BUILDING RESILIENCE SERIES

Guide to Healthy Housing

NAIMA CANADA

REPRESENTING MINERAL FIBRE INSULATION MANUFACTURERS

INTRODUCTION

Disclaimer

The NAIMA Canada Building Resilience series is informational in content and is solely intended to assist construction / renovation professionals in understanding aspects of energy efficiency and resilient assemblies in relation to climate change events such as fires, windstorms, floods and/or energy grid fluctuations. These documents are NOT intended to replace the advice, planning, design, or practical work of professionals in the fields of construction and renovation / retrofit. Always consult with qualified experts when planning, constructing or retrofitting buildings.

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INTRODUCTION

About NAIMA Canada

NAIMA Canada is an association serving as the voice of manufacturers specializing in fiberglass, rock wool, and slag wool insulation within Canada and across North America. Our core mission revolves around advocating for the widespread adoption of insulation products as a sustainable solution for reducing energy consumption, curbing greenhouse gas emissions, and fostering environmental stewardship.

At the heart of our mandate is a dedication to promoting the importance of insulation in new construction and the energy retrofit of existing homes and buildings. By emphasizing the use of fibre insulation materials, we aim to create a shift towards high performance, resiliency, and improved comfort, by capitalizing on the strength of these well understood and easily installed insulation materials.

Through collaborative efforts with industry stakeholders, policymakers, and the wider community, we strive to elevate an understanding of the benefits that insulation offers. We're committed to fostering a future where buildings not only adhere to energy efficiency standards but also enhance overall resilience in the face of a changing climate.

NAIMA Canada's mission extends beyond advocating the optimization of thermal comfort; it encompasses the elevation of energy performance measures, longevity, and sustainability standards within the national built environment.

OUR MEMBERSHIP

certainteed SAINT-GOBAIN

ROCKWOOL

JM Johns Manville

KNAUF

OWENS CORNING

INTRODUCTION

Acknowledgements & Resources

This manual uses information collected from the following publications and websites:

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- Rebuild Healthy Homes – Guide to Post-Disaster Restoration for a Safe and Healthy Home (May 2015, Claudette Hanks Reichel, Director LaHouse Resource Centre, LSU AgCentre). U.S. Department of Housing and Urban Development publication.
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A NOTE FROM OUR EXECUTIVE DIRECTOR

Foreword

Canada occupies a unique position in the world, with a relatively low population compared to the amount of territory we cover on the continent. We have a wealth of natural resources, with many sectors of industry that extract, manufacture, and supply the globe to make our economy one of the healthiest of all developed countries.

Though our population is low, Canada rated as 11th in the world for emissions in 2020 (source: Environment and Climate Change Canada). The intensity of our energy consumption and emissions per capita, particularly in heating and cooling our structures, stands out on the world stage.

The routines we've adopted over the past century have inadvertently led to significant consequences. Scientists from Environment and Climate Change Canada highlight that human-induced emissions are driving increasingly severe climate events. These events profoundly impact our economy, communities, and even the very buildings where we live and work. Canadians are confronting unprecedented challenges, from wildfires to floods and powerful winds, unlike anything before.

The federal government places paramount importance on fortifying our buildings against potential hazards, prompting the creation of a National Adaptation Strategy. This plan outlines measures aimed at enhancing our built environment's capacity to withstand the impacts of climate events.

With those strategies in mind, NAIMA Canada has collected information from environmental and technical experts to create this Healthy Housing Guide – a compendium of building science fundamentals, suggestions for envelope improvements and considerations for major elements of construction and renovation / retrofit.

Treating our built environment with a ‘house-as-a-system’ and envelope first approach may help us to increase resilience, as well as maintain comfort, indoor air quality and live-able conditions while lowering our emissions and energy use at the same time.

There are approximately 15 million existing buildings in Canada, many that will require resilience and energy efficiency upgrades in the years ahead. We have created this guide to help Canadian designers, energy advisors, contractors and renovators to better understand and plan for this monumental task.

Jay Nordenstrom
Executive Director,
NAIMA Canada

INTRODUCTION

Purpose of this Guide

The NAIMA Canada Building Resilience series shares information and best practices for increasing the resilience and energy performance of homes & buildings.

This **Guide to Healthy Housing** presents building science-based strategies for creating and retrofitting buildings that promote occupant health and well-being over the long term. The guide will examine the role and application of envelope control layers, with emphasis on material properties, sequencing, indoor air quality and energy conservation that may increase occupant comfort and potentially increase survivability in the event of grid outages or climate related disasters.

INTRODUCTION

What is a Healthy House?

In 2007, The Canada Mortgage and Housing Corporation (CMHC) EQuilibrium Housing initiative identified five key principles for sustainability in housing:

- Health
- Energy efficiency
- Resource conservation and efficiency
- Reduced environmental impact
- Affordability

Taking cues from the CMHC National Healthy Housing design competition in the 1990's, homes of the EQuilibrium initiative were built to high standards for indoor air quality, passive solar heating, energy efficiency and climate specific design.

Today, Canadians are dealing with challenges presented by a quickly changing and unpredictable climate. Natural disasters happen more frequently and with greater strength:flooding, wildfires, heat events, wind events, snow, and ice storms. Equally, the COVID pandemic highlighted the need for improved indoor air quality & fresh air exchange.

The defining characteristics of a "healthy house" must change from the 1990's description, to include features that speak to our more pressing issues:

- Durable and resilient material choices for building envelope assemblies.
- Constant, filtered fresh air ventilation and stale air exhaust.
- Greatly reduced energy demand to improve capacity for renewables and grid independence.
- Clean and contaminant-free.
- Consistent levels of comfort year-round in all Canadian climate zones.
- Affordable low-carbon operation of building systems.

The physics of heat, air and moisture movement inside buildings are well understood, but we need to better prepare our living and work spaces for environmental effects due to a rapidly changing climate. Having a better grasp on the whole building and its place in the environment may help us create living and working spaces that reduce stress, increase comfort, and contribute to our long-term health.

RESILIENCY STRATEGY

First, Improve the Building Envelope

In Canada, we use most of our energy to heat our buildings. Too much of that heat energy escapes our buildings and energy systems through waste, mainly because of air leakage and insufficient insulation.

To reduce the amount of energy we need to keep our buildings comfortable, we need to use less energy in the first place. This translates into creating buildings that conserve as much energy as possible. We know how to do this! The materials and building techniques we need are commonly used today.

WHAT IS THE BUILDING ENVELOPE?

The skin of the building that separates the indoors from the outdoors is the building envelope. This includes the structure, the doors and windows, finishes and “control layers”:

- Insulation
- Air barriers
- Vapour barriers / retarders
- Water management layers like flashing

Elements of the building envelope help to control the behaviour of heat, air and moisture inside our buildings – they help to maintain comfort for occupants. When we create a strong envelope that is super insulated, airtight, and durable, we can then apply right sized mechanicals to provide heating and cooling and, most importantly, a constant supply of fresh air.

Creating high-performance building envelopes can potentially create homes, businesses and communities that are more resilient and better equipped to ride out climate events with ease. At the same time, we could reduce GHG emissions from our buildings, decrease the load on our energy grids and set ourselves up to use renewable energy systems that bring us to the goal of a net zero energy future.

RESILIENCY STRATEGY

Reducing Operational Energy

We know how to create buildings that are energy efficient by improving the control layer components in the building envelope:

- Insulation Levels
- Air Tightness
- Windows and Doors
- Eliminating Thermal Bridges

Once we do this, we can add appropriately sized mechanical systems for heating, cooling, and ventilation, maintaining comfortable temperatures while balancing humidity levels and providing a constant flow of fresh air.

If we reduce energy needs significantly, there may be an opportunity to use renewable power sources - PV solar, wind and geothermal - to offset our dependence on grid power systems.

STRATEGY POINTS: REDUCING OPERATIONAL ENERGY

- **PURPOSE**: Reduce energy demand and energy losses, open opportunities for energy independence.
- **PRIMARY METHOD**: Increase attic insulation and airtightness ($)
- **SECONDARY METHOD**: Add exterior continuous insulation, replace windows and doors ($$)
- **HIGH PERFORMANCE METHOD**: Deep energy retrofit, replacement and optimization of insulation, maximize air tightness below 1.0 ACH, replace windows and doors ($$$)
- **SYSTEMS**: Electrified heating, cooling, ventilation, hot water - cold climate air source heat pump, Energy Recovery Ventilator (ERV), renewable energy sources, drain water heat recovery, heat pump DHW ($$$)
- **EFFECT**: Create 72-hour emergency stability, staying comfortable & safe in your home.

RESILIENT, HEALTHY, AND ENERGY EFFICIENT

When we're planning energy and GHG reductions for buildings, tackling the envelope first allows for elements and efficiencies that may also improve overall resiliency and healthy indoor comfort conditions.

The diagram below outlines common strategies for high-performance construction and retrofits, emphasizing a building's energy efficiency and conservation. Measures like super insulation, air tightness, quality windows, and durable materials create an efficient shell, minimizing energy waste in heating and cooling. These envelope improvements could enable the integration of renewables like wind and solar by reducing the building's power demand, making it easier for renewable sources to handle the loads efficiently.

Maximizing insulation and airtightness levels in attics, walls and basements may create conditions where energy demand is reduced enough to allow for highly efficient, right-sized HVAC and fresh air supply systems.

When the systems and energy needs of a building are optimized and simplified, this can create a more stable and resilient safe haven, where indoor comfort conditions are easily maintained even during the coldest winter freeze or summer heat events.

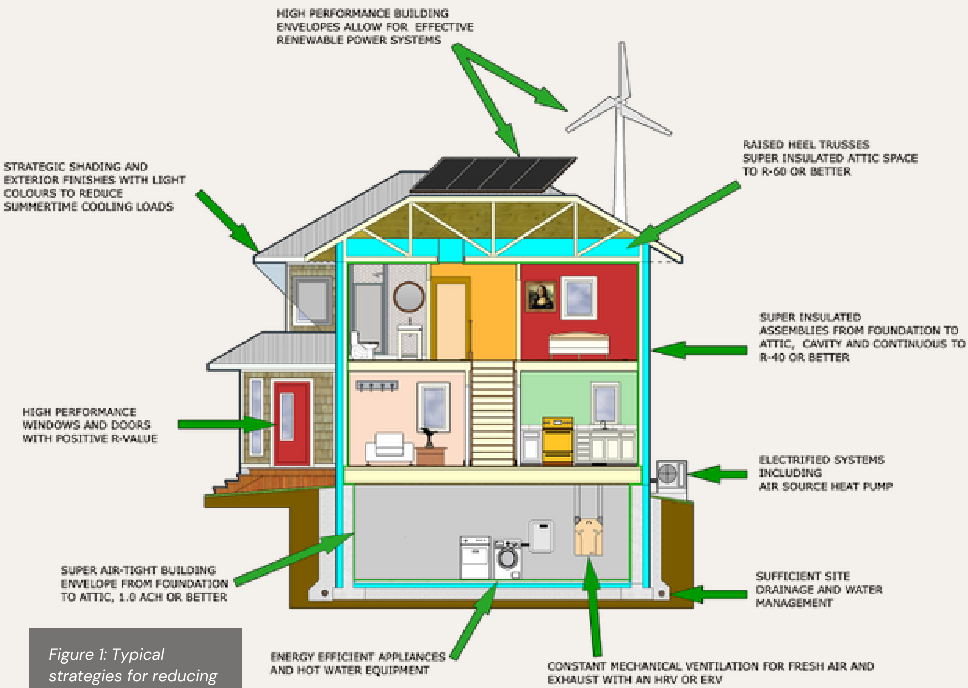


Figure 1: Typical strategies for reducing operational energy required in a hosue

RESILIENCY STRATEGY

Envelope First Retrofit: Foundation

The improvement of building envelope assemblies for insulation and air sealing will go a long way to making a building more energy efficient. From foundation to roof, insulation and air sealing should be optimized for energy efficiency.

FOUNDATION

An existing foundation could be treated by interior or exterior applications of control layers. The less expensive route is to work from the inside unless there are problems with the structure or with water infiltration. These problems need to be addressed before any retrofit can be done.

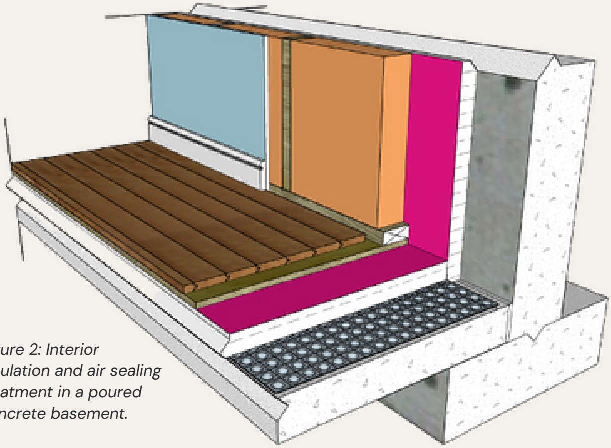


Figure 2: Interior insulation and air sealing treatment in a poured concrete basement.

INTERIOR APPLICATION:

- Use appropriate air sealing & insulation layers against masonry or concrete – they will be exposed to moisture.
- Allow for drying potential toward the inside.
- A wood framed wall with cavity insulation is installed to the inside of air sealing and foundation insulation.
- A floating subfloor set above slab insulation can accommodate interior floor finishes.
- Air seal and insulate floor system headers at the foundation wall.
- **In flood prone areas:** Use materials that could stand up to being wet without degrading and that can be easily replaced if necessary.

EXTERIOR APPLICATION:

- Use materials appropriate for below-grade & exposure to outdoor conditions.
- Digging up around an existing foundation may be cost-prohibitive unless there are significant structural or water ingress problems that need fixing. This could open an opportunity to improve foundation drainage & insulation layers at the same time.
- Masonry foundations, like stone and brick, should be inspected by a qualified masonry contractor, with additional consultation on the proper application of control layers against the walls.
- Building code dictates how much insulation is required in conditioned foundation and crawl spaces. Energy efficiency programs like Net Zero and Passive House may require greater insulation amounts to achieve best performance.
- Installing an insulation 'skirt' around the foundation may be done with moderate earth moving (see Fig. 4). This strategy takes advantage of the thermal mass of the earth around the foundation, using the skirt to slow the passage of heat through the soil.
- Performing any exterior work on the foundation should include improvement of drainage layers – crushed stone backfill, weeping tile, dimple-mats on wall surfaces and properly sloped grades will help to move water quickly away from the building.

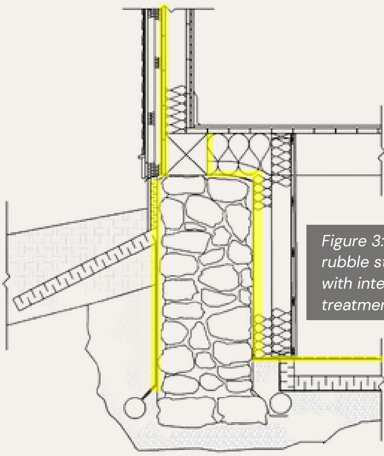


Figure 3: An existing rubble stone foundation with interior and exterior treatments.

STRATEGY POINTS: FOUNDATION

- **PURPOSE**: Improve insulation and air sealing in the foundation, reducing losses through masonry or concrete.
- **METHOD**: Treat interior walls and floors with airtight & moisture control layers, insulate walls, slab and floor headers, air seal openings. ($$)
- **HIGH PERFORMANCE METHOD**: Deep energy retrofit – excavate around exterior, improving drainage layers, weeping tile and dimple mats, adding insulation and air sealing on foundation exterior. ($$$)
- **SYSTEMS**: HRV/ERV in conditioned basement to manage air quality and temperature. Additional mechanical dehumidification if necessary.
- **EFFECT**: Drier and warmer foundation/basement area, reduction in moisture problems like mold and mildew (improved air quality).

MINERAL FIBRE AND MOLD

Mold can grow in any environment where there's moisture and food for mold spores, so many organic materials can be food for mold. Even though some products claim to be mold-resistant, mold can grow on any surface under moist conditions if organic material exists to support the spores. Understanding how mold grows is crucial to fully evaluate insulation safety.

Note: Mineral fibre insulation products are made from inorganic materials that mold cannot feed on.

RESILIENCY STRATEGY

Envelope First Retrofit: Exterior Walls

The exterior walls of a building are exposed to wind, rain, snow, and sun all year long. Using resilient materials is critical for a building that will last through many seasons. Choose materials that are hardy, resistant to moisture and impact damage and that will stand up to the test of time.

All building envelope elements can happen in an exterior wall system, and the control layers must work together to maintain air tightness, thermal comfort, and reasonable levels of humidity year-round. The key focal point is **continuity**.

Working from the exterior of the building is often easier unless the building is being gutted.

Note: A working knowledge of how modern and older buildings were constructed is valuable for planning an energy retrofit. Spacing and size of framing materials used in buildings over the last century may differ greatly.

Figure 4: Exterior framing added to timber frame structure

INTERIOR APPLICATION:

- Removal of interior finishes and trim may happen in a deep energy retrofit with something called a “full gut renovation”. This approach removes almost all layers to get back to bare framing (as close to new as possible) and then building out again.
- Cavity insulation may be applied more consistently, especially in older buildings.
- If interior floor space is not too tight, it may be possible to add a layer of continuous insulation toward the inside.
- If aesthetic renovations are being planned – i.e. kitchen, bathroom, living space – this is the ideal time to incorporate improvements to the building envelope from the interior.
- **Note:** Opening up interior walls may expose hazardous materials. Always consult with certified remediation professionals.

EXTERIOR APPLICATION:

This approach may be the easier strategy for improving the building envelope. There can be more broad, flat surfaces that allow for more consistent application of control layers.

- Sidewall insulation installation may be possible. This involves cutting small holes along the exterior wall to blow in loose insulation into the framed cavities from the outside. The holes can then be covered over with patches and new siding. **NOTE**: This method may not provide complete coverage because of obstructions inside a wall.
- Continuous insulation on exterior walls may be done by building up layers of insulating materials, by applying insulated panels (pre-fabricated) or by installing a framing system on the exterior of the walls.
- Windows and doors may need to be moved outwards to align with new finish surfaces, or they could receive new flashing to manage bulk water.

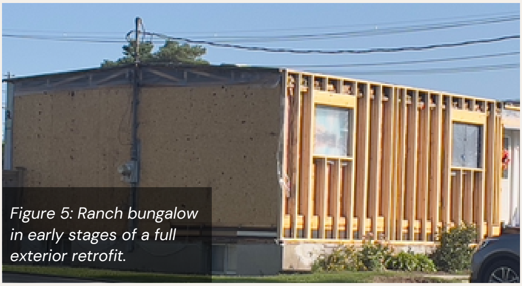


Figure 5: Ranch bungalow in early stages of a full exterior retrofit.

- Continuous fibre insulation on exterior walls may contribute to a positive drying potential toward the outside.
- New building envelope materials must integrate with foundation and roof layers for best performance.

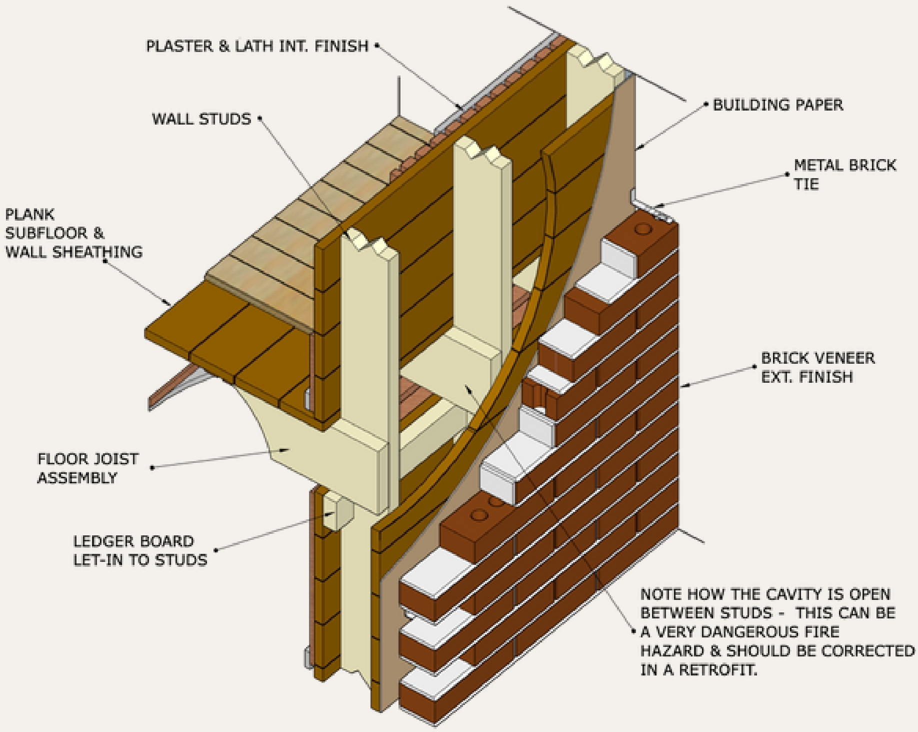
STRATEGY POINTS: EXTERIOR WALLS

- **PURPOSE**: Improve control layers in exterior walls – cavity and continuous insulation, air sealing, windows and doors.
- **PRIMARY METHOD**: Investigate and improve wall cavity insulation – sidewall filling from exterior. Improve interior air sealing w/ caulking, aerosol fogging, outlet gaskets, weather stripping. ($$)
- **HIGH PERFORMANCE METHOD**: Deep energy retrofit. Maximize insulation on exterior, provide for airtight layer, replace windows and doors to integrate with new control layers, install new flashing and rainscreen drying layer. ($$$)
- **SYSTEMS**: Continuous air, moisture and thermal control layers, air sealed penetrations for utilities.
- **EFFECT**: Reduce heat losses through exterior walls, warmer and more comfortable interior conditions, improved drying potential to exterior.

OLD BUILDINGS: BALLOON FRAME

Working on buildings that were constructed before 1950 may see you dealing with framing that is not using platform style walls or spacing.

A working knowledge of older buildings and how they are constructed is integral to the energy retrofit process. Spacing of structural elements may not follow modern "on centre" patterns, and there may be many decades of layers to peel away. Be careful of potential hazardous materials. Train your crews in historic retrofits and renovations.

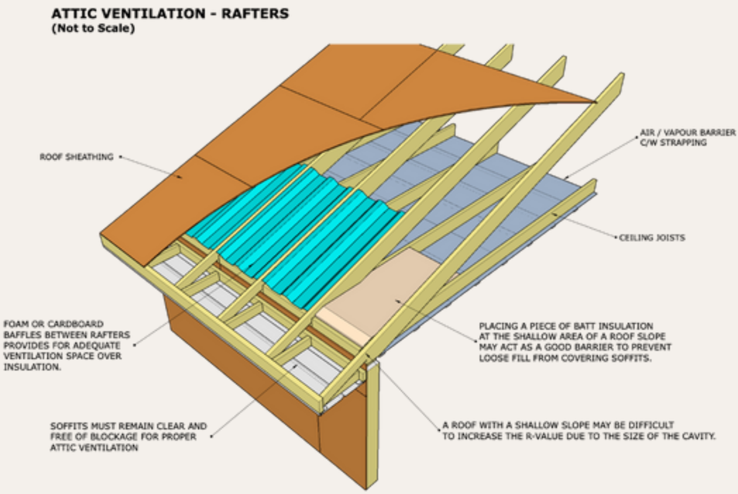


RESILIENCY STRATEGY

Envelope First Retrofit: Roof Structures

The attic is one of the most easily accessible and effective spaces for added insulation and air sealing.

But it needs to be done properly to create an airtight ceiling surface and an evenly ventilated space above the insulation.



RETROFIT AIR SEALING ATTICS:

- Remove old insulation materials from attic space and prepare the area for air sealing.
- Sealing may be done with barrier materials, low expansion foam or aerosol-type sprays.
- Install rafter baffles and blocking to ensure that venting from the soffits has a clear path over the insulation and out through upper vents. Blocks will help to prevent insulation from spilling into the soffit cavity.
- Use durable materials for vents.
- Consider using vents with fine steel mesh to reduce entry of embers in the case of fire.

INSULATION SETTLING

Fibreglass and mineral wool batts do not settle when installed properly in framed cavities. Loose fill fibreglass and mineral wool settling is negligible. Because they retain their integrity, mineral fibre insulation maintains its thermal performance for the life of the building.

INSULATING ATTIC SPACES:

- Install “R-Stick” rulers to gauge the depth of insulation being installed.
- ‘Flash and fill’ insulating may be done by installing a thin layer of expanding foam insulation for sealing and topping up the remaining insulation with loose fibre.
- In low sloped roofs, the wedge-shaped space where the rafters or trusses meet exterior walls will be challenging to insulate to a good depth. If possible, insulate this area with a high R-value insulation type to compensate.
- Attic insulation levels are determined by building code. Programs like Net Zero and Passive House require high R-values and airtightness to maximize performance. Consult with your energy advisor and contractor to ensure that you’re getting the required amounts.

Figure 6: R-Sticks attached to a truss assembly or rafters can provide an easy depth reference for loose fill insulation.

STRATEGY POINTS: ROOF STRUCTURES

- **PURPOSE**: Air seal and insulate attic, ceiling and roof spaces to reduce heat losses. The attic is one of the most effective areas for improvements.
- **PRIMARY METHOD**: Air seal ceiling area connected to the attic, ensure proper ambient ventilation in attic, maximize insulation levels. ($$)
- **HIGH PERFORMANCE METHOD**: Deep energy retrofit – Cut roof eaves/ overhang to allow for continuous insulation from exterior walls over roof structure. Install new roof deck, overhang and finishes. (See Chainsaw Retrofit).
- **SYSTEMS**: Continuous air, moisture and thermal control layers, air sealed penetrations for utilities, ambient venting.
- **EFFECT**: Reduced heat losses through ceiling and attic spaces, warmer and more comfortable interior conditions, improved drying potential to exterior, reduction or elimination of ice damming.

RESILIENCY STRATEGY

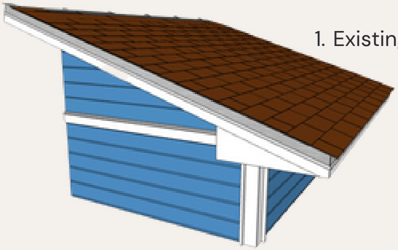
Envelope First Retrofit: Chainsaw Retrofit

WHAT IS A CHAINSAW RETROFIT?

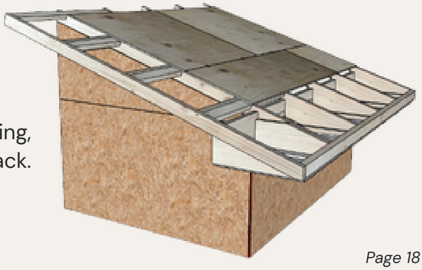
The overhanging eaves of the roof are cut off (hence the name chainsaw) and a Larsen Truss system is installed up the exterior walls and over the roof with greater depths of insulation and upgraded air sealing. This method was first used in the late 1980's in Saskatchewan by building scientist Harold Orr and has proven to be an effective energy retrofit method.

The chainsaw retrofit takes the building envelope back to sheathing and builds back out using continuous airtight layers, insulation and new finishes. The approach may use layers of medium-density mineral fibre insulation boards with strapping, insulated panels with plywood or OSB nailing layers, or a wood frame skeleton with mineral fibre insulation cavity infill.

With the new air barrier and maximized insulation to the exterior, the occupants might experience a lot less disruption with the chainsaw retrofit approach. Improved airtightness and insulation may also eliminate thermal bridges and reduce the risk for condensation within the main structure – the original building is essentially getting a new windbreaker and warm sweater toward the outside.

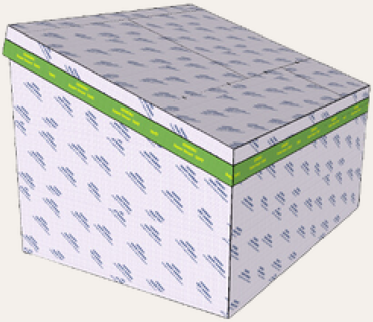


1. Existing building before retrofit.

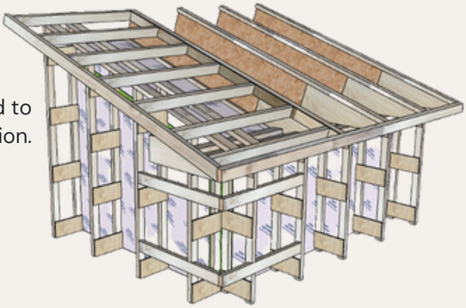


2. Exterior layers are taken back to sheathing, roof assembly prepared for cutting back.

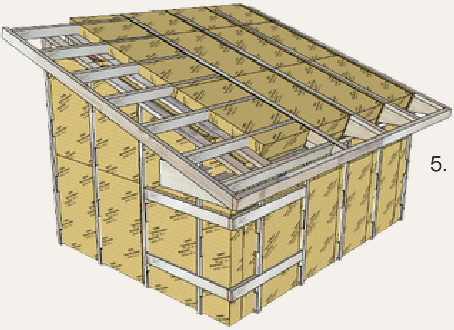
WHAT IS A CHAINSAW RETROFIT? CONTINUED



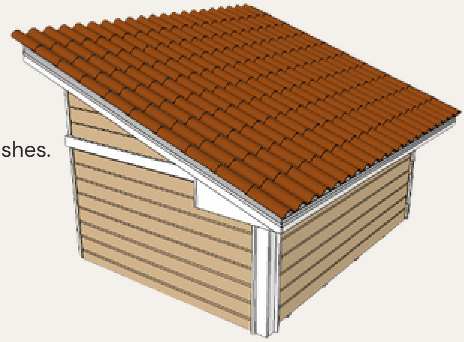
3. Eaves cut back, gaps covered, and new smart barriers are installed for airtightness.



4. Panels, framing, or trusses attached to exterior to carry new insulation.



5. Exterior shell super insulated.



6. Closed in with new, durable exterior finishes.

BACKGROUND

Building Envelope First

Creating the optimum conditions for a healthy indoor environment requires that heating, cooling, and fresh air supply in a building are consistent in all seasons, with temperatures and relative humidity levels that are easily maintained by mechanical systems. To make the most effective use of those appliances, we must carefully detail the building envelope.

WHAT'S IN THE BUILDING ENVELOPE?

- **Control layers**: Insulation, air barriers and vapour retarders.
- **Structure**: The foundation, the exterior walls, and the roof.
- **Openings**: Windows, doors and holes for utilities.

Notice that the elements of the building envelope are things that usually last the life of the building or may only get replaced once every 50 to 100 years.Modern mechanical systems may have a useful life of just 20 years. This longevity is important to consider, especially when we plan for more resilient buildings now and in the future.

Consider this…

- An airtight and well insulated building envelope can reduce heat and cooling losses.
- Reduced losses may mean reduced energy costs.
- Reduction of heat & cooling losses can mean that mechanical equipment won't have to work as hard to maintain comfortable conditions, potentially extending their useful life.
- Very airtight and super insulated buildings may be able to maintain comfort with smaller mechanical systems that use less energy.
- A more easily maintained indoor climate may provide better comfort, better air quality and improved long-term health.

The fixed and unmoving elements in the building envelope contribute to the comfort and overall well-being of occupants, just by being there.

Figure 7: Renovation underway. Will the owner improve the control layers?

BACKGROUND

Control the Passage of Heat

Insulation has been used in buildings for hundreds of years in many forms – anything that was soft, fluffy, and able to hold onto air made for good insulation. Putting a warm sweater on our buildings is an easy way to think about how it works.

Understanding how much insulation you need for include the following considerations:

- The climate zone location of your building and heating degree days*.
- The part of the building you're insulating – attics, walls, basements, etc..
- The surface area and volume of the space you're insulating.

The **Canadian National Building Code** has tables that describe the required amount of insulation by region and by building element. For example, the amount of exterior wall insulation required in southern B.C. is going to be different than northern Newfoundland and Labrador. This is because their climates are different, and the amount of energy required to keep their buildings comfortable all year will vary greatly too.

HEAT LOSS

Heat loss is how we express the movement of heat as it escapes a building – heat energy will always move from hot to cold. Heat loss surfaces include walls, ceilings, windows and doors, foundation walls and floors. Heat will also leave through cracks and openings that are poorly air sealed.

Figure 8: Early 20th century house experiencing ice damming due to heat loss.

HEATING DEGREE DAYS

*Heating Degree Days is a term that we use to describe how many days and how much heat energy is required to keep a building around 22 degrees Celsius (72 degrees F) in the coldest seasons. The higher number of cold days a region has, the higher the number of Heating Degree Days, which translates into higher amounts of required insulation. Remember to think about cost effective insulation – batts and loose-fill mineral fibre.

BACKGROUND

Control the Passage of Air

Air tightness is just as important as insulation in a building – one can't function very well without the other. In fact, the greatest amount of heat loss a building will experience is through air leakage.

Tightening up the building envelope to reduce air leaks and providing for optimized levels of insulation is a recipe for a well performing, energy efficient building.

In the past, leaky buildings would naturally exchange fresh and stale air as the wind blew or when windows were opened. This is called **Air Changes per Hour (ACH)** and some old buildings might have 10 to 15 changes every hour!

Modern targets for air exchange rates are much lower than in the past, because we now have a better understanding of how air leakage affects the overall performance of a building. The goal is to increase airtightness to the point where mechanical systems can easily handle all the heating, cooling and ventilation needs of a building.

Figure 9: Optimizing air tightness can be done with aerosol fogging. Photo: Airtight Home Technologies.

INDOOR CLIMATE CONTROL

Indoor Climate Control is what a healthy house uses to maintain comfort and good air quality all year long. Air tightness helps to minimize heat and moisture losses through the building envelope – the more airtight and well insulated, the easier it is for HVAC systems to keep indoor conditions consistently comfortable.

Fresh air supply and stale air exhaust are handled by **mechanical ventilation** – this is the function of heat recovery and energy recovery ventilators (HRV and ERV).

HRVS AND ERVS

- **HRVs** exchange warm outgoing stale air with cooler incoming fresh air, warming up the fresh air as it passes by.
- **ERVs** do the same thing as an HRV, except they also take some of the humidity or moisture from the outgoing air and give it back to the fresh air coming in.

CONCLUSION

Embracing Resilient Living

A house is more than just a building - it's a haven, a place where we can find comfort and safety. Resilient homes, fortified by a robust building envelope, embody this sanctuary. Building envelopes act as shields that protect us through our Canadian seasons, providing a sense of stability and security.

Durability isn't just about walls and a roof. It's about the lasting memories. A solid building envelope ensures that these spaces last over time, weathering everyday life. It's a quiet assurance for families that their home will stand strong through years of shared moments.

It's about the warmth and predictability of a healthy home. Through smart building science, our homes breathe life into the space, keeping it fresh and vibrant. Good ventilation, proper insulation, and moisture control work hand-in-hand to create spaces for fresh air, creating a healthy and nurturing environment.

In healthy houses, we find a sense of peace - a foundation where health and resilience work together as a system, creating spaces that support and protect us in our homes.

APPENDIX: CONTROL LAYER COMPONENTS AND SYSTEMS

Insulation: Optimizing R- Value Super insulated and highly airtight buildings stay comfortable longer and are more easily conditioned. New buildings should optimize insulation levels for energy use reduction. **Retrofits** Conducting an Energy Audit with a registered Energy Advisor can identify areas where your insulation needs help. Things to ask about: • Thermographic images of the building • Bore-o-scope inspection of building cavities (behind finishes) • Visual inspection of assemblies	**Attic Insulation** • Air seal ceiling surfaces to reduce heat loss by convection. • Maximize depth of insulation & ensure even distribution out to and over wall plates. Use R-Sticks! • Ensure passive ventilation over insulation from soffits and out upper vents. Use rafter baffles! • Insulate and seal attic hatches, ceiling penetrations and pot light boxes. • Use appropriate insulation around high-heat areas (e.g. chimney). **Exterior Walls** • Air seal wall surfaces to reduce heat loss by convection. • Maximize cavity insulation, ensuring a uniform depth and minimal gaps. • Apply insulation on the exterior of the building to provide continuous, unbroken layers. **Basements & Crawlspaces** • Insulate & air seal floor joist headers around the perimeter of floor system. • Deal with water and moisture problems in your foundation *before* insulating. • Insulate ducts and freshwater plumbing pipes to retain heat. • Apply insulation to basement walls to maximum depth possible, considering appropriate materials for exposure to moisture. **Foundations & Slabs** • Insulate under basement & floating slabs, continuing insulation layers around the slab perimeter. • Install insulation skirt in shallow, sloping excavation around building perimeter. • If site/budget permits, consider installing insulation layers on exterior of foundation walls to keep structural components warm to the interior.
Airtightness The last 20 years of building science practice and research have proven the importance of airtight assemblies in our buildings. The tighter we can make our buildings, the better. When we combine this with super insulation and high efficiency fresh air ventilation machines, we can truly create climate-controlled spaces.	**Dedicated & Continuous Layers** • Install smart air & vapour barriers on warm side of exterior walls. Allow for drying potential inside & out. • Use durable materials that will last lifetime of building. • Minimize perforations in the air barrier by strategic use of sealant tape over fasteners. • Apply airtight layers from foundation to roof, with as few interruptions as possible. • Use a taped weather resistant barrier and rainscreen strategy to create exterior airtight layer & drying potential. **Gaskets & Grommets** • At outlets & utility penetrations in the air barriers, use self-adhering grommets & foam gaskets to maintain airtight continuity. Work with your subtrades to ensure that these gaskets are properly installed when rough-ins and hookups are being done. **Caulking, Tapes & Sealants** • Use companion tapes and sealants recommended by air barrier manufacturers. • Apply sealants strategically at critical times and at common air leakage locations: bottom plates, interior partition junctions at exterior walls, behind stairs, etc. Work with your framer to ensure timing is right for sealant application. • Consider using atomized air sealing spray applications to enhance the effectiveness of the airtight layers and overall airtightness of the building.

Windows and Doors Openings in the building envelope have traditionally been weak points for energy performance. Modern windows and doors are better built, better insulated and more airtight. They must be incorporated into the building envelope control layers to provide effective continuity of heat, air, and moisture management.	**U-Value vs. R-Value?** • U-Value is the measurement of heat loss through a collection of materials. • Window and door performance is rated by U-Value: the thermal conductivity of the assembly: glass, frame, spacers, and coatings. • A **low** U-Value rate is best for windows and doors. • A quality window or door will have a positive thermal resistance (R-Value) **Performance parts in windows** • Look for triple glazing with low-emissivity coatings. • Specify high quality spacers between the glass panes: they need to last for the life of the window without failing. • Window frames should be insulated & incorporated into the thermal control layer. • Inert gases like Argon and Krypton can be injected between layers of glass to slow the passage of heat. • Choose windows with frame materials that are low conductance. **Door units** • Frame and threshold should integrate easily with control layers. • Insulation & glazing in the door should be create a low U-Value, similar to windows. • Seals on the door and frame should create an airtight connection. • Look for durable exterior facing materials. **Integrations into Control Layers** • Rough openings for windows and doors must be carefully planned to accommodate the unit, shims, surrounding insulation, air sealing, and moisture management layers inside and out. • Air & vapour control layers should seamlessly incorporate doors & windows. • Self-adhering membranes used for flashing rough openings must use positive overlaps to encourage bulk water flow down and away. • Use high quality, durable flashing materials that incorporate with exterior finishes.
Eliminating Thermal Bridges	**Continuous Insulation** • Exterior continuous insulation is applied to eliminate thermal bridges that occur because of structural intersections at foundations, floors, walls, roofs. • Sufficient R-Value must be used to keep layers toward the interior warm & dry. Insulation thickness can be determined by energy modelling or through building code. • Rainscreen/vented siding layers should be used to allow for drying potential to the outside. **Advanced Framing** • Increased spacing of on-centre structural elements allows for a decreased ratio of conductive materials to insulation. • Stacked structure in advanced framing may provide more continuity and consistency for cavity insulation. **Clusters & Conductive Materials** • Corners, intersections, bump-outs and projecting elements in a building create areas that are challenging to insulate & air seal. • Carefully detail areas with highly conductive materials like steel, aluminum, and masonry. Ensure these receive sufficient insulation to eliminate thermal bridging.
Mechanical Ventilation & HVAC	**Energy modelling to size systems** • An EA can assess the performance of an existing building or model a plan for a new building. This allows them to create envelope & systems that work most effectively. • With carefully detailed insulation and air tightness measures, a building envelope may maintain indoor climate conditions more easily. This could mean that a smaller heating, cooling, and ventilation system can be installed. • Energy efficiency planning might involve the electrification of systems, with the opportunity to use renewable power sources. **Cold Climate Air Source Heat Pumps** • Replacing older HVAC systems with super-efficient air source heat pumps may reduce the energy requirements in a building significantly. • With building envelope improvements to get a building heat pump ready, this technology can decrease energy demand & incorporate with electrification plans. **HRV & ERV fresh air machines** • Airtight & super insulated buildings require constant fresh air supply & stale air exhaust. • HRVs and ERVs are fresh air machines that handle the exchange of warm outgoing exhaust & cool incoming fresh air. Mechanical ventilation is critical for high performance construction & energy retrofits.

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