# Developing Guidelines for Energy Retrofits on Heritage Houses

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## Disclaimer

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organisations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region.

This project was conducted under the mentorship of City staff from the City of New Westminster. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of the City of New Westminster or the University of British Columbia.

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Photo by: Todd Conner

# Acknowledgements

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I also wish to recognize the contribution of the key informants who provided guidance and feedback for this project. Throughout the project, I met with over 15 professionals including City staff, members of the Community Heritage Commission and heritage and energy professionals.

Furthermore, I would like to thank Karen Taylor and the Sustainability Scholar Program for their support and for providing opportunities for students to contribute to real-life initiatives.

I wish to respectfully acknowledge my position as an uninvited guest living on the ancestral and unceeded territories of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish) and səlílwətaʔɬ (Tsleil-Waututh) Nations. The following work was conducted for the place now called New Westminster or the ancestral and unceded territories of the qiqéyt (QayQayt) as well as the Coast Salish Nations. I recognize and respect them as the traditional custodians of the land on which this work was conducted.

There are many culture, values and people that are currently not represented within the built environment. It is important to acknowledge that the built heritage targeted as part of this research only represent a narrow view of the history of the region.

Photo by: City of New Westminster

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# Background

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# 1. BACKGROUND

## 1.1 Context

In 2019, the City of New Westminster officially declared a climate emergency. As part of this declaration, the City set a target to reduce greenhouse gas emissions by 45% by 2030. Improving energy efficiency in residential buildings was among the list of action items that the City identified to achieve this goal. As of right now, in August 2021, buildings are responsible for most of the the municipality's energy consumption. There are currently a few incentives for energy efficiency targeting new houses (e.g., energy step code requirements matched with density bonus). However, existing houses haven't yet been targeted to the same extent.

As B.C.'s oldest incorporated colonial city (1859) and the province's first capital, older buildings represent a large share of New Westminster's building stock. For instance, the City has a Conservation Area composed of over two hundred residential buildings. While they are important community assets that should be protected, these buildings are also "prone to having compromised air sealing from windows, doors, poor or no insulation of walls and inefficient furnaces and water heating appliances" (City of New Westminster, 2011).

For staff, permits related to heritage houses have been particularly challenging as they are often trying to advocate for the preservation of heritage features while stressing the importance of energy retrofits. This work is usually done through Heritage Revitalization Agreements (HRA) or Heritage Alteration Permits (HAP). As part of this process, the City negotiates formal protection of building components such as the original materials and architectural details. Given the number of HRA and HAP projects that the City undertake each year as well as the City's current energy goals, staff believes that there is a strong potential for renovation techniques that can improve energy efficiency while also preserving heritage features.

## 1.2 Project Goal and Objectives

The goal of this project is to gather best practices for "greening" heritage buildings. These findings will inform the creation of a resource guide that the municipality can use to support homeowners and builders during energy retrofits. The focus of this work is on the main part of the City's heritage assets, wood-frame single-detached dwellings that were built between 1880 and 1930. The City already has a solid system in place to implement this kind of resource, as they have published a variety of similar guides in the past. As a result, this research does not target the process of implementing these guidelines, it seeks to identify the most relevant content.

This project is supported by several objectives:

- Understand the current challenges that New Westminster faces in their work to support energy retrofits on heritage buildings.
- Summarize relevant literature on building techniques and approaches for greening older buildings.
- Identify existing guidelines and programs that may be pertinent to the project.
- Develop a preliminary guide for homeowners and builders that incorporate the findings from this research.

### Research questions

To frame this research, the following research questions were identified:

Primary research question: (1) How can the City balance the goals of energy efficiency and heritage conservation?

Secondary research questions: (2) Which interventions would have the greatest impact on the energy efficiency for the targeted buildings? (3) Which interventions are low hanging fruit? (4) How might we present the information in a way that will best support homeowners and builders?

## 1.3 Alignment with City Goals

This project aligns with several City policy goals and actions. The impact of existing buildings on community emission has been recognized by City policies for many years already. The Community Energy and Emissions Plan (CEEP), adopted in 2011, was one of the first policy documents that acknowledged the importance of tackling existing buildings as part of the City's greenhouse gas emissions(GHG) reduction efforts. In 2019, the City also declared a climate emergency. As part of this statement, seven bold steps were endorsed by Council with the goal of moving the City towards a zero-carbon future by 2050. Included in those steps was the reduction of community carbon emissions for all homes and buildings. By 2030 it is expected that all new and replacement heating and hot water systems will be zero emissions (City of New Westminster, n.d).

At the time of this report, as of August 2021, a lot of older homes still use natural gas as their primary source of energy. However, a large portion of these systems are coming to the end of their life span. To reach the City's goal, it is estimated that around 444 residential buildings using natural gas will need to be converted to zero carbon heating every year from now until 2030 (City of New Westminster, 2019). In the Community Energy and Emissions Inventory Report(fig.1), 47% of community emissions were attributed to buildings (residential, commercial, and small/medium industrial).

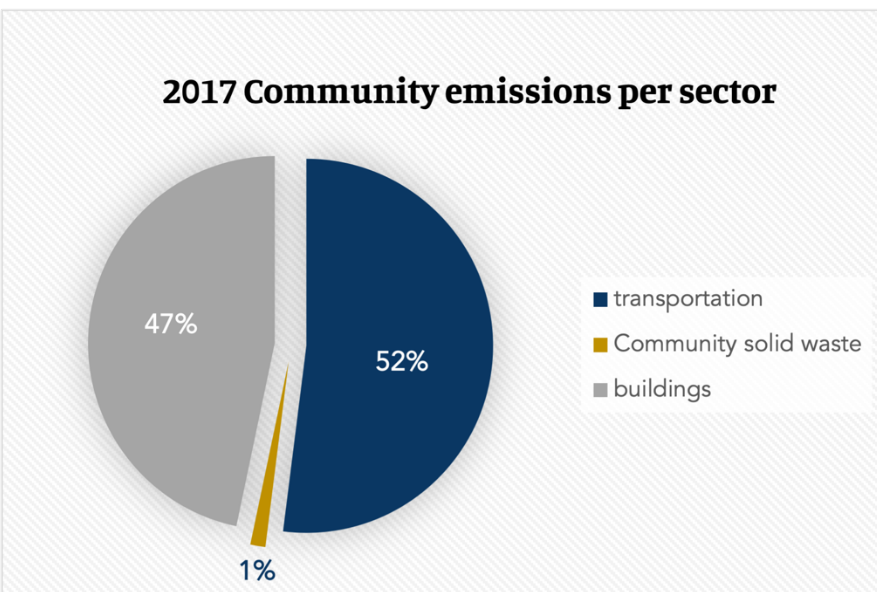



Fig 1. Community emissions per sector
Source: City of New Westminster

In the energy emissions and climate change chapter of the Official Community Plan (OCP), Policy 4.2 is aimed at “achieving continuous improvements in energy conservation, energy efficiency and greenhouse gas reduction for new and existing buildings”. In this section, the City commits to supporting programs “that help advance the technical skills and knowledge of local homebuilders and architects in designing and constructing high-performance, ultra-low-energy homes and communicating the benefits to homebuyers”.

In the heritage chapter of the OCP, Policy 7.1 is “to retain and protect physical heritage assets city-wide”. As part of this policy the OCP states that “the conservation of a place’s heritage value is best done by appropriately protecting and maintaining the entire building and its character-defining elements. Rather than be replaced, deteriorated elements should be repaired using recognized conservation methods. A building’s gradual deterioration over time can make retention and rehabilitation difficult and costly and result in a building being demolished”.

The general perception is that heritage and climate goals are not compatible. This project aims to bring together those two important goals which calls for an interdisciplinary and creative approach.

## 1.4 Approach

A mixture of literature review, site visits and semi-structured interviews helped inform the findings. The work was divided into two phases(fig.2): the research phase and the production phase.

Due to the technical nature of the project, the literature review consisted mostly of governmental reports and builder’s websites. Guidelines with similar goals were also identified and used as sources of inspiration. Particular attention was given to the local climate where these guides were produced as it influences the type of interventions required. Similarly, local construction techniques and materials were also considered.

Interviews were conducted with both staff and professionals from a variety of backgrounds (heritage planners and consultants, energy advisors, inspectors, etc.). The aim of the staff interviews was to understand how the guide might support their work. External interviews helped to identify current best practices and to understand community knowledge on the topic of energy efficiency for heritage houses.

Phase 1. Research and Summary of the Findings

- Main deliverables and activities:
  - Project proposal (May 28);
  - Literature review and interim report (June 21).

Phase 2. Guidelines Development

- Main deliverables and activities:
  - Workshop with the Community Heritage Commission (July 7);
  - Presentation to Development Services staff (July 22 and 27);
  - Final report and guidelines (August 13).

Fig 2. Phases of the project

## Limitations

A few limitations are worth considering that were impactful and unique to each phase of the report's development.

- While energy retrofits on heritage houses are gaining momentum, B.C. is among the leaders of that movement in the Pacific Northwest. As a result, relevant municipal guides were hard to find.
- With only three months to gather findings, this limited the number of interviews that the scholar was able to conduct and the literature that could be consulted.
- Considering the time frame of this project, the scope had to be limited to energy retrofits. Yet, it should be noted that energy efficiency is only a part of a wide range of retrofit approaches meant to target climate change and the built environment. Homeowners and builders might benefit from further information on other approaches such as seismic retrofits on heritage houses.
- Heritage houses can be unique as they were typically modified and renovated over their lifespan. Thus, the findings may not apply to all homes.

# 02.

# Findings

Literature Review • Interviews •
Case Study: The Irving House

# 2. FINDINGS

*[The guide – located in section 3 - reflects the learnings gathered in this section. Not all information appears in the guide and vice versa. Yet, extra information contained in this section may still be valuable to City staff.]*

## 2.1 Literature Review

### 2.1.1 Planning a Retrofit

“Interventions on heritage buildings require special planning as they were constructed from different materials and in different structural forms compared with modern buildings and consequently, they perform differently. Responsible retrofits should provide a net reduction of energy use while also improving the comfort and health of building’s occupant while preserving the house’s original character.” (STBA, 2015).

The literature suggest that retrofit planning efforts for older buildings should take a holistic and comprehensive approach. Often referred to as the Whole Building Approach, this approach involves the integration of the fabric measures (insulation, new windows, draught proofing, etc.) and services (ventilation, heating, controls, and renewables) along with proper consideration for how people live in and use the buildings. These considerations must be coupled with the context of the buildings (status, condition, form, exposure to the sun, rain and wind, neighborhood context, etc.) (STBA, 2015).

Individual and uncoordinated effort will only provide limited benefits and may ultimately require greater expense (D.C. Historic Preservation, 2019). There are complex inter-relationships between the different “thermal elements'' of a building (walls, floors, roofs, windows, etc.), the space heating and ventilation systems, the use of the building and its context. For example, when introducing better-performing windows, air leakage will be reduced, and additional ventilation will likely be needed (STBA, 2015).

## Step 1. Knowing your building

For homeowners, the first fundamental step is to gain a better understanding of their building. They should carefully examine their house's history and evolution over time, its relationship with surroundings and neighboring buildings, its physical aspects such as its materials and assemblies, its character-defining features and its systems and operating functions (D.C Historic Preservation, 2019). It is crucial to understand how the building was originally designed to function with respect to energy (lighting, heating, and cooling systems, building envelope, etc.). Some important themes to consider include:

| | |
|---|---|
| Past and current uses | The type of building, its use, and activities will play a large role in the type and amount of energy used and as a result, the best strategies to implement in a retrofit. e.g., a home-office might use more energy for appliances and heating. |
| Location and orientation | How is the building oriented towards the sun? Where is it located on a block or in relation to its neighbors?<br><br>Location and orientation can influence a property's visibility, sun exposure, shading, potential moisture issue and more. |
| Construction | When was the building constructed and what are its primary materials? Was there an extension or subdivision? etc.<br><br>These changes can affect the moisture movement in the house and may require different interventions. |
| Character-defining elements | Character is defined by the elements that make a building unique or special, including distinctive materials, features, and spaces, architectural styling or design, and unique construction methods or craftsmanship. These character-defining features should be identified during the planning phase and preserved when implementing the retrofit. |

| | |
|---|---|
| Inherently sustainable features | What passive systems and inherently sustainable features exist on the building and what is their condition? Are there passive systems that could be integrated into the retrofit?<br><br>Inherently sustainable features should be identified and incorporated into the overall plan, so they work in cooperation with other strategies implemented. Operable windows and shutters are a good example as they help to control daylight and provide natural ventilation, reducing dependence on mechanical systems and artificial lighting. Porches are another sustainable feature that provide sheltered outdoor living space, take advantage of winds to maximize cross ventilation, and shade exterior walls and windows from the sun. |
| Current systems | How is the house cooled and heated? Forced air, water pipes or steam pipes? Are the existing systems performing properly? Are there any inherently sustainable features that can be taken advantage of for passive heating and cooling? |
| Condition of current features | E.g., maintenance of the windows, the way previous renovations were undertaken and their quality, etc. |
| Heritage | There are various mechanisms in place to protect heritage houses in New Westminster. It is important to be aware of the type of protection that the house falls under as this will affect the type of permits required and might influence the modifications that can or cannot be undertaken. In New Westminster, houses can either be registered, designated or they can be part of a Conservation Area. |

(Sustainable Traditional Building Alliance, 2015; Federal Provincial Territorial Ministers of Culture and Heritage in Canada, 2016 and Town of Concord, 2020)

## Step 2. Evaluate Current Energy Performance

Prior to any retrofit, it is recommended to work with a knowledgeable energy advisor to understand the current weaknesses of the house. Common tests to measure energy losses include:

- Blower door test: This test measures to what extent the house is "airtight". A temporary blower door is installed either on the front or back door. The fan can be used to pressurize the building positively or negatively (either by blowing air into or sucking air out of the building) to identify and measure air leakage locations.

- Thermal imaging: Thermal imaging tests are well-established inspection tools that measure missing insulation and determine locations of air leakage. By displaying the surface temperature of buildings through a camera it locates patterns and heat losses typically invisible to the naked eye. This test can be performed on the interior or exterior of the house.

## Step 3. Develop a Plan

Retrofit strategies can vary considerably in complexity and cost. Given the range of interventions available to homeowners, it is important to develop a coordinated plan based on the current energy performance and the goals of the project (e.g., improving comfort, reducing monthly energy costs, etc.). Something to consider in all retrofits and rehabilitation projects is to use a "minimum intervention approach". As indicated in Parks Canada's Standards and Guidelines for the Conservation of Historic Places in Canada, building's rehabilitation should always consider repairing character-defining elements rather than replacing them. Homeowners who are looking to improve energy efficiency should first ensure the passive design features of the building are as efficient as possible, without making physical alterations (Canada's historic places, 2009).

## Materials Lifespan and Impacts

When considering the approach that you might use to retrofit your building, special attention should be given to materials lifespan and impacts. "Certain materials are intended to be repairable and have a long lifespan such as wood windows. You should try to minimize intrusions, alterations, and long-term impacts to these features." (Town of Concord, 2020). Throughout the retrofit process, if new materials are installed, the best practice is to consider their impact on the environment and health. Original materials should be preserved as much as possible considering their embodied energy (the energy consumed by all the processes associated with the production of the material including manufacturing, transport, and product delivery).

When retrofitting heritage houses, temporary and additive changes should also be prioritized. "Alterations that are temporary or easily reversible have less of a lasting impact on the character of a historic property than changes that permanently change, damage or remove important features (D.C. Historic Preservation, 2019). Some materials might require solvent to be removed, so it is important to read all labels carefully before undertaking a project.

## Financial

When budgeting for a retrofit and energy-efficient upgrades, it is important to consider the long-term savings and ease of maintenance. The initial cost of a product or design is only part of the true cost and homeowners should consider the costs and savings over the lifetime of the upgrade.

It is also worth exploring available financial opportunities. Energy Save New West is a local program meant to support homeowners in the retrofit of their house. They can provide general guidance but also point residents to the most advantageous rebates. For instance, Energy Save can offer energy assessments done by energy advisors for only $75, which represents savings of about $420 (Energy Save New West, n.d.).

### Professional Services

It is generally recommended to seek advice from professionals when undertaking an energy retrofit on a heritage house. Experience is key when working on heritage houses. Thus, before hiring a contractor, it is important to make sure that they have experience working with both heritage and sustainable design.

Professionals typically involved in heritage house retrofits include, but is not limited to:

- Heritage consultant/specialist: Can support your work by helping to identify the features of heritage value on the house. They can also provide guidance on heritage issues and formulate strategies to maintain them.

- Energy advisor: They conduct home inspections and use various methods (e.g., thermal imaging) to analyze the current energy usage and determine ways to make the building more efficient.

- General contractor: Oversee day-to-day activities and manage subcontractors.

- Architect or designer: Usually employed for more major work such as the remodeling of the house. They can design basic to comprehensive renovation and give advice on materials, costs, and process.

## Step 4. Monitor the Performance after the Installation

After performing upgrades, the building should be regularly monitored for its performance to determine how the strategies are working and if adjustments still need to be made in the long-term. Existing buildings must be maintained regularly to preserve their historic character and maximize their reliability, performance, and efficiency (Town of Concord, 2020). A plan should also be developed for the maintenance of the building post retrofit. It is recommended that homeowners identify future dates for work, estimated cost and contact details for relevant tradespeople (STBA, 2015).

## 2.1.2 Retrofit Strategies

### 2.1.2.1 Air Sealing

Reducing air leakage should be one of the first intervention to undertake on a heritage house because it is highly efficient, inexpensive, it requires minimal changes and can address moisture and air quality problems. Because air usually contains water vapor, uncontrolled air leaks can cause condensation and mold, which can also cause damage to the building.

Caulking and weatherstripping it is possible to save 10 percent on energy bills. “Air flows through cracks and gaps in buildings because of wind pressure, mechanical pressure and the stack effect” (fig. 3) (Connecticut Green Bank, 2017). As presented previously, the blower door test can help to detect the most significant sources of air leakage in a house.  Caulk is generally the recommended material to seal air leaks. Spray foams are not recommended for heritage houses, because they are not reversible, thus they are very hard to remove without damaging the original materials.

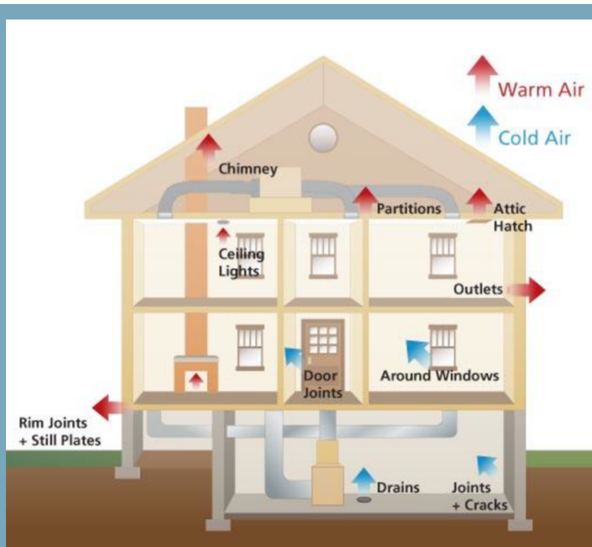



Fig. 3 Stack effect

One of the leading forces of convective losses is the “stack effect” – or heat movement in and out of buildings due to temperature and moisture differences. As showcased(fig.3), in the winter as heat escapes the roof, cold air is sucked through the basement and the first-floor openings. In the summer, the opposite happens. Building height increases the stack effect. Since infiltration and exfiltration forces are more intense at the top and bottom of the building envelope, basements and attic floors should be properly sealed. To prevent the stack effect, seal all cracks in the attic and in the basement.

Source : Connecticut Green Bank, 2017

In order of importance, areas to focus on when air-sealing are:

- Any area that is being insulated - if insulation is added anywhere in the house this is where air-sealing should be added first or else the insulation won't be as performant.
- Target the largest leaks first – such as around the tub, toilet and sink drains and where plumbing supply lines come into cabinets in kitchens and bathrooms.
- Attics – every point of penetration like the fireplace, pipes, vents, the attic hatch and even the top floor ceiling lights.
- Basement – look for cracks in the cement on exterior and foundation walls and seal basement doors, electrical boxes, and all other penetrations. Rim joists can also be sealed if they can be accessed without damaging original materials.
- Main floor – remaining gaps around the windows and doors, mail slots, fireplace damper, outlets.

### Balance Between Air Tightness and Ventilation

Older buildings were designed "to breathe" and sealing them too tightly through air sealing or by adding insulation may create moisture issues that may in turn cause wooden parts to deteriorate. When making a heritage house more airtight, air circulation should be considered at each step. Areas that are particularly humid such as the kitchen should be properly ventilated with range hoods and bathroom fans. Attic and basement are also prone to moisture.

### 2.1.2.2 Insulation

After the house has been properly air-sealed, insulation should also be considered to reduce heat transmission. Just like air sealing, insulation can usually be added without damaging the original features of the house. Houses in the 1880-1930 era were not often insulated or insulated with lower R-value materials like paper, fabric, or horsehair. However, it is common that insulation was added over time as building techniques evolved and homeowners changed. A general recommendation would be to look at the current state of the insulation in places like the attic. Insulation might have been moved, damaged over time, or could even contain toxic materials like asbestos. In that case, it should be removed and remediated by a professional.

Insulation comes in various forms: blanket or batts, loose fibers or granules, rigid boards, spray-applied materials, and more (Connecticut Green Bank, 2017). It is measured in R-value which is a material's resistance to heat transmission. The higher the R-value, the better the insulation. In general, increased insulation thickness will proportionately increase the R-value (Energy Saver, n.d.). Beyond its R-value, special attention should be given to the way the materials perform when exposed to moisture. Some materials buffer moisture (e.g., loose fill cellulose, recycled cotton), and others may trap it (e.g., fiberglass) (Fann,2014). Additionally, reversibility is important to investigate when choosing a material. Spray-foam insulation have been found to be problematic when used on heritage houses because they expand as they cure and can damage historic materials. It is also extremally hard to remove (Connecticut Green Bank, 2017).

Areas to focus on when insulating a heritage house include:

<u>Lowest Risk of Damage</u>

- Attic – the key and most effective place to focus is the attic and not the walls. As heat rises, the attic is where most heat is lost. In unfinished and unheated attics, blown-in cellulose, batt, or rigid foam insulation can be installed between attic rafters, often without professional assistance. There are many areas of the attic where insulation can be added: above the roof deck, below the roof deck or in the attic space below a roof, on the floor between the ceiling joists. It is important to allow for proper ventilation as well and ensure that insulation is not placed over soffit vents (Region of Waterloo, 2017).

- Mechanical system parts - pipework, duct, valves, boilers, and hot water cylinder can be wrapped in insulation.

- Basement – depending on the use and the condition of the basement, different measures will be required. For unconditioned basement focus on the ceiling to keep the living space upstairs comfortable. Insulation can be added to the basement ceiling or between the first-floor joists. For a conditioned basement, keep the heat in that space by focusing on the walls instead. Again, special considerations should be taken to prevent the collection of moisture as these spaces are prone to being damp which can result in rot.

<u>Higher Risk of Damage</u>

- Walls - Wall insulation should be part of a ''whole house'' plan, and should only be considered last, after the insulation of the attics and basement spaces. Half the heat loss in average older houses comes from the attic and basement. Wood-framed walls can be insulated with cellulose or spray foam. Insulation can be blown into the cavity of a wood-framed wall, from the inside or outside. Wall insulation is controversial among preservation expert as it can damage the original plaster walls and woodwork. The loss of historic fabrics needs to be weighed against short-term energy savings because ultimately wall insulation is only a small portion of a whole house energy plan and like window replacement it should be carefully evaluated (Connecticut Green Bank, 2017). They key is to work with an experienced professional to ensure that interventions won't damage the house.

### 2.1.2.3 Windows and Doors

Windows and doors are often a significant element in the character value of the house. Concretely, in New Westminster, wooden windows with ornate trim are authentic part of local heritage (Paulsen, 2014). There is a misconception that to achieve significant improvement in energy retention, windows and doors should be entirely replaced. Old wood windows can almost always be repaired instead and still produce similar results. They are also extremely durable and with good maintenance they can last for a very long time. "Vinyl windows cannot be repaired and since the sealed units must be replaced after 15-20 years, they will cost more over the life of the house than you will save in energy. The original windows have lasted for decades if not centuries and with maintenance will likely last that much longer. Also, even though you can replace your heritage windows with new wooden windows, the quality of your heritage windows' old-growth lumber cannot be replaced." (Vancouver Heritage Foundation, 2019).

The thermal performance of old windows can be greatly improved through simple non-invasive maintenance and rehabilitation strategies:

Regular Maintenance and Repairs:

Ongoing maintenance and repairs will ensure that they continue to operate as designed, avoiding the need for more significant repairs down the road (Ontario Heritage Trust, 2018).

- Removing excess paint built-up, wood treatment and add new paint matching the original color.
- Frequent cleaning.
- Ensuring that windows are well seated and sealed in the envelope.
- If there is weatherstripping on the windows or doors, making sure that it is in good condition.
- Restoration or repair of missing or stuck shutters.
- Repairing or replacing locking mechanisms to prevent excess air and heat loss.

Thermal Efficiency:

- Weatherstripping: Metal weather stripping, such as spring bronze weather stripping, can be added at operable joists to help minimize air infiltration. Strippable caulking can also be used on the inside of the window to prevent air leakage (Ontario Heritage Trust, 2018).

- Wood Storm Windows and Doors: Storm windows and doors are an excellent way to improve efficiency. It can serve as a seasonal or permanent retrofit for existing windows. When installed correctly, they can create an air barrier (with the existing window or door) that has an insulating value. Storm doors and windows should be compatible with the appearance of the original door or window by considering the original material and color. Storm windows and doors should be manufactured to allow moisture to escape to prevent condensation and rot.

- Secondary Glazing: Another option is to add a removable "storm window" on the inside of the building. This can be a good option when exterior storm windows may negatively impact especially attractive windows. They are usually made of plexiglass set in a frame which attaches to windows sash with small magnets or fabric hook and loop fasteners (Connecticut Green Bank, 2017). The primary glazing (interior) needs to be airtight while the secondary glazing (existing window) needs to allow moisture to travel to the exterior to prevent the buildup of condensation (Ontario Heritage Trust, 2018).

To reduce solar heat gains or heat loss, homeowners can install interior blinds curtains or UV window shades. It is also possible to plant deciduous trees at the south and west elevations to block summer sun and allow in winter sun and plant conifer trees at north to reduce the effect of winter winds.

### 2.1.2.4 Mechanical Systems

Energy efficiency can be improved by either reducing heat loss or replacing the source of heat. Mechanical system upgrades are a great way to improve the energy-efficiency of a heritage house as they don't affect the appearance of the house. It is recommended to consider the replacement of the mechanical system when it is close to its end-of-life.

Heating and Cooling System Upgrade: Air-Source Heat Pump

When considering an upgrade of the mechanical systems, air source heat pumps can be a good option to consider as they can significantly improve the thermal efficiency of a house at a reasonable incremental cost. As their name suggests, air-source heat pump extract heat from outside air and releases it into a building using electricity. In the summer the opposite happens where the pump will move hot air out of the building. They provide clean heating and cooling because they do not create heat, they move existing heat in the outdoor to the inside of the building.

Air-source heat pumps can also serve as a primary heating system. They provide heating, cooling, and dehumidification in a same system (Town of Concord, n.d.). Compared with conventional electrical systems, heat pumps can produce up to 4 units of heat for every 1 unit of electricity. As a result, they can offer considerable savings on homeowner's energy bills. They are well suited for climates that do not experience extended periods of sub-freezing temperatures and are ideal for the Vancouver climate (Fann, 2014).

There are two main types of air-source heat pumps: ducted or ductless(fig.4). "Ducted systems have an outdoor unit (like a central air conditioner), which is connected to an indoor air-handling unit that connects to the house's ductwork. Ductless systems work with a main outdoor unit that connects to one or more indoor units ("or heads"). Heads typically serve one room or area of the house (Town of Concord, 2020).

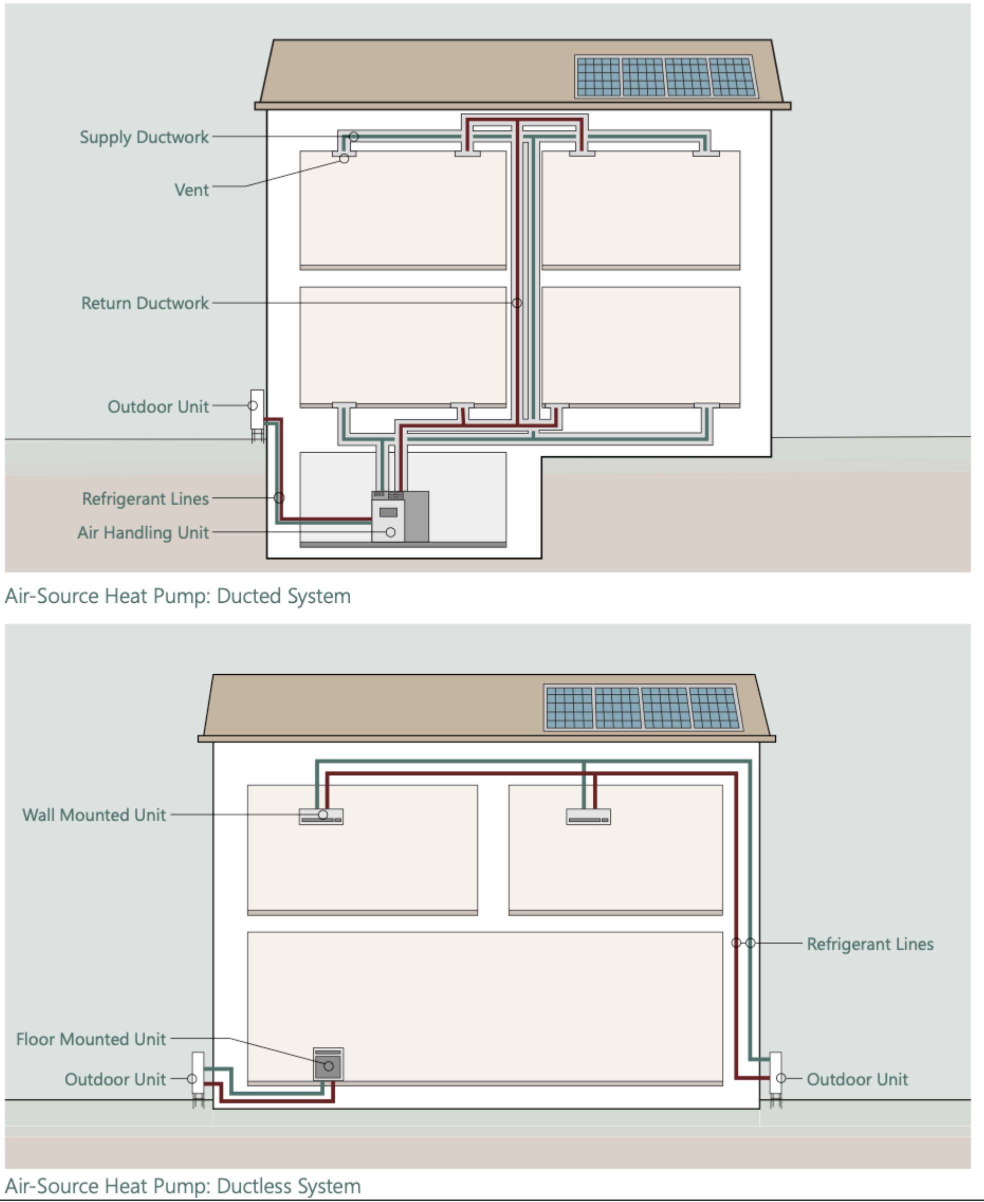



Fig.4 Visual comparison between ducted and ductless system
Source: Town of Concord, 2020

Air-source heat pumps can adapt to many houses. For instance, a building that might already has ducts can install a ducted heat pump at a lower cost. Houses can be outfitted with a combination of ducted and ductless systems to allow for a custom configuration that meets the house’s needs (Town of Concord, 2020). The cost of air-source heat pumps has been going down in price in recent years.

Water heater upgrade:

Another intervention to consider is to upgrade your domestic hot water system to an energy efficient model. There are a variety of energy-efficient water heaters. Condensing units are an example of high efficiency boiling system as they recycle their heat through a double exchanger system. Heat pumps can also be used to provide domestic hot water, or the water used for washing and bathing. They are more performant than electric resistance models (Smarter House, n.d). Heat pump water heaters are available with built-in water tanks called integral units, or as add-ons to existing electric resistance hot water tanks.

### 2.1.2.5 Behavioural Strategies

Older houses were built with the goal of residents being an integral part of their cooling and heating “system”. In fact, during their conception, designers and architects considered that inhabitants would regularly adapt their habits to fit the design of the house. These practices have mostly been lost today in our culture as we generally expect houses to “regulate themselves”. It is possible to make a heritage house much more comfortable by considering little changes in our habits. Heritage homeowners should consider the following:

- “Lower the thermostat in the winter, raise it in the summer, and use a programmable thermostat to modify temperatures on occupancy patterns.
- Control the temperature in rooms that are used and establish climate zones throughout the building with separate controls (if possible) so that unused rooms are not actively conditioned.
- Reduce the number of lights used, maximize natural light, and switch light bulbs to light emitting diodes (LEDs).
- Use operable windows, shutters, awnings, and vents as originally intended to moderate the interior temperature.
- Monitor occupant behavior regarding energy and modify if necessary. Simple things like turning off lights when leaving a room saves energy and money that can be invested in other energy-saving upgrades.” (National Trust for Historic Preservation, 2009).

## 2.2 Interviews

Considering that energy retrofits on heritage houses are influenced by the local context such as traditional building techniques, climate or material accessibility, key informants' interviews were completed to gather further insights on the following themes:

- What are some traditional building techniques used for houses of that period in New Westminster?
- What are some common misconceptions when it comes to heritage houses and energy efficiency?
- What are the retrofit techniques that they typically recommend?
- What is the best way to advocate for balance between energy efficiency and heritage conservation in the guidelines?

From these interviews, key points emerged which led to the creation of the guidelines and are summarized below.

### Heritage Houses are Inherently Sustainable:

- Heritage houses were built using local materials. The bulk of the building including local lumber, plaster, concrete, stone, and glass was all local (apart from some bricks and metal insertion that were imported).
- Original materials were built to be easily repaired and maintained. Understanding the original repair techniques is key. For instance, original wood windows were meant to be painted not stained and staining might not last in the wet climate of the Pacific Northwest. Interviewees also emphasized the importance of preparing a maintenance plan where you monitor past and future work.
- A common misconception with regards to older houses is that their architectural features were decorative. Homeowners should seek to understand the role of each

element as they generally served a purpose. New constructions have a greater tendance to build for the aesthetic purposes.

- One reason why heritage houses don't perform as well from an energy standpoint, is because of a change in culture. Nowadays, houses are built to require very little work from its inhabitants as they can be regulated electronically. Heritage houses were built to require human interventions (e.g., use double-hang windows to ventilate, dress for the temperature in the house, changing curtains twice a year, etc.).

## Energy Retrofits on Heritage Houses Need to be Planned Differently:

- The building should be perceived holistically with many interrelations and connections. It is crucial to use this approach or else interventions may conflict with the original system of the house (e.g., forced air system in a house made for radiant heat).

- There is an ideal timing to do an energy retrofit. Given that a minimal intervention approach is preferred, homeowners might want to make energy efficiency retrofits as part of another major renovation. For example, during a basement remodeling, it is possible to add insulation on the ground floor joists.

- Reversibility is key. Sometimes homeowners might want to add weatherstripping materials that are currently on trend such as silicone or resin. However, these materials are very permanent and might end up damaging the original materials.

## "Low-Hanging Fruits" Retrofit Techniques:

- Air-sealing and adding insulation in the attic was considered by a few interviewees as "low-hanging fruit". It is an area of the house that typically loses a lot of energy since warm air rises and interventions in the attic don't require any invasive methods. A lot of older houses already have insulation in the attic but over time it might have moved and could be unequally distributed.

- Updating the mechanical system could also be considered as low-hanging fruit. Given that all houses eventually need to change their system and that heritage houses will never be as airtight as newer houses, installing a high-performance system like a heat pump, can considerably upgrade the house's performance and reduce community emissions.

- Regarding mechanical system upgrades, one interviewee pointed out that houses in the region from the 1880-1930 era were made for radiant heat systems. As a result, more modern distribution systems such as "forced air systems" tend to not perform as well in older houses. They tend to blow hot air towards the cold surfaces of the house like windows and doors. This highlights the importance of knowing what type of system your house was built for.

## Repair and Maintain Original Windows:

- One of the biggest misconceptions in the industry is that vinyl windows are performing better than wood windows. Wood windows are practically indestructible and can last for a very long time if owners perform regular maintenance like ensuring that locks and mechanisms are functioning properly.

- All interviewees acknowledged that storm windows (both interior and exterior) are among the best techniques to prevent drafts as they are very effective, and they don't negatively impact the appearance of the house.

## Beware of the Risk of Insulating Older Houses:

- Interventions can easily cause harm to the house both from a heritage protection and energy-efficiency perspective. Adding insulation in the walls, for instance, can be complex because it might disturb the air barrier and create mold issues. When considering a significant intervention, homeowners should seek the advice of a professional.

## 2.3 Case Study: Irving House Museum


Fig.5 Irving House Museum
Source: Paul Fuoco

Irving House is a two-storey wood framed colonial house built in 1865. It is the oldest intact house in the Lower Mainland. Multiple generations of the Irving family occupied the house until they sold it to the City to serve as a museum in 1950. Today, the museum holds a collection of artifacts belonging to the original owners. As one of the few houses of that era remaining in B.C., Irving House is a rare demonstration of mixed gothic features and represent an invaluable opportunity to learn about the daily life of New Westminster's wealthiest residents during the early stages of the colonisation (McCullough, n.d).

Fig.6 Wallpaper degradation

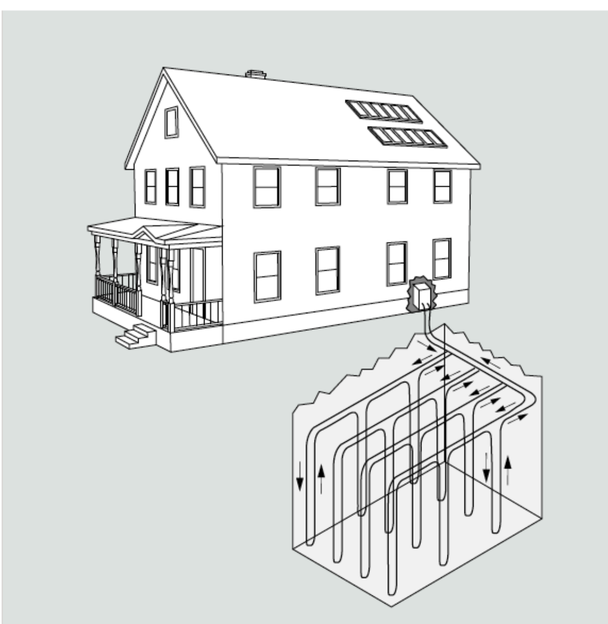


Fig.7 Vertical Closed Loop System
Source: Town of Concord

One of the incentives for the energy upgrade was the degradation of the wallpaper as showcased on fig.6. The environment is of great importance for the ageing stability of paper and high temperature and humidity can accelerate the breakdown process. As a result, improving the stability of the environment was crucial. The updates would also contribute to the preservation of the artifacts in the house given that they need to be kept in a dry environment.

## Restoration Plan

Museum staff started planning for the restoration in 2008 with support from various professionals including a team of architects, mechanical engineers, energy advisors and heritage specialists. A report by mechanical consultants (DEC Design, 2010) recommended that the Irving House be retrofitted using a ground source heat pump with vertical closed loops. The main reason why the vertical closed loop system was recommended is that the house doesn't have a large landmass and this system doesn't require a lot of space compared with other ground source heat pumps.  The consultant estimated that energy savings of about 60% could be achieved with this update.

Ground source heat pumps are highly efficient systems that take advantage of the relatively stable temperature in the ground, transferring hot air to the building in the winter and cold air in the summer. A closed loop system uses a continuous

Fig.8 Blown-in cellulose insulation in the attic

Fig.9 Batt insulation and foam board on the door

loop of buried polyethylene pipe. The pipe is connected to the indoor heat pump to form a sealed, underground loop through which an environmentally friendly antifreeze and water-solution is circulated. (Water furnace, 2021). The great advantage of this technology is its reliance on naturally produced heat, rather than producing heat by burning fossil fuels (DEC Design, 2010).

### Insulation and Air Sealing (2011-2012)

Insulation and air sealing were the first energy measures to be implemented. Considering that most heat loss could be attributed to the attic and crawl spaces, interventions were focused in these areas. Blown-in cellulose was added all over the attic space(fig.8). Similarly, insulation was added in the space below the dormer windows using batt and a piece of foam to seal the door(fig.9). Window frames and gaps were also sealed.

Staff and consultants decided to exclude the option of insulating the walls as they were worried that wall insulation may lead to rot in the original lath and plaster wood walls.

Fig.10 Hidden pipes in the second-floor bathroom

### Mechanical System Upgrade (2013-2014)

For the mechanical system update, the City followed the recommendation of DEC and upgraded to a ground source heat pump. A forced air distribution system using ductwork was installed in the crawl space and attic.  The pipes were carefully run through the house to preserve its integrity. For example, in areas where it was challenging to hide the ductwork, contractors build boxes using the same material as the original wall(fig.10). Overall, eight heat pumps and seven thermostats were installed around the house and cover all rooms of the house. The house also has a backup electric heating system.

### Exterior Upgrades (2016)

In 2016, the exterior of the house was restored. The exterior walls were painted in a lighter turquoise to prevent heat gains in the summer. Most of the building envelope was found to be in very good condition showcasing the durability of historic materials like local timber. The only area that required more intensive restoration was the embellishments that had started to rot.

### Outcomes

Overall, the retrofit greatly contributed to the maintenance of the home. The comfort of the house was improved with a stable year-long temperature of around 19-21°c. Dust accumulation was also reduced due to the installation of filters in the new HVAC system. Following this retrofit, the temperature of the house became much more stable and further conservation work could be performed including the repainting of areas of the wallpaper that were damage. Today Irving House serves as an excellent example of a successful energy upgrade that was respectful of original architectural features.

*For more photographs, please refer to Appendix II.*

Photo by: New Westminster Heritage Foundation

# 03. Conclusion

# 3. CONCLUSION

As one of the biggest energy consumers in New Westminster, existing buildings can play a major role in tackling GHG emissions. To support this goal, this report attempts to fill a gap in current best practices in the field of energy retrofits on heritage houses. Through the creation of these guidelines, it is our hope that heritage homeowners in New Westminster will be better equipped and feel inspired to undertake energy retrofits. Homeowners should take pride in living in houses that have successfully served many families before them and be enthusiastic about the work that they are doing to make it better for future generations.

As showcased in this report, energy retrofits on heritage houses can be done at a relatively low cost while still protecting authentic features and materials. A preferred approach for planning a sustainable retrofit was discussed followed by a variety of strategies that have been proven to achieve desirable outcomes. The whole building approach was presented as a necessary part of all good retrofits given that building operate as a system with complex interrelations. Four steps were identified to guide homeowners in the process ranging from understanding the building to performing post-retrofit monitoring. Findings from interviews, literature review, and case studies suggested that retrofits can fit in four main categories: air-sealing, insulation, windows and doors, and mechanical system. Overall, experts recommend targeting the lowest impact easiest measures first such as air-sealing and insulating. Spaces like the attic and basements are often mentioned as they are prone to significant energy losses.

Ultimately, homeowners should remain conscious that heritage houses are unique and while this report showcases "generalized best practices", it is always preferable to work with an experienced building professional. Furthermore, this report only discusses one area of interventions that can help to make houses more resilient. Future relevant area or research or guide may include interventions on disaster risk management for heritage buildings or fire-resiliency.

Photo by: Paul Fuocco

# 04. References and Appendix

# REFERENCES


Canada's Historic Places (2010). Standards and Guidelines: For the Conservation of Historic Places in Canada. https://www.historicplaces.ca/media/18072/81468-parks-s+g-eng-web2.pdf

City of New Westminster (2019). Community Energy and Emissions Inventory Report.PDF

City of New Westminster (2011). Community Energy and Emissions Plan. https://www.newwestcity.ca/database/rte/files/NewWest%20CEEP%20Final.pdf

Connecticut Green Bank (2017). A Practical Guide for Homeowners. https://portal.ct.gov/-/media/DECD/Historic-Preservation/03_Technical_Assistance_Research/Energy-Efficiency-in-Connecticut_Text-3-2020.pdf

D.C. Historic Preservation Review Board (2019). "Sustainability guide for existing and historic properties"https://planning.dc.gov/sites/default/files/dc/sites/op/publication/attachments/Sust ainability%20 Guide%20for%20Existing%20and%20Historic%20Properties.pdf

DEC Design (2010). Irving House: Restoration HVAC Assessment Interim Report. PDF

Energy Save New West (n.d.). Existing Homes. http://www.energysavenewwest.ca/existing-homes/

Energy Star. (n.d.). "Sealing the Attic Hatch or Door". https://www.energystar.gov/campaign/seal_insulate/do_it_yourself_guide/sealing_air_leaks_attic/attic_hatch_or_door

Fann, D (2014). "Greening a Heritage Building". City of Vancouver. Sustainability Scholars Program, UBC. https://sustain.ubc.ca/sites/default/files/2014-07_Greening%20a%20Heritage%20Building_Fan.pdf

Federal Provincial Territorial Minister of Culture and Heritage in Canada. (2016). "Practical Guideline for the Sustainable Rehabilitation of Buildings in Canada". https://www.historicplaces.ca/pdf/Building%20Resilience.pdf

Historic England. (2017). "Traditional windows. Their Care, Repair and Upgrading."https://historicengland.org.uk/images-books/publications/traditional-windows-carerepair-upgrading/heag039-traditional-windows-revfeb17/

Historic England. (2017). "Energy Efficiency and Historic Buildings". https://historicengland.org.uk/images-books/publications/eehb-heat-pumps/heag172-heat-pumps/

McCullough, R. (N.D). "Irving House Museum (1865)". https://newwestheritage.org/m-irving-house/

Morrison, D (2010). "The stack effect: when buildings act like chimneys". https://www.greenbuildingadvisor.com/article/the-stack-effect-when-buildings-act-like-chimneys

National Trust for Historic Preservation. (2009) "Energy advice for owners" https://archive.epa.gov/region5/sustainable/web/pdf/energy-advice-for-owners-of-older-homes.pdf

Paulsen, M. (2014). "Energy Retrofits for Older Buildings". Presentation for the City of New Westminster.

# REFERENCES


Peter Meijer Architect, PC. (2017). "The challenge of insulating historic buildings" https://pmapdx.com/blog-pmafindings/1224/the-challenge-of-insulating-historic-buildings

Region of Waterloo (2014). "Practical Conservation Guide for Heritage Properties" https://www.regionofwaterloo.ca/en/resources/Practical_Guide_Insulation_2017-access.pdf

Ontario Heritage Trust (2018). "Windows Rehabilitation and Restoration Guidelines for Heritage Conservation to Reduce Greenhouse Gas Emissions". https://www.heritagetrust.on.ca/user_assets/documents/2018-12-Heritage-Windows-Info-Sheet.pdf

Smarter House. (n.d.). "Replacing your Water Heater". https://smarterhouse.org/water-heating/replacing-your-water-heater

Sustainable Traditional Building Alliance (2015). "Planning Responsible Retrofits of Heritage Buildings".http://www.sdfoundation.org.uk/downloads/Guide-1-Planning-Responsible-Retrofit-2015-08.pdf

Town of Concord. (n.d). "Air Source Heat Pumps Rebates." https://concordma.gov/1873/Air-Source-Heat-Pump-Rebates

Town of Concord. (2020). "Concord's sustainability guide for historic and older homes." https://concordma.gov/DocumentCenter/View/26195/Sustainability-Guide-for-Historicand-Older-Homes

US EPA, OSWER, & Office of Brownfields and Land Revitalization. (2009). Sustainable Solutions for Historic Houses in Northern California.

Vancouver Heritage Foundation. (2019). "Design criteria for wood windows." https://www.vancouverheritagefoundation.org/wp-content/uploads/2021/05/Wood-window-design-criteria_May-2021.pdf

Vancouver Heritage Foundation. (2021). "Heritage Energy Retrofit Grant Program. Criteria for Storm Window Grant". https://www.vancouverheritagefoundation.org/wp-content/uploads/2021/03/HERG-Storm-Window-criteria-May-2018.pdf

Vancouver Heritage Foundation. (2009) "New Life Old Buildings".https://www.vancouverheritagefoundation.org/wp-content/uploads/2021/02/VHF-GreenGuidewebbook.pdf

WaterFurnace. (2021). Geothermal Heating & Cooling. https://www.waterfurnace.com/literature/collateral/br-1521mw.pdf

# APPENDIX I. Guide

NEW WESTMINSTER

New Westminster is committed to reduce greenhouse gas emissions by 45% by 2030 (from 2010 level). To achieve this goal, all buildings will need to improve their energy consumption including heritage buildings as they are prone to having compromised air sealing from windows, doors, poor or no insulation of walls and inefficient furnaces and water heating appliances, all which can be improved. Though, higher energy efficiency is important, the character-defining elements of these homes are too, and should also be preserved.

**CARBON FREE HOMES AND BUILDINGS**

The City of New Westminster has established seven bold steps in the 2020 Climate Action Framework. Among those steps is to "*significantly reduce community carbon emissions for all homes and buildings. By 2030, all new and replacement heating and hot water systems will be zero emissions.*"

## Sustainability and Heritage Conservation

There is a misconception that the principle of sustainability and heritage conservation are not aligned. Maintaining heritage homes can actually contribute to sustainability by fulfilling the three pillars of sustainable development. Some of the benefits include, but are not limited to:

**Environmental:**
Preventing materials from being prematurely relocated to landfills.

**Socio-cultural:**
Reinforcing our sense of community and preserving connections with the past.

**Economic:**
Increasing property value through maintenace and improvements.

*New Westminster has a diverse range of high-quality heritage houses including a collection of Victorian (Pre-1900), Edwardian (1900-1920) and some Period-Revival era buildings (1920-1940).*

# Planning a Retrofit

Beyond selecting retrofit interventions, it is equally important to define project goals and develop a coordinated and educated approach. Four main steps are crucial for a successful energy intervention.

**STEP 1.**
Know your buildings
(page 2-4)

**STEP 2.**
Develop a plan
(page 4 - 5)

**STEP 3.**
Do the work
(page 6 -10)

**STEP 4.**
Monitor the performance
(page 10)

Modifying a heritage building can be complex and to ensure that they are successfully retrofitted, it is recommended to keep the following provisions in mind:

**Minimal Interevention Approach:** Minimally invasive solutions should always be prioritized especially for building features that contribute to the character of the house.

**Whole Building Approach:** Buildings operate as a system and should be considered as a single unit. For example, if you insulate a wall, it might also affect the windows, the floors, roofs and the internal air quality. Junctions and connections are particularly affected, but so are systems such as ventilation and heating.

**Reversibility:** Newly develop materials have not been around long enough for us to know their long-term impacts on older materials or buildings. Insulation or air sealing techniques that are not reversible might be difficult to remove without causing damage to historic building materials. Spray-foam or foam-in-place insulation is an example of insulation types that are not recommended for older buildings given that they may trap moisture and bond thightly to building materials.

**WHAT IS AN ENERGY RETROFIT?**

The process of improving a building's energy performance through technical interventions and improve the comfort and quality of the space in terms of natural light, air quality, temperature and cost of operation.

## STEP 1. Know your Building

Before initiating an energy retrofit, it is fundamental to gain a better understanding of your buiding and its evolution over time:

| Themes | Why is this important? | Relevant questions |
|---|---|---|
| Location and Orientation | *Location and orientation can influence a property's visibility, sun exposure, shading, potential moisture issues and more.* | *How is the building oriented towards the sun? Where is it located on a block or in relation to its neighbours?* |
| Construction | *Depending on the material and past alterations a different approach might be required.* | *When was your building constructed and what are its primary materials? Were there any alterations over time? What type of windows does the building have and how do they function?* |
| Character-defining elements | *Character is defined by the elements that make a building unique or special, including distinctive materials, features, design, and unique construction methods. These elements should be identified and preserved if possible.* | *What are the unique character-defining features on my building?* |
| Current systems | *Your heating, ventilation and air conditioning system(HVAC) are a crucial part of your home's energy performance as it dictate how energy is produced and the way it is distributed around the house.* | *How do you heat and cool your house? What distribution system do you use - forced air, steam radiant, hot water? Are your existing systems operating effectively? Do you have any inherently sustainable features that you can take advantage of(see p.3)?* |

| Theme | Why is this important? | Relevant questions |
|---|---|---|
| Inherently Sustainable Features | *Older homes have inherently sustainable features, given they may have been built before electricity, lighting and powered heating and cooling. They were designed to take advantage of natural elements like daylight, ventilation, and solar orientation. These types of features should be identified and maintained when they exist.* | *What passive systems and inherently sustainable features exist on your building and what is their condition? Are there passive systems that could be integrated into the retrofit? In what conditions are these features?* |

Inherently sustainable features include:

**Building Materials** - Local materials such as wood are extremally durable, organic were commonly used historically. They can be easily recycled.

**Windows** - The location and size of windows in heritage homes were chosen to optimise ventilation and control heat gain. In northern climate, windows were often smaller. Original windows were meant to take advantage of passive ventilation. Double-hung windows, for instance, have operable sashes that offer control over wind movement through the building.

**Attic Vents** - Attic vents and dormer windows help to circulate air, keeping a building cool and reducing moisture build-up. Dormers can also improve the functionality of attic spaces by allowing light and increasing space.

**Porches** - Porches provide shade on exterior walls and increase air circulation. They also allow windows to be open regardless of the weather conditions.

**Landscaping** - Traditional builders often considered the tree canopy when chosing a building site as landscaping can improve interior conditions by minimizing energy use providing shade in the summer and sun in the winter. Planting trees around buildings can reduce cooling needs by up to 30%.

**TREES AND ENERGY SAVINGS**

Strategically planting the right tree at the right space can change the temperature in a house, providing energy savings. For example, larger deciduous trees such as maples may be planted on the west and south facing sides to offer shade in the summer. As they lose their leaves in the fall, sunlight can warm the home.

*Porches were designed to cool off exterior walls, allow windows to be opened all year long and provide a sheltered living space.*

*Source: Zysblat, Schueck, Atkin, Gilbert, Hageomen, Toews*

| Theme | Why is this important? | Relevant questions |
|---|---|---|
| Current energy performance | *Prior to conducting an energy retrofit, it is recommended to work with an energy advisor to understand the current weaknesses of your building envelope and systems and identify where energy is lost.* | *What are the main areas where your home is loosing heat?* |


*Thermal imaging*
*Source: Polaris*

Commonly used methods to test energy performance include:

**Blower door test** - Measures to what extend a building is "air thight". A temporary blower door is installed either on the front or back door. The fan can be used to positively or negatively pressurize the building.

**Thermal imaging** - The surface temperature of buildings is displayed through an infrared imaging and measurement camera to identify where heat is leaking from a building.

# STEP 2. Develop a Plan

Retrofit strategies varry considerably in complexity and cost. Given the range of interventions available, it is important to develop a coordinated plan based on the current energy performance and the goals of the project. There are circumstances when an upgrade might make the most sense. For instance, when a current HVAC system is about to reach its end of life, it can be a good time to consider upgrading to a more efficient and less polluant system such as a air source heat pump (see page.9). Energy updates can also be added as part of another major renovation project like renovating a basement which represent an opportunity to add a better heating system or insulation.

## Consider Materials Lifespan, Impact and Long-Term Cost

Unlike some contemporary products, older materials and assemblies, including wood windows have a very long lifespan and are repairable. Best practice is to minimize intrusion and conduct regular maintenance.

Similarly, repairs on inherently sustainable features first as their have a high potential to provide energy savings. Enviromental considerations can also be added to the selection of products by using locally sourced materials and services when available.

The long-term savings and ease of maintenance are also important to take into account when budgeting for a retrofit. The upfront cost of a product or design is only part of the true cost. The cost and savings over the lifetime of a new material or system should be considered.

**FINANCIAL OPPORTUNITIES**

There are a wide range of ressources and funding opportunities available to homeowners seeking to perform energy updates. Energy Save New West offers rebates on energy assesments and access the latest utility rebate. energysavenewwest.ca/existing-homes/

## Examine and Evaluate Potential Solutions

Typical solutions include air sealing and adding insulation. Both can be done without compromising a building's historic value and are therefore the most improtant interventions to consider before any other upgrades. Beyong strategies for air sealing and insulation, newer HVAC systems can also be considered as they increase comfort and they can generate more heat and cold with less energy consumed. These strategies are further explained in the next pages.

!! Beware of hazardous materials like asbestos.

**Chimney** - insert a chimney damper or balloon into the flue.

**Whole Building/ Mechanical System** - air source heat pump / Upgrade boiler.

**Attic** - insulate internally / Add ventilation / Seal attic hatches.

**Windows** - repair or retain original or early windows / Enhance thermal efficiency with storm windows and weatherstriping.


**Doors** - repair or retain original or early doors / Enhance thermal efficiency with storm doors and weatherstriping.

**Basement** - add insulation in walls, ceilling and between floor joists/ Insulate around piping and ductwork.

**Walls** - add insulation.

**Behavioural Strategies** - a considerable amount of energy can be saved by adopting responsible behaviours such as controling air flow through windows or adjusting lighting.

**WORK WITH A CONTRACTOR?**

Depending on the size and scope of the project, it might be relevant to consider working with a contractor. Networks such as Clean BC and the Home Performance network are good ressources to find qualified trades.

## STEP 3. Do the Work

There are five types of interventions that are generally considered for retrofits: air sealing(A), insulation(B), windows and doors upgrades(C) and mechanical systems(D) and behavioural strategies(E).

### A. Air Sealing

Addressing air leakage requires minimal change and is typically easy to do yourself and cheap. Caulking and weatherstripping alone may save up to 10% on energy bills[1]. Air flows through cracks and gaps in loose-fitting windows and doors cause HVAC to work harder, which creates energy waste and higher bills. Although you might feel drafts around windows and doors on the main floor, in most homes, the most significant air leaks are often found in the attic/top floor and basement/lowest floor and are often hidden. A few areas that might require further draught-proofing are:

**Attic Hatches** - weatherstripping the edges and putting a piece of rigid foam board insulation on the back of the door. Treat the attic door like a door to the outside.

**Penetration Points in the Attic's Ceiling or Roof** - weatherstripping point of penetration like the fireplaces, pipes, vents and recessed lights.

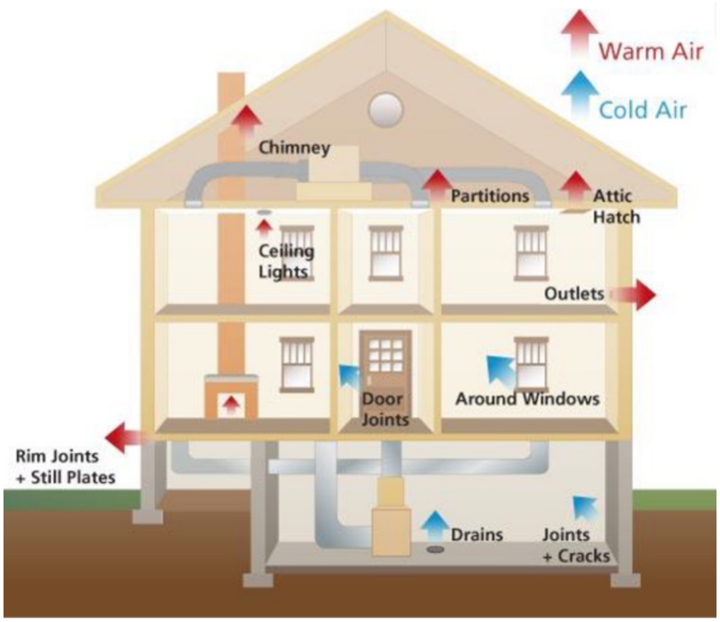
**Windows** - create a complete seal around the frames and sash.

**Doors** - use wiper seal to seal for large gaps under doors.

**Basement Walls** - use a silicone caulk to seal the cracks.

**Baseboards and Trims** - if they haven't been caulked and sealed by layers of paint they might be a source of draft.

**Electrical Outlets and Switches** - foam gaskets are recommended.




*Common areas to insulate*
*Source: Blank Space*

1. https://www.bchydro.com/news/conservation/2012/avoid-high-winter-bills.html

## B. Insulating

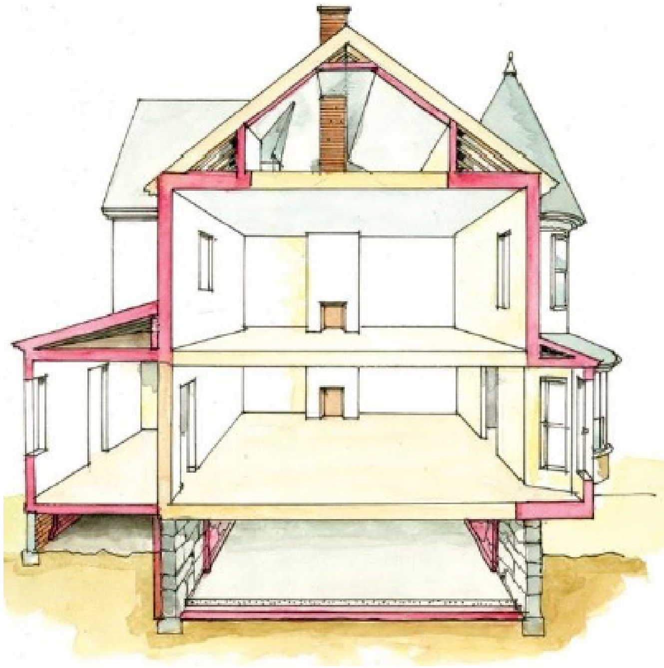
Upgrading insulation can result in greater comfort and money savings as it can help conserve energy by reducing heat transmission. Insulation in the attic and basement as well as on HVAC ducts and water pipes are a good way to start as they are the easiest and less intrusive areas. Insulating walls is more invasive and complex and should be undertaken with the help of a professional. Insulation's efficiency is measured in R-value, the higher the R-value, the better the insulation. Houses older than 50 years old are typically not insulated. It is possible that there might be insulation but it may be inadequate. Insulation can be added in the following areas:

**Attic** - after having air sealed cracked and gaps in the attic, add batt, rigid or blown-in cellulose between attic rafters. There are many areas of the attic where insulation can be added: above the roof deck, below the roof deck or in the attic space below a roof, on the floor between the ceiling joists. Regardless of the insulation arrangement, ventilating the space above the insulation by way of eave, gable and ridge vents is critical.

**Foundation** - depending on the condition of the basement, different measures will be required. For unfinished basement you might want to focus more on the ceiling to keep the living space upstairs comfortable. Insulation can be added to the basement ceiling or between the first floor joists. For a finished basement, keep the heat in that space by focusing on insulating the walls instead.

**Exposed Pipework, Valves, Boilers and Hot Water Cylinders** - can be wrapped with insulation.

**Walls** - wall insulation should be part of a "whole house" plan and should only be considered last, after insulation of the attics and basement spaces. Insulation can be blown into the cavity of a wood-framed wall from the inside or outside.



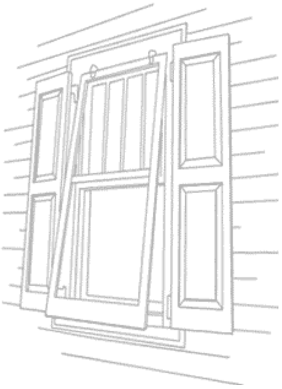
*Where to insulate an older house*
*Source: oldhouseonline.com*

**BALANCE BETWEEN AIR TIGHTNESS AND VENTILATION**

Adding materials and systems that do not allow the building to breathe can exacerbate existing problems or create new ones. Older buildings were designed "to breathe" and sealing them too tightly through air sealing or by adding insulation may create moisture issues that may in turn cause wooden parts to deteriorate. When making a heritage home more "airtight", air circulation should be considered at each step. Areas that are particularly humid such as the kitchen and the bathroom should be properly ventilated with range hoods and bathroom fans.

## C. Windows and Doors

In New Westminster, wooden windows with ornate trim are an authentic part of local heritage. There is a misconception that in order to achieve significant improvement in energy retention, windows and doors should be entirely replaced. Old wood windows can almost always be repaired. They are also extremely durable and with good maintenance they can last for a very long time. Even if you replace your windows with new wooden windows, the quality of your heritage windows' old-growth lumber cannot be replaced.



*An image of exterior storm windows on the exterior of the original wood-framed window and the installation process. Source: vintagewoodworks and Indow Windows*

### Basic Maintenance

A simple and effective method to "green older windows and doors" is to maintain them. A well-maintained film over the wood and good paint seals in the joints shed water and protect the wood by keeping it dry. Cleaning them frequently will also ensure that they resist to weathering such as dirt, moisture, soot and pollution which lead to the deterioration of windows.

### Improve Operation

Older window styles such as double-hung windows can offer maximum air circulation when proprely used. By simply ensuring mechanisms are working well you can acheive greater efficiency. Ensure that sash cords, chains and weights are functional or repair deteriorated components (such as parting bead that seperate window sash).

### Metal Weather Stripping

(See page.7 for air leaking) Metal weather stripping such as spring bronze is among the materials that are considered appropriate for older windows and doors. Some are more complicated than others to install and may require profesionnal assistance. When proprely installed they require little to no maintenance.

### Interior or Exterior Storm Windows and Doors

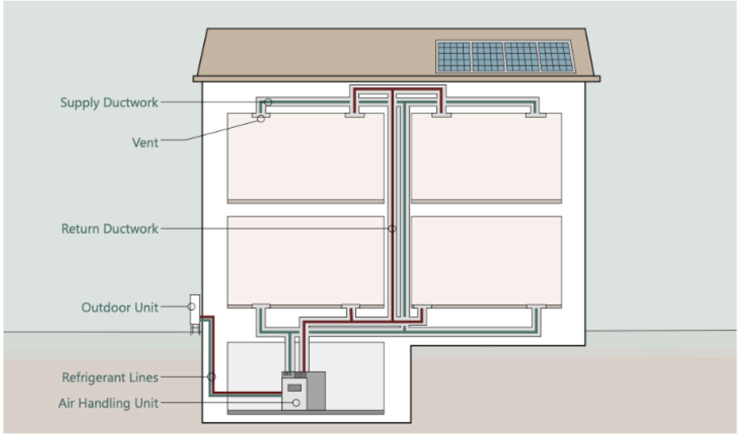
Storm windows and doors can significantly improve the thermal performance of a window by reducing air leakage and by adding a thermal barrier to the existing window or door. When installed correctly, it can create an air barrier with the existing window or door that has an insulating value.

## D. Mechanical Systems

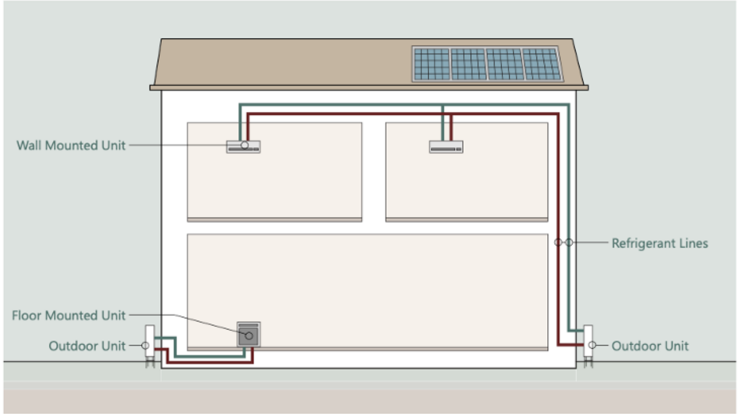
Energy efficiency can be improved by either reducing heat loss or replacing the source of heat. Previous solutions in this guide are for the former.
Mechanical system upgrades are a great way to improve the energy-efficiency of a heritage as they don't affect the appearance of the house. It is recommended to consider the replacement of your mechanical system when they are close to the end-of-life use. There are a variety of factors that go into deciding which mechanical systems are best suited for a specific house. The @ ENERGY STAR label can be a good indicator of the energy effiency of a model. It is recommended to ask an energy advisor, contractor, or energy coach to find the right system. Examples include:

**Air-Source Heat Pumps** - Air-Source Heat Pumps are heating and cooling systems that move heat into a home in the winter and draw heat out in the summer. Instead of burning fossil fuels, they operate on the same principle as your refrigerator: using a refrigerant cycle, powered by electricity. They can significantly improve the thermal efficiency of a house at a reasonable incremental cost. Compared with conventional electrical systems, heat pumps can produce up to 4 units of heat for every 1 unit of electricity. There are two types of heat pumps to choose from: ductless or ducted air source heat pumps. Choosing the right system depends on criteria such as the existing distribution sytem. For example, ducted systems may be well suited for houses that already have duct and vents as they can be reused for heat pumps.

**Boilers** - another intervention to consider is to upgrade your domestic hot water system to an energy efficient model. Many homes may have improperly sized and poorly installed heating equipment. Electric heat pump water heaters can save up to 50% of a home's water heating energy use[2].




Air-Source Heat Pump: Ducted System




Air-Source Heat Pump: Ductless System

*Visual comparison between ducted and ductless system*
*Source: Town of Concord, 2020*

**LOOK FOR REBATES**

Mechanical system upgrades may have a high upfront cost. Energy Save New West can help access some of the latest provincial rebates including HVAC system upgrades. energysavenewwest.ca/existing-homes/

2. https://www.bchydro.com/powersmart/residential/savings-and-rebates/new-electricity-saving-products.html

### E. Behavioural Strategies

Other strategies so far have been about physical building improvements. Yet significant energy savings can be acheived through behavioural strategies. Sustainability require a change of mindset which will involve that the occupant sees themselves as an integral part of the house's system. Older houses were built with the goal of having homeowners be proactive. In fact, during their conception, designers and architects took into account that residents would regularly adapt their habits to fit the design of the home. These practices have mostly been lost today as we generally expect homes to regulate themselves. It is possible to make a heritage house much more comfortable by considering little changes in habit. Here are a few tips:

**Use Inherently Sustainible Features -** Take advantage of operable windows, porches, awnings and other nonmechanical features to reduce heating and cooling.

**Alternate Rooms and Spaces -** Control the temperature in rooms that are used and establish climate zones throughout the building with seperate controls so that unused rooms are not actively regulated. You can also take advantage of the natural elements and live in rooms that are more shaded in the summer and in the ones that are more exposed in the winter.

**Adjust The Thermostat -** In order to save energy, heat to a lower temperature in the winter and cool to a higher temperature in the summer. Turning the water heater thermostat down can also help.

**Improve Lighting -** Replace incandescent light bulbs with Light Emitting Diodes (LEDS). LEDs have come down in price and can replace almosty any bulb. They can produce a warm light that can last about 50 times longer than incandescent bulbs. Over their lifetime, they can pay back 30 times their initial cost. They can be installed on the inside our outside of the house. It is also possible to save energy by simply reducing the number of lights used and maximizing natural light.

!! Extreme heat events are occuring and expected to become more frequent. Beyond energy effiency, safety should always the priority when regulating space heating and cooling.

## STEP 4. Post Retrofit Monitoring

After the retrofit, your building should be regularly monitored to determine how the strategies are working and if adjustments need to be made in the long-term. Existing buildings must be maintained regularly to preserve their character and maximize their reliability, performance, and efficiency. A plan should also be developed for the maintenance of the building post retrofit. Future dates for work, estimated cost and contact details for relevant tradespeople can be identified.

# APPENDIX II. Photographs - Irving House

Fig.11 East Facade window

Fig.12 Location of the ground loop on the eastern portion of the property

Fig.13 West side of the property

Fig.14 Original door on the front entrance

Fig.15 Distribution system in the crawl space

Fig.16 Buffer tank in the crawl space

Fig.17 Air Vent in the Parlour


Fig.18 Thermostats located in a closet on the main floor

Fig.19 Distribution system in the attic