulation (R-20) and upcoming changes to Building Code requirements will specify even higher levels, possibly up to R-40. So where does this leave older houses?

What About the Windows?

Modern windows and doors have a life expectancy of about 20 to 30 years after which the seals between the glass start to fail, causing fogging between the glass panes of the windows. This means that the windows are reaching the end of their operational life, and replacement will be required soon.

What About the Existing Cladding?

Cladding systems (stucco, vinyl, wood, masonry or metal) last longer than windows but can still begin to show their age after several decades. This is why thousands of homeowners have opted to replace or upgrade their home's cladding. This process gives their home a fresh, new look.

Upgrading an Older Home Is the Best Option

With the movement towards more insulation in new homes, the gap between the insulation levels in older homes and the insulation levels in new homes is getting larger. With increasing house prices, upgrading older homes can often produce an increase in the re-sale value which exceeds the cost of the upgrade. One of the key ingredients to higher re-sale value is improving the appearance of the home (curb-appeal) – and this is where wall upgrades become increasingly attractive since they can produce a major improvement in the home's appearance.

Upgrading wall insulation can be done at the same time as the cladding is being changed, and it can be as simple as adding insulation to wall cavities and adding external insulation, both of which can be done at very reasonable prices. This is particularly true if the cladding (this is the part of the wall that you can see from the outside) being replaced. If windows and doors are also being updated, the insulation becomes even smaller percentage of the total budget.

From a practical perspective, the opportunity to upgrade wall insulation only occurs about once every 20 to 30 years when an interior or exterior renovation is undertaken.

Upgrading Wall Insulation, Cladding and Windows Can Significantly Improve the Home's Resale Value

With new insulation and cladding, along with new windows and doors, the walls of this home will be comparable to those in a new home built to the Building Code. The appearance of the house will be improved, as shown in the pictures below of some typical wall retrofits. The impact on re-sale value can be significant, and can exceed the cost of the retrofit. This can put money in your pocket.

Wall Insulation and Airtightness Offer Additional Benefits

Aside from reduced energy bills and improved comfort, upgrading the exterior walls of your home has additional benefits including:

- Reduced transmission of outdoor noise into the house (insulation reduces the transmission of noise as well as heat)
- Improved resistance to moisture damage (due to the tighter building envelope)
- Fewer cold drafts and extra protection in the event of a power failure (the house will cool down slower with increased wall insulation)
- A generally improved indoor environment

What Are the Costs to Add Insulation If I am Re-Siding?

If a homeowner is considering replacing the windows and doors and/or the cladding in their home, then it makes a lot of sense to also consider upgrading the overall R-value of the wall system at the same time. **It will never be easier or less expensive than during the replacement of the cladding.**

First, consider the cladding. With the cladding removed, additional insulation can be added to the walls at comparatively low incremental cost. In these situations adding extra insulation adds about 15% to 20% to the overall project cost, or $27 to $51/m2 ($3 to $5/ft2) of wall area (2017 $) (Ref. 1).

These costs are illustrated in the Table below which shows the cost breakdown of retrofitting 100 m2 (1,076 ft2). In this example, we compare an exterior wall without additional insulation (thereby producing no energy savings) versus retrofitting the wall with additional insulation (RSI 1.32 to RSI 2.12 or R-7.5 to R-12) thereby producing energy savings.

Wall Retrofit Cost Without Adding Insulation (NO ENERGY SAVINGS)	Additional Cost of Insulation	Total Retrofit Cost With Additional Insulation Producing (ENERGY SAVINGS)
$14,320 to $20,400	$3,580 to $5,100	$17,900 to $25,500

What Are the Costs to Add Insulation If I am Re-Siding? Continued

Once the existing cladding is removed, wall cavities can be easily filled or topped-up with insulation. Then, additional rigid or semi-rigid insulation can be applied over the existing sheathing prior to the new cladding being added. This will increase the wall thickness and significantly reduce heat loss. It also permits many of the air leakage pathways which exist through the walls to be sealed, further reducing heating and cooling costs.

This picture shows a house where the cladding has been removed, an air barrier added (the blue material) and additional insulation added.
The new cladding will be installed over the insulation.

The Case for Adding an Air-Source Heat Pump

Heat pumps can provide space heating at efficiencies exceeding 100% while still offering effective cooling during summer months.

Heat pumps must be properly sized to provide optimum performance. Sizing depends on the thermal integrity of the building envelope – which basically means how well the house is insulated and sealed. If the heat pump is sized to meet the needs of the existing house and the house is subsequently retrofitted with additional wall insulation and air-sealing, the heat pump will be oversized and provide less-than-expected performance for both heating and cooling. Oversizing can reduce the life expectancy of the heat pump since it will cycle more frequently.

Timing and sequencing of changes to your house are important. Improve the thermal performance and airtightness before changing the heating and cooling systems to allow for correct sizing of the equipment. This will provide optimal performance of the equipment and a longer life.

Comfort – A Big Plus for Insulation

Heat pumps provide a means of supplying heat to the house. They do so at a much higher efficiency than conventional gas, oil or electric resistance heating systems, but they do not impact comfort levels in the house. A heat pump retrofitted into a cold, drafty house will still result in a cold, drafty house – but it will be less expensive to heat.

In contrast, insulation retrofits, coupled with sealing air leaks, will produce a much more comfortable home with more even temperatures and fewer cold drafts. Improved comfort!

In Conclusion

Upgrading of insulation levels and airtightness improvements have a major role to play in Canada's energy future, but so do residential heat pumps.

Timing matters!

Upgrading a house by adding insulation and improving airtightness should always be the first step in retrofitting a house before switching the heating and cooling systems. It's good Building Science and makes the best use of the technologies.

References

Survey of Conventional Retrofit and Replacement Practices for Residential Wall Systems. Proskiw Engineering Ltd., 2017.