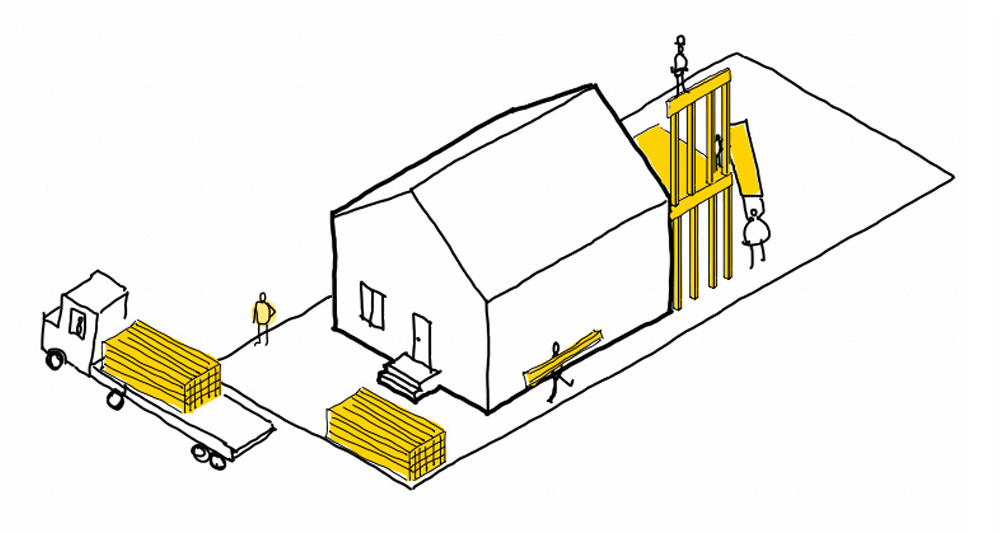
ReHousing

Low Carbon Guide for Multiplex Conversions



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This guide was co-authored by ReHousing and Ha/f Climate Design and funded by the Neptis Foundation.

neptis

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ReHousing

ReHousing is a non-profit focusing on housing creation through applied research, consultation and education. ReHousing began as a collaboration between the University of Toronto, TUF Lab, and LGA Architectural Partners. This partnership brings together structured design research methods with practice-based knowledge to address real-world problems.

Our research and platform is designed to empower citizen developers in converting single-family homes into multi-unit housing. As municipalities across Canada face the challenge of translating policy into more housing units, we bridge the gap between emerging policy initiatives and the housing creators they intend to serve.

ha/f

Ha/f Climate Design is an architect-led strategic consultancy for the built environment. Our mission is to halve the emissions of the built environment this decade, foster circular building practices and develop strategies for climate positive public infrastructure. Our services include life cycle assessment (LCA), climate risk analysis, energy modelling, operational performance modelling, and material reuse strategies.

Our team combines technical depth with design fluency, translating emissions data into clear, actionable strategies for buildings, landscapes, and infrastructure. We support partners of all sizes - from small studios to national institutions - with strategy, certification, education, and policy.





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1.
Introduction

Across Canada, municipalities are updating zoning rules to allow multi-family housing in single-family neighborhoods. This is a unique opportunity to build more housing in a way that minimizes its carbon impact.

By adding units in areas already served by infrastructure, we avoid the need for new roads, pipes, and transit. And by converting existing single-family homes into multi-unit dwellings, we can create these new units using less material overall.

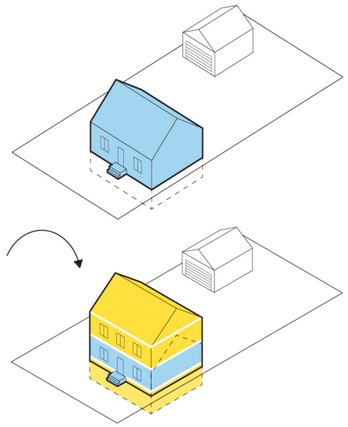


Fig 1. You can convert a single family home to multi unit housing by splitting existing units as well as constructing additions to add floor area.

Realizing these opportunities requires us to rethink both how we build and who our builders will be. We believe the group best positioned to take on this scale of development are citizen developers, including homeowners, small-scale builders, and non-profits. These groups are often more invested in the long-term outcomes of a project and are therefore uniquely positioned to make values-driven decisions.

The challenge is that citizen developers often lack experience. Construction projects can be overwhelming. With hundreds of decisions to make, from materials to mechanical systems, even the most committed individuals can quickly feel lost. While there's plenty of information available on sustainable building, much of it is overly technical or geared toward large-budget projects, making it difficult for non-professionals to apply knowledge to smaller-scale work.

The **Low Carbon Guide for Multiplex Conversions** was created as an accessible starting point for non-professionals. It offers practical guidance for balancing cost, performance, and carbon impact with a focus on making informed choices about construction materials and building systems like heating and cooling. The guide begins with an overview of how buildings contribute to carbon emissions, then offers two main sections of advice. The first, **Choose the Right Materials**, helps users select building materials that reduce embodied carbon. The second, **Lower Your Energy Use**, outlines strategies to reduce energy consumption in occupied buildings and minimize operational emissions. The concluding section highlights the importance of regular maintenance in ensuring long-term building performance and avoiding costly, carbon-intensive replacements.

Climate responsibility is starting to shape large-scale development, but it should also play a role in small projects. We hope citizen developers see their multiplex projects not only as part of the housing solution but also as part of the climate solution. And that this report can serve as a starting point for making sustainable construction decisions. With the right knowledge in the right hands, small choices can add up to make a big difference for both our housing needs and the health of our planet.

2.
Carbon and Buildings

When we say that we need to “decarbonize” the building sector, we mean that we need to reduce greenhouse gas emissions from the construction of new buildings and the use, maintenance, and renovation of existing buildings.

Reducing carbon emissions from buildings can also lead to cleaner air, lower energy bills, better health for occupants, and increased climate resilience over time.

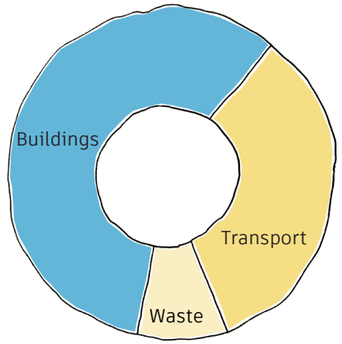


Fig 2. The buildings sector makes up most of Toronto’s carbon emissions, followed by transportation and waste.

In Toronto, the energy use in existing buildings and greenhouse gas emissions from new construction make up 60% of the city's carbon emissions.

In every construction project, we are faced with hundreds of decisions, from what kind of materials we build with to what types of systems we will use to make our homes functional, comfortable and beautiful. When we make these decisions, we consider things like how much it costs, whether it is functional and whether we like the way it looks. Today, more than ever, it is critical to add another factor into our decision making — what is the carbon impact of this choice?

By adapting, renovating, and adding to existing single-family homes, you are already making a positive impact. This approach allows us to create multiplex housing without the need for full demolition and building new. Your renovation project will also provide an excellent opportunity to reduce the “carbon footprint” of your homes by choosing energy-efficient systems and low carbon materials.

BUT FIRST, WHAT IS “CARBON”?

Carbon is an element that is found in rocks, soil, oceans, living beings, and the atmosphere.

Carbon is released into the atmosphere when we breathe, when things decay, when we burn fossil fuels and dig the earth to mine minerals and resources, usually in the form of carbon dioxide, methane, and fluorinated gases.

Carbon is naturally absorbed out of the atmosphere by photosynthesis in trees and chemical reactions of air with the ocean surface.

WHAT IS THE CARBON CYCLE, AND HOW DOES IT AFFECT THE ENVIRONMENT?

When the amount of carbon released into the atmosphere is equal to the amount that is naturally absorbed by trees and oceans, "the carbon cycle" is balanced and allows the planet to remain hospitable for life. Since the industrial revolution, human activities like deforestation, mining, and burning fossil fuels through the increased use of cars and trucks have disrupted the carbon cycle's balance, leading to more greenhouse gases being released into the atmosphere than are being taken up by plants and the ocean.

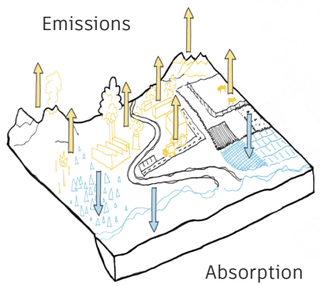


Fig 3. The carbon cycle is a constant flow of carbon emissions and carbon absorption.

IS CARBON FOOTPRINT THE SAME AS GREENHOUSE GAS EMISSIONS?

Gases like carbon dioxide that trap heat in the atmosphere are called greenhouse gases. An excess of greenhouse gases in the atmosphere means an excess of heat being trapped, leading to harmful effects of climate change.

"Carbon footprint" is the term used to measure the greenhouse gas emission of any human activity that is contributing to the warming of global temperatures. For example, one may talk about the carbon footprint of a flight from Toronto to New York or the carbon footprint of the construction of a new glass and metal office tower downtown.

WHAT IS A BUILDING'S CARBON FOOTPRINT?

Emissions from buildings are grouped under two main categories: embodied carbon and operational carbon.

Embodied carbon refers to the greenhouse gas emissions from the extraction, manufacturing, transportation, installation, maintenance, and disposal of building materials. Every time we build a new house, do a renovation, or demolish a building, we contribute to an embodied carbon footprint.

Operational carbon refers to the greenhouse gas emissions due to building energy consumption through systems like heating, cooling, ventilation, and lighting. Once we start using the building, all activities that involve using electricity, gas, fuel, or water add to our operational carbon footprint.

2. Carbon and Buildings



Fig 4. Embodied carbon emissions from building materials and new construction along with operational carbon emissions from energy use in buildings add up to the whole-life carbon emissions of a building.

We can reduce embodied carbon emissions by building fewer new structures, repurposing existing buildings, reusing building components, and choosing building materials with a lower carbon footprint.

We can reduce the operational carbon emissions by choosing energy-efficient building systems, improving insulation and airtightness, electrification, and eliminating the use of fossil fuels on-site.

The sum total of embodied and operational carbon is known as the whole-life carbon emissions of a building. We need to view both parts of this whole - and focus on adopting measures that help reduce this total carbon footprint.

3.
Choose the Right Materials

Buildings are made up of different material assemblies that make up their structure, skin, and finishes. The materials you build your house with have a big impact on its carbon footprint, but also affect occupant health and long-term affordability. This section is a guide to choosing long-lasting, low-carbon, and healthy materials.



Insulation

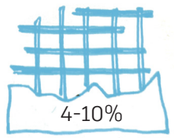


Finishes

3%



Glazing



Rebar

14-33%



Concrete

Fig 6. Reductions possible with low/no additional cost.

Building materials make up 13% of global emissions!

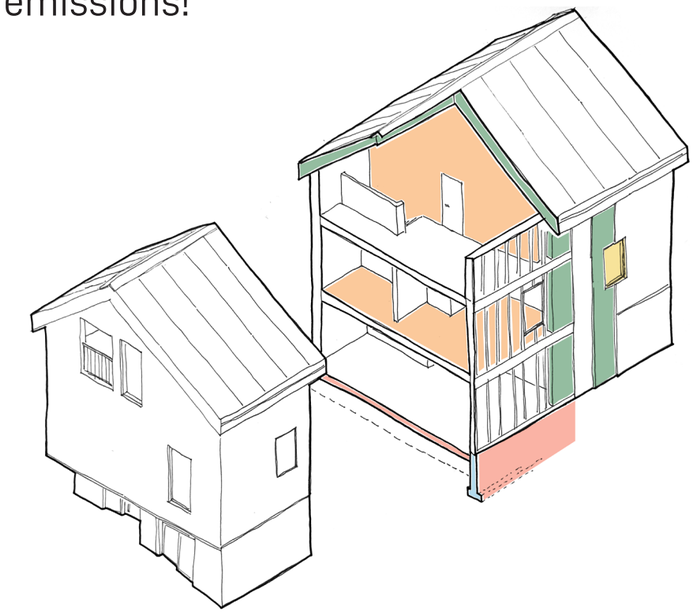


Fig 5. The material layers in a building include concrete foundations, insulated walls, windows and finished interiors.

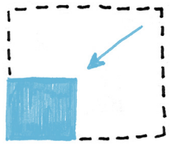
IS IT AFFORDABLE TO CHOOSE LOW CARBON BUILDING MATERIALS?

Yes! You can make material choices that will help reduce the carbon impact of your home without breaking the bank. Figure 6 illustrates that by optimizing your concrete mix and rebar and choosing low-carbon insulation and finishes, you can reduce your embodied carbon footprint by 39% - 64% at low or no cost premium.

Emissions that come from the extraction, manufacturing, transportation, installation, maintenance, and disposal of building materials are known as embodied carbon. Building materials may include reinforced concrete for your basement expansion, wood for your new deck, insulation for your low-energy retrofit, or vinyl siding for your new garden suite. Choosing the right building materials can help reduce embodied carbon footprint significantly.

What are some general rules of thumb that can help you choose the right materials?

REDUCE MATERIAL QUANTITY



The good news is that lowering the embodied carbon of your home does not necessarily mean higher costs. The most effective way to reduce the carbon footprint of materials is to build efficiently and use fewer materials, especially when it comes to structure and finishes. Using less material will also help you stay within your budget.

USE BIO-BASED MATERIALS



Bio-based construction materials are made from organic sources like plants, trees, and agricultural byproducts. Trees breathe in CO_2 while they grow - so building materials made from wood have a negative carbon footprint in their raw material phase as opposed to the high levels of greenhouse gas emissions during the extraction of metals and petroleum-based products like foam insulation. Increasing the proportion of bio-based material in a project often helps to reduce overall carbon footprint, replacing typically more carbon-intensive materials like concrete, steel, and aluminium with ones like wood, cellulose, hemp, or straw bales. Many of these product types are locally produced, affordable, and are becoming more common in the GTHA.

CHOOSE LOWER CARBON ALTERNATIVES



Building materials now come with Environmental Product Declarations (EPD), which specify its global warming potential (GWP). For example, if you have to use foam insulation in your project, EPS foam has a far lower carbon footprint than XPS foam, although they perform similar functions and are priced closely. Ask your contractor for material EPDs with low GWPs - you can work together to find the most environmentally viable options, that work within your budget.

3. Choose the Right Materials



REUSE MATERIALS

Whenever possible, try to salvage materials like brick, metals, broken concrete, or wood. Salvaged materials typically have a much lower embodied carbon footprint than newly manufactured materials since the greenhouse gas emissions from their manufacture are already in the atmosphere. For example, if you are doing a renovation where you take down a brick exterior wall, you can repurpose the bricks as paving stones or ornamental landscape elements - you save on both cost and carbon!



CONSIDER DURABILITY AND END OF LIFE

To cut down carbon emissions in buildings, it's important to think about how long materials last and what happens to them when they're no longer needed. Strong, long-lasting materials that don't need to be replaced often can save you maintenance cost and reduce carbon emissions from making and moving new materials. It's also better to use materials that can be reused, recycled, or that break down naturally when the building is taken apart. For example, if you are insulating your attic, consider using cellulose, which is made from recycled paper and can last the life of the building if installed properly to protect against water damage and rodents. At its end-of-life, cellulose insulation can be recycled and will biodegrade, as opposed to spray foam insulation, which will not biodegrade and become a permanent problem in the waste stream.

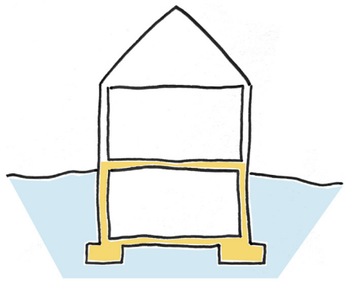
As a small scale citizen developer you can lower the environmental impact of your multiplex project by paying attention to:

- Reducing concrete elements.
- Choosing low carbon cladding, insulation, and finishes.
- Right-sizing and placing windows strategically.

3.a.
Reduce Concrete Elements

Concrete is the second most consumed product on earth, after water, and one of the highest drivers of embodied carbon in buildings. Cement is the binding agent that glues together the sand, gravel, crushed stone, and water that make up concrete.

Cement accounts for 26% of global industrial emissions. You can help decarbonize your project by reducing the use of concrete and specifying low cement concrete mixes.



Residential homes in Toronto are typically built on concrete foundations and basements.

Concrete is everywhere in our built environment. It is used in almost every building we have, as well as most infrastructure like pipes, bridges, roads, etc. It is the most abundant human-made material in the world! Typically, concrete is made up of coarse materials like gravel and fine materials like sand that are bound together by water and portland cement.

Common concrete elements in residential building construction include footings, foundation walls and slabs on the ground. It also includes basement walls, columns, cast-in-place concrete stairs, landscaping pavers, exterior wall blocks and sometimes interior finishes like polished concrete floors.

WHAT MAKES CONCRETE A HIGH CARBON MATERIAL?

Portland cement is the most common type of cement that is used as a binder in concrete mixes, and it is the biggest contributor to concrete's large embodied carbon footprint. Cement production involves heating a mixture of limestone, silica, alumina and gypsum in a kiln to 1,400-2,000 degrees Celsius. The heat-intensive process is often powered by fossil fuels, and the chemical reaction itself generates CO2. Anything you can do to reduce the amount of cement in your concrete mix will have a significant impact on the overall embodied carbon of the concrete.

LESS CEMENT = LESS CARBON EMISSIONS

One way to reduce a building's carbon footprint is to specify cement mixes that are less intensive. This is more typical for big projects but challenging at a smaller scale. For small residential projects, the most effective way to reduce the high carbon impact of concrete is to avoid its use altogether. For instance, in many parts of the country, people are deciding not to build basements due to the increasing frequency of flooding. There are also other ways to build basements using wood for the structure rather than concrete!

YOU CAN AVOID THE USE OF CONCRETE IN YOUR PROJECT BY REDUCING THE AMOUNT YOU BUILD UNDERGROUND

ReHousing helps you reduce your home's embodied carbon footprint by offering you strategies to reuse an existing home rather than build a new one. This means you are not building new basements with all of the concrete they require. If you do build new, our guide also provides some strategies for building with less concrete. These strategies include building additions without basements and reducing underpinning for renovations. If you do build a new building, you can also select a design without a basement.

YOU CAN REDUCE THE CARBON IMPACT OF CONCRETE BY USING STEEL REINFORCEMENT MORE EFFICIENTLY

Structural concrete includes a lot of steel - known as rebar - to make it strong. Greenhouse gases that are released in the process of manufacturing steel rebar also contribute to concrete's high carbon footprint. Even though most rebar in Canada is made from recycled steel, it still needs to be processed at very high temperatures, making it carbon intensive. You can work with your contractor and structural engineer to use more efficient strategies like steel mesh reinforcement, which uses less material than traditional steel rebar.

YOU CAN ASK FOR LOW CARBON CONCRETE MIXES

In case you are proceeding with a design that requires larger amounts of concrete, ask your contractor to procure lower carbon concrete mixes with the following specifications:

- Maximises the use of supplementary cementing materials or SCM.
- Uses portland-limestone cement, known as PLC or GUL, instead of General Use Portland cement, known as GU.

Less cement means lower carbon and, in some cases, lower cost, too!

3.a. Reduce Concrete Elements



Fig 7. Exterior wall construction using hempcrete blocks.



Fig 8. Gabion baskets can be used as retaining walls.



Fig 9. Salvaged concrete blocks reused as permeable pavers.

YOU CAN REDUCE THE USE OF CONCRETE BY CHOOSING ALTERNATIVES MADE OF RECYCLED MATERIAL

Ashcrete is composed of at least 97% recycled materials and is created from what is known as fly ash, which is a byproduct of burning coal dust. Ashcrete does not use traditional burning or cement production methods during production. It also needs less water than traditional concrete, which is a significant co-benefit.

Ferrock is produced from recycled materials, including steel dust from the steel industry and silica from ground-up glass. This results in a particularly durable building material that is stronger than traditional concrete and also chemically non-reactive, which makes it great in water or moisture. It's a fairly new material and is currently better suited to small-scale projects.

IN ABOVE GROUND CONSTRUCTION, YOU CAN REDUCE CONCRETE BY USING ALTERNATIVE MATERIALS AND REUSING "WASTE" FROM YOUR RENOVATION

Now that you know the large environmental impact of concrete, always try choosing another option:

- Replace concrete exterior walls with hempcrete.
- Replace concrete beams and columns with glulam (glue laminated mass timber).
- Replace concrete facade tiles with engineered wood siding, wood shingles, or cork cladding.
- Use gabion baskets filled with reused masonry and concrete chunks as retaining walls.
- Reuse concrete blocks for the construction of new walls or floors.

Building above ground is cheaper, uses less insulation and other materials, is less prone to dampness and flooding, and creates spaces with better light and ventilation. It also means concrete use can be replaced by more bio-based materials, which are better for the environment.

3.b.
Low Carbon Cladding, Insulation and Finishes

A building's walls, floors and roof are made up of a series of material layers. Cladding is the outer layer that is exposed to weather and has a big visual impact. Insulation is material used within the wall to maintain comfortable indoor temperatures. Finishes like paint or flooring make up the inner layers of the building and are surfaces we interact with daily.

This section includes a guide to available material options in five common material categories - that are arranged from lowest embodied carbon to highest embodied carbon footprint.



*The net carbon metric refers to the total embodied carbon footprint, including replacements, over the 60 years.

**In the case of bio-based materials, the biogenic carbon stored in them has been deducted from the total embodied carbon, and the net carbon number is reported in green. This number can often be negative.

Cladding

Cladding is the outermost material layer on exterior walls. It shields the building from weather elements, reduces maintenance, and improves energy efficiency. Here are some cladding materials that are widely available in Canada, with their corresponding embodied carbon metrics noted alongside their typical lifespans, and life cycle costs.

Low Carbon Materials → High Carbon Materials



Cedar Wood Siding

Net Carbon**	-8 kgCO2/m2
Lifespan	50 -60 years
Cost	$



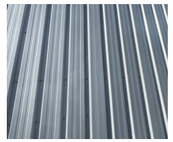
Engineered Wood Siding

Net Carbon**	-6 kgCO2/m2
Lifespan	25 -30 years
Cost	$$$



Fibre Cement Siding

Net Carbon*	14 kgCO2/m2
Lifespan	50 -60 years
Cost	$



Steel Cladding

Net Carbon*	16 kgCO2/m2
Lifespan	50-60 years
Cost	$ - $$



Vinyl Siding

Net Carbon*	26 kgCO2/m2
Lifespan	25 - 30 years
Cost	$$ - $$$



Brick (90mm)

Net Carbon*	59 kgCO2/m2
Lifespan	60+ years
Cost	$$$

Rigid Insulation

Rigid insulation is attached to the outside of a wall, just underneath the cladding. Rigid insulation can be reused unless it is foamed-in-place or glued to another material. Here are some rigid insulation materials that are widely available in Canada, with their corresponding embodied carbon metrics noted alongside their typical lifespans, and life cycle costs.

Low Carbon Materials



Wood Fiber Board
38mm for R-5

Net Carbon**	-5 kgCO2/m2
Lifespan	60+ years
Cost	$



Mineral Wool Board
30mm for R-5

Net Carbon*	3.4 kgCO2/m2
Lifespan	60+ years
Cost	$



EPS Expanded Polystyrene
35mm for R-5

Net Carbon*	3.8 kgCO2/m2
Lifespan	60+ years
Cost	$



Polyiso Foam Board
25mm for R-5

Net Carbon*	16 kgCO2/m2
Lifespan	60+ years
Cost	$



XPS Extruded Polystyrene
22mm for R-5

Net Carbon*	26 kgCO2/m2
Lifespan	60+ years
Cost	$ - $$

High Carbon Materials

3.b. Low Carbon Cladding, Insulation and Finishes

Cavity Insulation

Cavity insulation goes inside a wall, between wood or metal "studs". Bio-based cavity insulation like cellulose and hemp fiber can last as long as conventional options if they are installed well, and protected against moisture damage. Here are some cavity insulations that are widely available in Canada, with their corresponding embodied carbon metrics noted alongside their typical lifespans, and life cycle costs.

Low Carbon Materials



Hemp Fiber Batt
38mm for R-5

Net Carbon**	-0.6 kgCO2/m2
Lifespan	60+ years
Cost	$$



Loose Blown-in Cellulose
40mm for R-5

Net Carbon**	0.4 kgCO2/m2
Lifespan	60+ years
Cost	$$



Unfaced Fiberglass Batt
35mm for R-5

Net Carbon*	1 kgCO2/m2
Lifespan	60+ years
Cost	$$



Mineral Wool Batt
38mm for R-5

Net Carbon*	1.1 kgCO2/m2
Lifespan	60+ years
Cost	$$



Closed Cell Sprayfoam
21mm for R-5

Net Carbon*	22 kgCO2/m2
Lifespan	60+ years
Cost	$$

High Carbon Materials

Floor Finishes

Flooring will take the largest amount of daily wear over the lifespan of your project, so try to select a material that is durable and easy to clean. Here are some flooring materials that are widely available in Canada, with their corresponding embodied carbon metrics noted alongside their typical lifespans, and life cycle costs.

Low Carbon Materials



Hardwood
19mm

Net Carbon**	-27 kgCO2/m2
Lifespan	60+ years
Cost	$$$



Linoleum Tile or Sheet
3mm

Net Carbon**	-1 kgCO2/m2
Lifespan	20 years
Cost	$$



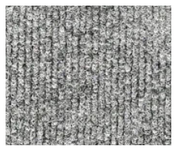
Engineered Wood
8mm

A-C Carbon**	4 kgCO2/m2
Lifespan	30 years
Cost	$$ - $$$$



Ceramic Tile
8mm

Net Carbon*	28 kgCO2/m2
Lifespan	30 years
Cost	$$$ - $$$$



Carpet Tile
8mm

Net Carbon*	43 kgCO2/m2
Lifespan	15 years
Cost	$$$ - $$$$



Vinyl Tile, Roll, or Plank
8mm

Net Carbon*	76 kgCO2/m2
Lifespan	25 years
Cost	$$

High Carbon Materials

3.b. Low Carbon Cladding, Insulation and Finishes

Wall Finishes

The most frequently replaced material in a home is paint, usually every ten years or more often. Given that paint dries in the home, and is usually applied by the owner or occupant, health considerations are also important so try to avoid plastic based paints. Here are some wall finishes that are widely available in Canada, with their embodied carbon metrics noted alongside their typical lifespans, and life cycle costs.

Low Carbon Materials



Limewash Paint
1 mm coat

Net Carbon*	0.3 kgCO2/m2
Lifespan	10 years
Cost	$$



Mineral Paint
1 mm coat

Net Carbon*	1.4 kgCO2/m2
Lifespan	10 years
Cost	$$

Acrylic/Latex Paint
1 mm coat

Net Carbon*	1.6 kgCO2/m2
Lifespan	10 years
Cost	$$

Latex Primer
1 mm coat

Net Carbon*	23 kgCO2/m2
Lifespan	10 years
Cost	$$



Porcelain Tile
6 - 10 mm

Net Carbon*	24 kgCO2/m2
Lifespan	30 years
Cost	$$$

Vinyl Wallpaper
5 mm

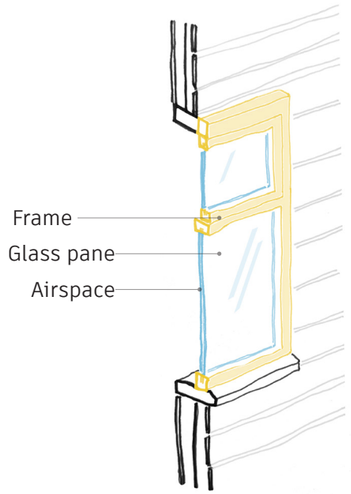
Net Carbon*	143 kgCO2/m2
Lifespan	10 years
Cost	$$$

High Carbon Materials

3.c.
Windows

Windows make a building comfortable and livable - but they can be some of the most expensive and carbon intensive parts of your construction project.

When designed and placed properly, windows can help reduce your energy needs, lower your embodied carbon footprint, and improve the comfort of your home.

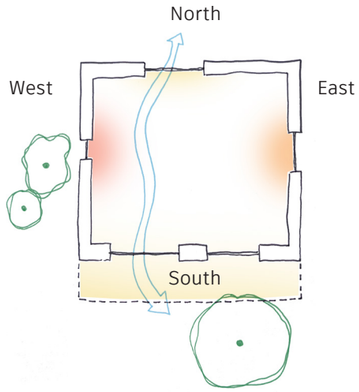


Windows account for around 10% of a building's embodied carbon footprint and up to 30% of your energy use through heat loss.

WHAT ARE WINDOWS MADE OF, AND WHY ARE THEY HIGH CARBON?

Windows are one of the most important parts of a home, providing light, air, and views outside. They can also be expensive and very carbon intensive. Typically, windows are made up of glass panes with an airspace filled with inert gas, which are held together by a frame. The frame is typically wood, vinyl, aluminum, or a composite of these materials.

Windows are often an embodied carbon hotspot since framing materials like vinyl and aluminium are very carbon intense. Windows also need to be replaced every 25-30 years since the insulating gas between panes leaks out over time and starts letting heat out of the house in the winter. Because of replacements and maintenance, windows are expensive in terms of both carbon value and dollar value over a period of time.



HOW SHOULD WINDOWS BE SIZED AND LOCATED?

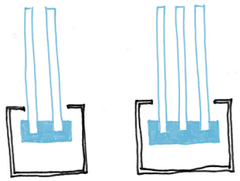
In a low carbon, energy efficient home, windows should make up 15-25% of the total area of all exterior walls. Any greater amount of glazed area results in too much heat gain and loss through the glass panes. Since windows have very little insulation, and glass is not very resistant to heat transfer, very large windows can make space heating and cooling more energy-intensive and drive up your monthly utility bills. So, the ideal approach is to strike a balance and limit oversized windows to strategic parts of your building.

Larger windows should be placed facing south, where they are easier to shade using overhangs, awnings, or other shading devices (even trees!) to prevent overheating in summer. South facing windows also allow for light and heat to enter the home in the winter.

North facing windows allow for natural ventilation but lose more heat during cold weather and should generally be smaller. East and west facing windows will cause overheating, and west facing windows are responsible for most summer overheating. Using smaller windows and ample interior shading like curtains and blinds can help reduce the overheating from the afternoon sun on the west face of your home.

SHOULD YOU BUY "DOUBLE-GLAZED" OR "TRIPLE-GLAZED" WINDOWS?

When you start looking to buy windows, you will be able to choose between "double-glazed" and "triple-glazed" windows. Double-glazed windows have two layers of glass with a gas-filled space in between, while triple-glazed windows have three layers and two insulating gaps. Triple glazing offers better insulation and reduces heat loss and outside noise more effectively. However, it is heavier, more expensive, and has a higher embodied carbon footprint.



Triple-pane windows take more carbon to make but save more energy over time. If you are located in a region where the power grid is mostly based on fossil fuels or in extremely cold climates where the energy demand for heating is very high, you could opt for triple-glazed windows to save on utility bills over time.

However, if you are located in Ontario, Manitoba, Quebec or BC, where the power grid is based on "clean" fuel sources like hydro or nuclear, it takes about twenty years for the energy savings from the extra glass pane to outweigh the additional energy required to make the window. Given the need to replace windows every 25-30 years, high-quality double-glazed windows are recommended.

If your project location has a moderately clean power grid - double-glazed windows with a low carbon frame like wood, if properly sized and placed, can make significant reductions to the whole-life carbon footprint of your building.

Windows

Low Carbon Materials



Aluminum Clad Wood Frame

Net Carbon**	82 kgCO2/m2
Lifespan	30 years
Cost	$$$



Insulated Fiberglass Frame

Net Carbon*	216 kgCO2/m2
Lifespan	30 years
Cost	$$$



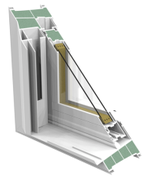
Anodized Aluminum Frame

Net Carbon*	277 kgCO2/m2
Lifespan	30 years
Cost	$$$$



Wood-Plastic Composite Frame

Net Carbon*	200 kgCO2/m2
Lifespan	30 years
Cost	$$$$



Insulated Vinyl Frame

Net Carbon*	249 kgCO2/m2
Lifespan	30 years
Cost	$$ - $$$

High Carbon Materials

4.
Lower your Energy Use

Energy use in existing buildings currently makes up 28% of our global carbon emissions. These emissions come from the energy used to heat, cool, ventilate, light, and provide electricity and water to buildings.

Collectively, these are known as operational carbon emissions. Reducing our reliance on mechanical systems and electrifying our building systems can help us reduce this impact significantly.

WHAT ARE BUILDING SYSTEMS?

Building systems refer to all mechanical, electrical and plumbing components that work together to make a building function properly for people to use and occupy comfortably.

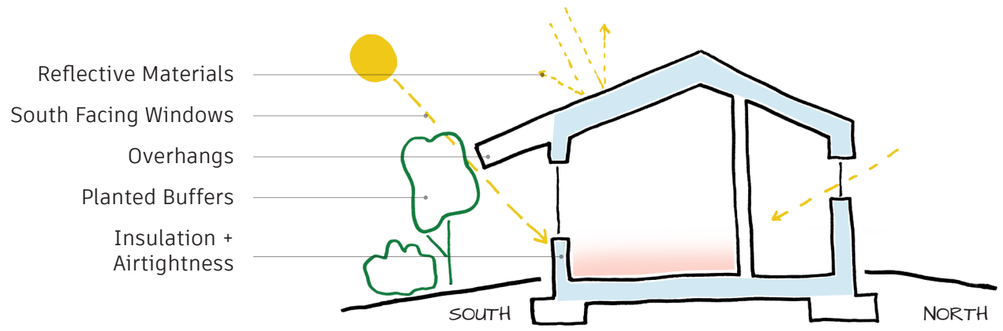
Mechanical Systems include heating, cooling, ventilation and air filtration systems, also known as HVAC.

Electrical Systems act like the central nervous system of the building, taking power from the grid and supplying it to lights, appliances, and all components powered by electricity including security and fire safety systems.

Plumbing systems include domestic hot water tanks, water pipes, stormwater drainage and sewage systems.

WHAT ARE SOME WAYS TO REDUCE YOUR RELIANCE ON MECHANICAL SYSTEMS, TO LOWER YOUR ENERGY NEEDS ?

You can reduce a building's operational carbon by using "passive strategies", which are smart building design choices that don't rely on machines. For example, using good insulation keeps heat inside during winter and outside during summer, so we don't need to use heaters or air conditioners as much. Designing for natural airflow can ventilate the building in mild weather. By reducing the "loads" on heating, cooling, and ventilation systems, we also make buildings comfortable in case of power failures or extreme weather.



"PASSIVE STRATEGIES" CHECKLIST

- ☐ **Compact Building Form**
  A smaller, box-like shape helps reduce the amount of outside surface exposed to cold air, making it easier to keep the inside warm.

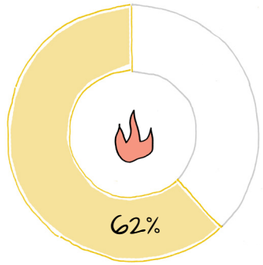
- ☐ **Solar Heat Gain**
  Arrange primary living areas (living rooms, kitchens) and larger windows on the south side to maximize winter solar gain. Bedrooms can be placed on the north side where solar gain is less critical. Limit large windows on the east and west sides of the building, which get strong morning and afternoon sun, which can quickly heat up interiors.

- ☐ **Overhangs and Awnings**
  Add roof overhangs or shades above the windows to let the low winter sun in for warmth, but block the high summer sun to avoid overheating.

- ☐ **Insulation and Air Sealing**
  Make sure the walls, roof, and floors have sufficient insulation, and seal gaps and cracks so that warm air doesn't leak out, and cold air doesn't get in.

- ☐ **Plant Trees and Shrubs as Buffers**
  Use shade trees, green roofs, and planted areas to cool the space around the building. Place trees, bushes, or fences on the windy sides of the building (usually north and west) to block cold winter winds, and help the building stay warm.

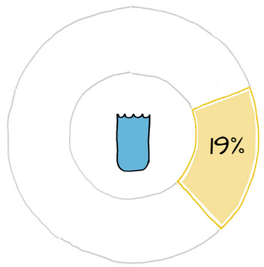
- ☐ **Use Light-Coloured, Reflective Materials**
  As we experience longer and hotter summers, choose light-coloured roofs, walls, and hardscapes to reflect sunlight instead of absorbing it, which keeps the building and surroundings cooler.



IN CANADA, SPACE HEATING MAKES UP 62% OF THE TOTAL RESIDENTIAL ENERGY USE

Here are some ways to reduce the energy consumed for heating your home:

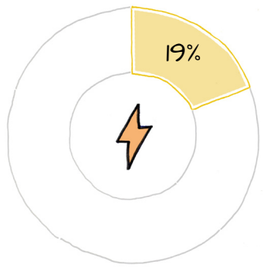
- Upgrade from a gas furnace system to a heat pump system that is more energy efficient and will soon be cheaper to operate thanks to carbon pricing.
- Properly insulate basements, walls, ceilings and attics.
- Improve the airtightness of your home by minimizing air leakage through walls, windows, and doors.



WATER HEATING MAKES UP 19% OF THE TOTAL RESIDENTIAL ENERGY USE

Here are some ways to reduce the energy consumed for heating your home:

- Upgrade from a gas-powered boiler system to a heat pump water heater system that is more energy efficient.
- Install low-flow fixtures on showerheads and faucets.
- Use dishwashers and clothes washers only when their capacity is full.
- Use cold water when possible.



APPLIANCES, LIGHTING AND SPACE COOLING MAKE UP THE REMAINING 19% OF RESIDENTIAL ENERGY USE

These are already powered by electricity, but you can do the following to reduce your consumption as well as save on your utility bills:

- Use heat pumps for cooling in place of air conditioners.
- Use Energy Star certified appliances.
- Use LED light bulbs.
- Use outdoor lights with motion detectors.
- Use multiple switches and light dimmers.
- Turn off unnecessary lights.

WHAT ARE THE SOURCES OF ENERGY THAT POWER OUR BUILDING SYSTEMS?

All building systems are powered by energy. The sources that generate this energy release varying degrees of greenhouse gases and can be broadly classified as "clean" or "dirty." Whether you are on a clean or dirty electricity grid depends on which sources provide the majority of the power, which varies depending which province you are in. You can see out how "clean" or "dirty" your power grid is by looking at the map in Figure 10.

Currently building systems in Canada are mainly powered by:

Natural Gas which is a fossil fuel. While the largest component of natural gas is methane, it also contains carbon dioxide and other hydrocarbons. When natural gas is burnt - typically to heat homes - all these greenhouse gases are released into the atmosphere.

Hydroelectricity is electricity generated by using the energy of moving water. It usually involves water flowing through turbines in a dam or river, which powers generators to produce electricity. It's a renewable and "clean" energy source because it doesn't burn fuel or release greenhouse gases.

Nuclear Energy comes from splitting atoms of uranium, a process which releases a large amount of heat that used to produce steam. The steam spins turbines connected to generators that make electricity. It is considered "clean" because it does not produce air pollution or greenhouse gases like carbon dioxide during electricity generation.

Wood or Biomass contains carbon, which is released as carbon dioxide when wood is burned to heat spaces or water in homes.

Heating Oil is also known as diesel or kerosene, which is derived from petroleum and, therefore, is a fossil fuel. It has a very high carbon footprint.

4. Lower your Energy Use

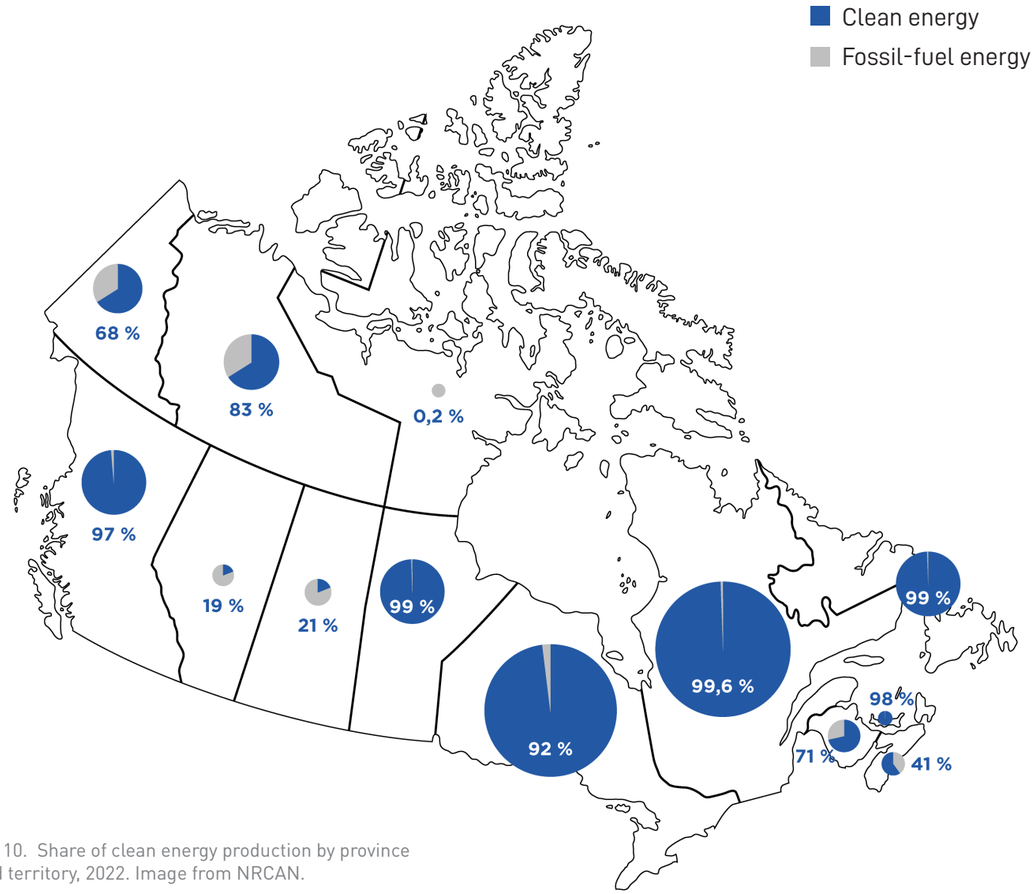


Fig 10. Share of clean energy production by province and territory, 2022. Image from NRCAN.

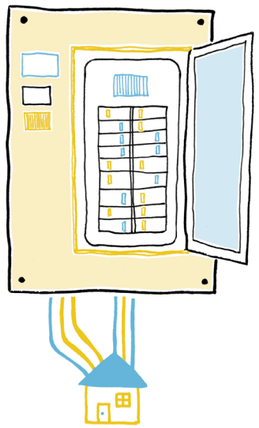
Natural gas, which is commonly used for space and water heating, is the largest source of building sector emissions in Toronto, accounting for 54% of community-wide emissions.

In provinces like Ontario, Quebec, Manitoba, British Columbia, and others that are on a clean electricity grid (see map above), electrifying building systems is a major pathway to reducing operational carbon.

4.a.
Electrify your Home

One of the most impactful ways of reducing your building's operational carbon footprint is to stop using fossil fuels and switch to electric appliances. Even if a province still uses some fossil fuels for electricity, the electrical grid can get cleaner over time.

As more renewables, like wind, solar, and hydro, are added, electric appliances automatically become lower-carbon without needing to be replaced.



WHAT ARE SOME OF THE BENEFITS OF ELECTRIFYING YOUR HOME?

Environmental
Switching to electric appliances helps reduce greenhouse gas emissions. Modern electric equipment is usually more energy efficient than its fossil-fueled predecessors, which means we can get the same services from electric equipment while using less energy. Even if the electricity still comes partly from fossil fuels, the grid is getting cleaner every year, so your home's carbon footprint will get smaller over time, helping fight climate change.

Health
Gas appliances release air pollutants like nitrogen dioxide and carbon monoxide into your home. These can cause or worsen breathing problems, especially for children and seniors. Electric appliances don't produce these indoor pollutants, making your home's air cleaner and safer. On a larger scale, reducing fossil fuel use also cuts outdoor air pollution, which benefits the health of your entire community.

Economic
Electric appliances use less energy to do the same job, which can lower your utility bills in the long run. As more clean electricity becomes available, electricity prices are expected to stay more stable than the price of fossil fuel, which can be unpredictable. There are also rebates and incentives available in many provinces to help cover the cost of switching.

ELECTRIFICATION CAN SEEM EXPENSIVE AND CHALLENGING. WHAT IS THE BEST WAY TO APPROACH IT?

Minimize Upfront Costs
Installing electric appliances like heat pumps or electric water heaters can be costly at first. However, federal and provincial rebates can help reduce these costs. Local governments, utilities, and non-profits are offering more guides, workshops, and tools to help people make informed choices. Speaking with an energy advisor or participating in a home energy audit can also provide tailored advice. Homeowners can also electrify their homes in steps—for example, replacing appliances when they naturally reach the end of their life rather than all at once.

Upgrade Electrical Panels
Older homes may need an electrical panel upgrade or new wiring to handle additional electric loads. To address this, some incentive programs now include support for electrical upgrades. Planning ahead and working with a licensed electrician can make this process smoother and more cost-effective.

Work with a Certified Contractor
Finding experienced installers can be a challenge in some areas. To solve this, look for certified contractors through government or utility programs, which often maintain directories of qualified professionals. As demand grows, training programs are expanding, which will increase access to skilled tradespeople over time.

ARE THERE WAYS IN WHICH YOU CAN AVOID AN ELECTRICAL PANEL UPGRADE?

Demonstrated Load Calculations
In Toronto (and across Ontario), you can have more circuits listed on your panel than its breaker capacity if a qualified person (like a licensed electrician or engineer) performs demonstrated-load calculations under Canadian Electrical Code Rule 8-106(9). Talk to your electrician to find out if this is an option for you.

Energy Management Systems
Ontario has updated its electrical code to let homeowners use energy management systems (EMS) to control how much electricity their home uses at once. This means you can add things like EV chargers or electric heating without upgrading your electrical panel, as long as the EMS keeps your total usage within the panel's limit. It's a smart, cost-saving way to handle growing energy needs at home.

Efficient Appliances
You can choose appliances that provide two functions in one, such as a combined range and stove or a combined washer/dryer, which will use less electrical panel space than separate appliances. Choose more efficient appliances that draw less power - for example, a 120V condensing dryer will require a 15- or 20-amp circuit, while conventional dryers require a 30-amp circuit.

ELECTRIFICATION CHECKLIST

- ☐ Identify what you want to electrify now and what your longer term plans are.

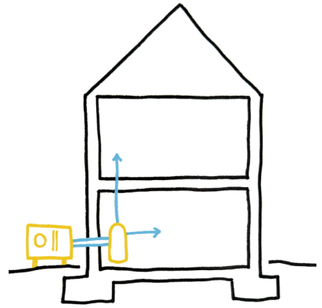
Equipment Type	Typical Lifespan of Gas Equipment	Budget Needed to Electrify
Heating System	15 - 20 years	$$$ - $$$$
Cooling System	15 - 20 years	$$$ - $$$$
Water Heater	10 - 15 years	$$ - $$$
Stove	10 - 15 years	$$ - $$$
Dryer	10 - 15 years	$$ - $$$
Fireplace	10 - 25 years	$$ - $$$
Yard Equipment	5 - 10 years	$$ - $$$
BBQ and Grill	5 - 10 years	$ - $$

- ☐ Check your electrical panels and wiring to assess if upgrades are needed.
- ☐ Consider getting a home energy audit.
- ☐ Explore prices, incentives, and financing options.
- ☐ Get quotes from multiple sources.

4.b.
Heat Pumps

Heat pumps offer the most energy-efficient way to heat and cool buildings. By transferring heat from the air, ground, or water, they use far less energy than systems that generate heat from fuel.

Their versatility makes them suitable for homes with central ducts, radiators, or even those without a traditional heating system.



In hot weather, air source heat pumps operate like air conditioners, pulling heat from inside the home and transferring it to the outside. In colder months, it absorbs heat from outside air and transfers it inside to heat the home.

WHAT MAKES UP A HEAT PUMP SYSTEM?

A heat pump system has two main parts - an indoor air handler unit and an outdoor compressor. The compressor circulates the refrigerant that absorbs and releases heat as it travels between the two units. The indoor unit "handles" or delivers the warm or cool air throughout your home.

WHY CHOOSE A HEAT PUMP SYSTEM?

Maintain a Single System: It provides heating and cooling all in one system. It also means you have only one set of appliances to maintain.

Reduce Carbon Emissions: A new heat pump can reduce greenhouse gas emissions by 46% to 54% compared to natural gas alternatives.

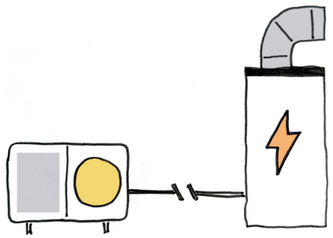
Increase Energy Efficiency: Heat pumps use 300% less electricity than electric baseboards for heating and 50% less than air conditioners for cooling.

Potential Savings on Utilities: Energy efficient equipment like heat pumps require less electricity to operate every month, leading to lower utility bills!

What kind of heat pump system works for you?

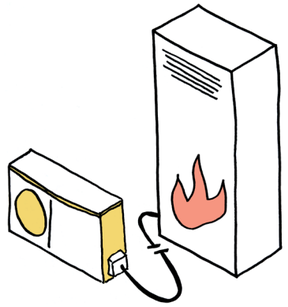
WHEN YOU HAVE AN OLD GAS FURNACE THAT NEEDS TO BE REPLACED ...

You can choose to get off gas heating entirely and opt for a **centrally ducted heat pump system** that connects to the existing ductwork in your home in the same way as a furnace and central air-conditioner. This type of system looks similar to a furnace and air-conditioner and takes up similar spaces in your house. It is the most carbon-positive option for heating and cooling your home, and there are several grants and rebates that can help you with initial installation costs.



WHEN YOU ARE SEEKING A MORE AFFORDABLE OPTION RIGHT NOW ...

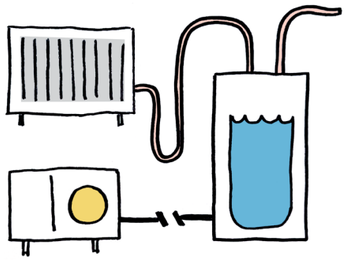
You can opt for a new **hybrid heat pump system** that is used in combination with a new gas furnace. The heat pump is used for all cooling and for heating in temperatures above -5 degrees. In more extreme lower temperatures, the furnace takes over. While this type of system does not entirely eliminate gas heating from your house, installing a hybrid system is cheaper than going all-electric, and will significantly reduce your emissions when compared to an all-gas system. Gas companies, in collaboration with federal and provincial governments, are offering rebates to assist with this kind of upgrade.



Myth 1:

HEAT PUMPS STOP WORKING IN THE WINTER

Contrary to popular belief, modern cold-climate heat pumps can heat a home efficiently even when the temperature drops to -30 degrees. Please consult with an experienced installer to pick the right heat pump model for your climate.

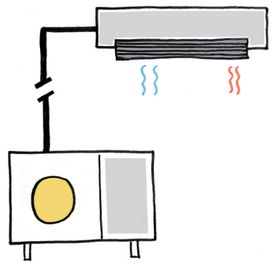


WHEN YOU HAVE A GAS FURNACE WHICH STILL HAS MANY YEARS OF LIFE LEFT ...

You can install a **hybrid heat pump system alongside your old gas furnace.** The heat pump is used for all cooling and for heating in temperatures above -5 degrees, which will significantly reduce your emissions when compared to an all-gas system. However, installing a hybrid system with your old furnace does not qualify for any currently available rebates.

WHEN YOU HAVE A GAS POWERED BOILER AND RADIATORS THAT HEAT YOUR HOUSE ...

You can install an **air-to-water heat pump system**. This heats water in a tank rather than the air inside the home. They are a great option for replacing your gas boiler in homes that have in-floor radiant heating systems that use piped water and a series of radiators to heat the home.



WHEN YOU HAVE TO INSTALL A HEATING AND COOLING SYSTEM IN A NEW ADDITION OR GARDEN SUITE ...

Ductless heat pumps are a great option when there is no existing ductwork inside the home. There are two types of ductless heat pump systems: a "mini-split" system, which has one outdoor unit connected to one indoor unit, and a "multi-split" system, which has multiple indoor units connected to a single outdoor unit that together provide heating and cooling for multiple rooms.

Myth 2:

HEAT PUMPS ARE NEW AND UNTESTED TECHNOLOGY

Heat pump technology has been around for a long time! Heat pumps were invented in 1856 and use the same technology as refrigerators and air conditioners. Heat pump sales in Canada surpassed gas furnaces for the first time in 2021. It is now possible to buy heat pumps at Home Depot, Rona, and other national home supply chains.

Installation FAQs

WHERE SHOULD YOU INSTALL THE OUTDOOR UNIT?

The outdoor compressor unit of a heat pump system should be installed in a space with:

- Sufficient air circulation.
- Space for pipes, ducts, and power cables.
- Access around the unit for servicing and maintenance.
- Location away from windows if possible, to minimize impact of noise and vibrations. Also avoid wall mounting the exterior unit for similar reasons.
- Drainage to manage condensation in the winter months and prevent water from pooling and icing.



Fig 11. Outdoor heat pump unit.

WHERE SHOULD YOU INSTALL THE INDOOR UNIT?

In a centrally ducted system, the indoor unit should be in your mechanical room, where it can connect up with all the ductwork, pipes, or radiators that are heating and cooling your house. It can replace a furnace in a typical location like the basement

In a ductless system, the indoor units are also known as "mini-splits". These can be wall mounted in the specific room or area in the home that requires heating and cooling. These will have an aesthetic impact on your room, so make sure to check placement and alignment and ensure that it works for you visually as well as functionally.



Fig 12. Indoor ductless heat pump, part of a “mini-split” or “multi-split” system.

CAN YOU INSTALL A HEAT PUMP ALONGSIDE YOUR EXISTING GAS FURNACE?

If you have budget constraints or your furnace still has a long lifespan, you can opt for a hybrid heat pump system alongside your existing furnace. In a hybrid system, the heat pump would replace the air-conditioner for cooling and be used for heating in milder temperatures. The furnace would take over for heating in temperatures below -5 degrees.



Fig 13. Electric water heating system.

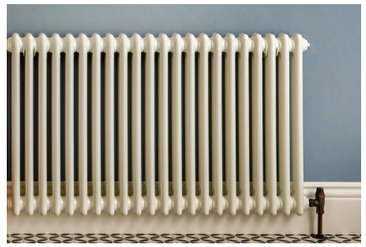


Fig 14. Heat pumps can be used to power an existing radiator system.

WILL YOU NEED TO UPGRADE YOUR ELECTRICITY SERVICE?

Heat pumps can typically be installed in homes with a minimum of 100 amp service. If you are electrifying other systems simultaneously, your installer may advise you to upgrade to a 200 amp service.

CAN YOU USE YOUR EXISTING AIR DUCTS WITH A NEWLY INSTALLED HEAT PUMP?

Typically most existing ductwork can be reused. Your installer will be able to advise you on this based on the size and heating capacity of your system.

CAN YOU INSTALL HEAT PUMPS IF YOUR HOME HAS RADIANT HEATING USING HOT WATER?

Yes, you can install an air-to-water heat pump to replace your gas powered boiler. These typically connect to hot water radiators in your house.

ARE HEAT PUMPS NOISY?

Just like your air conditioning system, your heat pump unit contains various fans and pumps that have a basic level of mechanical noise and vibration. However, current models of heat pumps are a lot quieter than they used to be and, if installed correctly, should not impact you or your neighbours.

- Keep the outdoor unit away from any neighbouring windows.
- Install the outdoor unit behind existing visual and sound barriers like fences, hedges, and garden sheds.
- Install the unit on a solid base such as a concrete pad or block, with rubber pads or dampeners to further minimise vibration.

How much does it cost to install?

- A centrally-ducted air-source heat pump system may cost between $9,500 to $15,000*, after applying eligible rebates.
- A hybrid system with a new furnace and a new heat pump may cost around $7,500 to $ 10,500* after applying eligible rebates.
- A hybrid system with your old furnace and a new heat pump to replace your air conditioner may cost between $4000 - $6000*. However currently there are no incentives or rebates for adding a heat pump to your existing furnace.
- A ductless mini-split that consists of a single indoor unit and cools a single room or "zone" and may cost between $4000 - $6000.*

* These prices are estimates based on prices in Toronto in June of 2025. Pricing for construction is constantly changing! These prices are here to give you a sense of which types of systems are most or least expensive to help you as you consider your upgrades. You should always contact a licensed installer, experienced supplier or consultant for accurate pricing.

HERE IS A LIST OF GRANTS, AND REBATES CURRENTLY AVAILABLE

- Canada Green Homes Grant
- Home Efficiency Rebate Plus
- Clean Home Heating Initiative
- Canada Greener Homes Loan
- City of Toronto's Home Energy Loan Program

* Each grant, rebate or loan program has its own eligibility criteria. Please review these on their respective websites immediately before purchasing and installing a new system since they are periodically updated and you want to make sure that all your choices enable you to get financing.

Myth 3:

ELECTRIC HEATING IS MORE EXPENSIVE THAN GAS

While heat pumps have higher upfront costs than fossil fuel heating systems, in most regions of Canada, they will have lower overall lifetime costs because they are less expensive to operate.

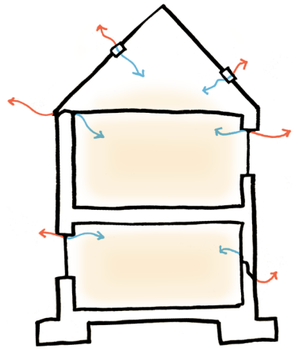
QUESTIONS FOR INSTALLERS

- ☐ Do you use load calculations to determine the size of heat pump needed? Will I require any electrical upgrades to accommodate the new system?
- ☐ Do you assess existing ductwork to determine if changes will be needed?
- ☐ Can I avoid an electrical panel upgrade with a demonstrated load calculation?
- ☐ What is the total cost of the system, and the upfront deposit? What financing options do you offer?
- ☐ Where will you install the outside/inside units?
- ☐ Will you help me program the system and thermostat for maximum efficiency?
- ☐ How long will the install process take?
- ☐ How do you test and ensure the system is working properly?
- ☐ What do the warranties cover and how long do they last?
- ☐ How can I maintain and monitor the performance of the system?

To ensure the most energy-efficient space heating and cooling, it is also advisable to upgrade the insulation and airtightness of your home. You should note that some of these upgrades are necessary to receive a rebate for your new heat pump. Your licensed installer will be able to advise you about the specific additional upgrades that will be required to qualify.

4.c.
Airtightness

Air transports water, moisture, heat, and airborne pollutants. Air leakage in buildings is the unwanted flow of air through gaps, cracks, and openings in the building envelope, which can lead to moisture issues and heat loss in your home. This causes damage to the building, energy waste, and low indoor air quality that affects your health and comfort.



Air leakage also has a significant impact on building energy use. Hot air will escape during winter and infiltrate during summer, making your building systems work harder and increasing energy use and cost.

WHAT CAUSES AIR MOVEMENT THROUGH YOUR BUILDING?

Temperature Differences: Air naturally moves from hot to cold - this means that in winter, heated indoor air will want to leave the building. Air will move through any gaps in the exterior walls and become trapped within the wall cavity. If there is no air barrier (typically located just behind the interior finish), hot, moist air can collect inside the wall and cause condensation, leading to mold issues.

Pressure Differences: In cold weather, the difference in temperature between heated indoor air and cold outdoor air creates a difference in pressure. This pressure can force air out of the top of the building while pulling air in through the lower part of the building. If there are multiple units in your project, this can also cause smells and moisture to move between them.

Wind: Wind movement around a building creates zones of negative and positive pressure around the roof and walls of your project. These draw indoor air out of the building and force outdoor air inside the building.

WHY BUILD AIRTIGHT?

Energy Savings: Building airtight can significantly decrease your energy use, thus lowering your utility bills and reducing your operational carbon footprint.

Moisture Issues: Moisture movement can cause condensation inside the walls of your project, leading to mould and rot. Building airtight will prevent poor indoor air quality, health issues, and long-term damage to the building.

Comfort and Health: Airtightness is not only important in your exterior walls but also in walls between units if there are multiple in your project. Building airtight will prevent odours, noise, contaminants, pests, and even fire from spreading between units, improving privacy and comfort.

WHAT ARE THE PRINCIPLES OF AIRTIGHT BUILDING DESIGN?

Impermeability is the most basic aspect of airtightness. Choose membranes, materials, and methods of attachment that are truly airtight. Most building "membranes" (which may be sprayed on, paper or plastic rolls, or plastic with a sticky adhesive) do not control airflow unless properly installed.

Continuity is the most important part of airtightness. If there are any gaps in your air barrier, there will be leakage. Pay special attention to joints, fastenings (like nails, staples, or screws), transitions (between roof and wall, for example), and anywhere the wall is interrupted (by a vent, pipe, or chimney, for example).

Durability means the air barrier will last for the lifetime of your building. Constantly moving air and changing air pressure will strain this system, which is usually made of relatively thin materials, so this is an important consideration to discuss with your contractor.

Strength and Stiffness are important qualities in an air barrier to withstand the pressure of air movement, especially where they are fastened. This can be achieved using a combination of durable fasteners, tapes, sealants, strapping, exterior insulation, or fully adhered products.

4.c. Airtightness



Fig 15. Sheathing and exterior air barrier systems are the most common for new construction

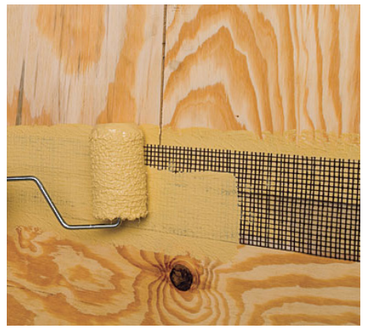


Fig 17. All air barrier systems require sealing any seams, often with tape.

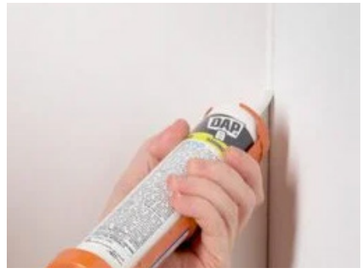


Fig 16. The airtight drywall approach involves sealing all joints and gaps.

Which airtightness approach is best for your project?

Depending on the type of system you choose, it will either be installed by the same construction team building the rest of your project, or by a specialist. Specialized installers are usually only called in for installing membranes below ground, like when waterproofing a basement. But if you choose a newer product, the manufacturer may send someone to help your team work with their system.

EXTERIOR SHEATHING AND EXTERIOR AIR BARRIER MEMBRANE APPROACH

In this approach, the air barrier membrane is applied on the outside of the structure. This membrane is typically a plastic sheet, which sometimes has an adhesive side, and is applied on the exterior sheathing of the building's walls. Any joints, holes, or interruptions in this membrane are sealed using tape, sealants, or adhesive strips. This membrane should be covered by cladding when the building is finished. In this solution, the air barrier membrane is usually also used to resist water.

INTERIOR AIR BARRIERS AND "AIRTIGHT DRYWALL" APPROACH

In an existing building, improving airtightness can be difficult because there is limited access to the insides of walls, where an air barrier would typically be installed. In this case, an "airtight drywall" approach can work, in which the interior finish (usually drywall) is sealed at its joints with tape and rubber caulking sealant to make each room airtight.

Special attention should be paid to make sure every possible gap is sealed, including window frames, outlets, vents, piping, joints where two walls meet, and joints between walls, floors, and ceilings.

SPRAY-APPLIED LIQUID MEMBRANE APPROACH

Spray-applied or roll-on liquid membranes cure into a seamless air barrier with no seams and fewer weak points. Liquid air barriers are especially effective for complicated joints around windows, doors, and other openings. However, these liquid-applied products should be used sparingly since they are typically both higher cost and higher carbon than sheathing membranes.



Fig 18. Spray-applied membrane under installation on a solid masonry wall.

AIRTIGHT SIPS OR ICFS

Structural Insulated Panels (SIPs) and Insulated Concrete Forms (ICFs) are prefabricated building systems that are naturally airtight. SIPs are made of a foam core pressed between two rigid boards, like plywood or OSB, while ICFs are hollow blocks that are filled with concrete. These systems are quick to install and help reduce heat loss by minimizing thermal bridging. However, it's important to carefully seal all the joints and any areas where wires or pipes pass through, in order to maintain airtightness.



Fig 19. SIPs require special design attention at joints to achieve airtightness.

BLOWER DOOR GUIDED AIR SEALING

Blower door-guided air sealing uses a special fan, called a blower door, to check for air leaks in a home during or after construction. Builders use the test to find and seal leaks using materials like caulking, foam, or gaskets. This approach helps ensure the building meets a specific airtightness level, such as 1.0 air changes per hour (ACH50) or lower. However, it requires extra time and careful coordination during the building process.

To combine airtightness with natural ventilation, choose windows or vents that can be sealed tightly when not in use, and position them to support cross-ventilation and stack-ventilation. Integrate this with a mechanical ventilation system, like ERV, to ensure consistent indoor air quality when natural ventilation is not possible.



Fig 20. "Blower tests" are commonly used to measure air leakage using fans.

4.c. Airtightness

AIRTIGHTNESS CHECKLIST

- ☐ Decide on an airtightness approach with your contractor - consider whether this is a renovation or new construction, the number of units in your building, if maintenance will be required, and the ease of construction
- ☐ Design a continuous barrier - are you able to draw a line along a section drawing of your building without lifting your pen? Review this with your contractor and construction team.
- ☐ Identify all of the materials which are part of your air barrier system, and ensure they are compatible
  - ☐ Do they meet the principles of airtight design listed in this chapter?
  - ☐ Will they be stable and airtight through all weather conditions?
- ☐ During air barrier installation, make sure the system does not have any gaps at these important locations:
  - ☐ Below the slab on grade or basement
  - ☐ Below-grade to above-grade (if applicable)
  - ☐ Walls to roof
  - ☐ Windows, doors, or other openings
  - ☐ Interruptions including vents, pipes, or chimneys
- ☐ After the air barrier is installed, make sure there are as few holes as possible made by sub-trades who are installing systems, cladding, or plumbing through exterior walls.

5.
Prioritize Maintenance

Building maintenance means taking care of a building so it stays safe, works well, and lasts a long time. It includes regular tasks like cleaning, checking for damage, fixing small problems, and making sure that building systems are working properly.

By keeping up with maintenance, you can avoid bigger repairs and replacements, save energy, reduce costs, and make the building more comfortable and healthy for the people using it.



Regular maintenance can save up to 40% in energy consumption and cost over the life of the building.

WHAT ARE SOME TYPES OF BUILDING MAINTENANCE?

Routine Maintenance includes everyday tasks like cleaning, landscaping, and painting that help keep the building looking nice and working properly. These regular activities make sure the space stays safe, pleasant, and in good condition for everyone using it.

Preventive Maintenance is upkeep done at regular intervals to stop problems before they start. It includes tasks like cleaning out gutters, checking the roof for leaks, and servicing heating and cooling systems. This kind of maintenance helps keep everything in good working condition and prevents costly repairs later.

Corrective Maintenance involves fixing things when they break or stop working properly. This includes repairing a leaking pipe or replacing a broken window. This type of maintenance is done as needed to restore the building to a safe and usable condition.

HOW DOES BUILDING MAINTENANCE HELP REDUCE EMBODIED CARBON?

Good building maintenance helps reduce embodied carbon by keeping materials and systems in good condition so they last longer. When a building is properly maintained through actions like sealing roofs, repainting surfaces, and preventing moisture damage, there is less need to replace parts of the building. Fewer replacement parts mean fewer new materials are needed, which lowers the overall carbon footprint of the building over its lifetime. Taking care of what is already built helps make the most of the carbon already used.

HOW DOES BUILDING MAINTENANCE HELP REDUCE ENERGY USE AND OPERATIONAL CARBON?

Regular maintenance helps reduce energy use and operational carbon by keeping the building systems in good condition. When heating, cooling, and ventilation systems are regularly cleaned and serviced, they use less energy to do their job. Fixing air leaks, sealing windows and doors, and repairing insulation helps maintain a stable indoor temperature. This means less energy is needed for heating and cooling, leading to a lower operational carbon footprint.

HOW DOES PRIORITIZING MAINTENANCE SAVE MONEY OVER TIME?

Avoid Expensive Replacements by fixing small problems like leaks, cracks, or worn-out parts early. These issues are usually inexpensive to repair, but if ignored, they can turn into much bigger and more costly problems. For example, fixing a small roof leak might cost only $200 to $500, but if the leak causes water damage, replacing the roof and ceiling could cost $5,000 to $15,000.

Extend Equipment Life for HVAC systems, appliances, and plumbing by following a proper maintenance schedule. For example, regular servicing of an HVAC system might cost $150 to $300 per year and can make them last 5 to 10 years longer than if they are not maintained. This means you can defer a much larger investment in replacing a furnace or heat pump, which can cost between $5,000 and $15,000.

Lower Utility Bills by making sure that building systems are running efficiently. Cleaning filters, sealing air leaks, and fixing insulation can reduce energy use by 10 - 30%. For example, sealing gaps around windows and doors can save up to $200 a year on heating costs. Also, fixing leaks and servicing equipment prevents wasted water and electricity, which lowers monthly bills and saves money over time.

Maintain Property Value by keeping the building in good shape and preventing damage. When a property is well cared for, it attracts buyers and tenants, making the property easier to sell or rent. Fixing problems early stops them from becoming expensive repairs that can lower the property's value.



Fig 21. Maintaining brick will prolong its life and avoid larger repairs down the line.



Fig 22. Many repairs can be done easily by owners or residents.



Fig 23. Cleaning is a simple but essential form of maintenance.



Fig 24. Regular HVAC maintenance saves money and energy in the long run.



Building maintenance is an essential and low-cost approach to decarbonization because it keeps materials and systems working efficiently. Properly maintaining your building reduces the need for new materials and saves energy, lowering both embodied and operational carbon without the high cost of major replacements.

6.
List of Resources

This section lists a variety of resources that were referenced in the making of this guide. These include government websites, research papers, reports, and articles from trusted sources. You can reference them to learn more about the topics covered here.

This guide was researched and written between September 2024 and July 2025. Since carbon policies, data, and technologies are constantly evolving some information may become outdated over time. For the most current updates, it's always a good idea to check official government websites or trusted organizations in your community that share reliable, up-to-date information and guidance.

CARBON AND BUILDINGS

National Oceanic and Atmospheric Administration. “What is the Carbon Cycle?”
https://oceanservice.noaa.gov/facts/carbon-cycle.html#transcript

UNEP - UN Environment Programme. “Building Materials And The Climate: Constructing A New Future”
https://www.unep.org/resources/report/building-materials-and-climate-constructing-new-future

World Green Building Council. “Embodied Carbon”
https://worldgbc.org/advancing-net-zero/embodied-carbon/

UK Green Building Council. “What is Operational Carbon in Buildings”
https://ukgbc.org/news/what-is-operational-carbon-in-buildings/

The Atmospheric Fund. “We thrive in better buildings – how a new bylaw could transform retrofits in the GTHA”
https://taf.ca/we-thrive-in-better-buildings-how-a-new-bylaw-could-transform-retrofits-in-the-gtha/

CHOOSE THE RIGHT MATERIALS

Ha/f Climate Design. “Project Planning & Design Primer for Low-Carbon Construction”
https://drive.google.com/file/d/1_zE3Wz8T32VxNIgD4E4ngGLx6VRDYMiY/view

Clean Energy Canada. “Building Toward Low Cost and Carbon”
https://cleanenergycanada.org/wp-content/uploads/2025/04/Report_BuildingLowCostLowCarbon-V4.pdf

Henning Larsen. “Unboxing Carbon - Exterior Materials Catalog”
https://henninglarsen.com/projects/unboxing-carbon

RDH Building Science. “New Design Resources for Embodied Carbon Targets”
https://www.rdh.com/wp-content/uploads/2024/01/RDH_TMU_Embodied-Carbon-Resources-01-30-2024.

Builders for Climate Action. “Emissions of Materials Benchmark Assessment for Residential Construction “
https://www.buildersforclimateaction.org/uploads/1/5/9/3/15931000/bfca_pbc-embarc_report-web.pdf

Government of Canada. “Roadmap to Net-Zero Carbon Concrete by 2050”
https://ised-isde.canada.ca/site/clean-growth-hub/en/cement-and-concrete-canada/roadmap-net-zero-carbon-concrete-2050

6. List of Resources

LOWER YOUR ENERGY USE

Government of Canada. “Energy Fact Book, 2024-2025: Energy efficiency”
https://energy-information.canada.ca/en/energy-facts/energy-efficiency

Net Zero Cities. “Passive building design strategies: building orientation, passive heating and cooling”
https://netzerocities.app/resource-194

Building Decarbonization Alliance. “Canada’s Home Electrification Toolkit”
https://buildingdecarbonization.ca/canadas-home-electrification-toolkit/

City of Toronto. “Incentives & Rebates to Green Your Home”
https://www.toronto.ca/services-payments/water-environment/environmental-grants-incentives/and-rebates-to-green-your-home/

City of Toronto. “Heating & Cooling with a Heat Pump”
https://www.toronto.ca/services-payments/water-environment/net-zero-homes-buildings/heating-cooling-with-a-heat-pump/

BC Housing. “Achieving Airtight Buildings”
https://www.bchousing.org/publications/Illustrated-Guide-Achieving-Airtightness.pdf

Natural Resources Canada. “Keeping The Heat In - Section 7: Insulating Walls: insulating, renovating and building additions”
https://natural-resources.canada.ca/energy-efficiency/home-energy-efficiency/keeping-heat-section-7-insulating-walls-insulating-renovating-building-additions

PRIORITIZE MAINTENANCE

CMHC. “Home Care. A guide to repair and Maintenance”
https://publications.gc.ca/collections/collection_2017/schl-cmhc/NH15-32-2003-eng.pdf

Historic England. “The Role of Maintenance and Repair in a Low Carbon Future”
https://historicengland.org.uk/research/heritage-counts/heritage-and-environment/maintenance-repair/

SGI Canada. “Seasonal Home Maintenance Checklist”
https://sgicanada.ca/documents/37159/2993246/Seasonal+Maintenance+Checklist.pdf/6340d73f-5b5a-df58-ff12-bb6a28bd6d04?t=1712181599816