RETROFIT MEASURES ACTION REPORT

For Residential Buildings

City of Grand Forks Flood Mitigation Program

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PROJECT INTRODUCTION:

In May of 2018 the City of Grand Forks experienced a 1-in-200-year flood. The flooding damaged over 400 homes, more than a quarter of the community's housing, much of which was luckily repairable. The City received $55M from federal and provincial governments as needed to enact a flood mitigation program. This program includes the downtown infrastructure upgrades, additional erosion protection, and the buyouts and removal of 79 homes from the North Ruckle community as needed to make space for permanent flood protection infrastructure.

When the 2016 census was completed, Grand Forks was a city of only 1605 homes. Representing almost 5% of the city's housing stock, the loss of North Ruckle was the loss of the city's most affordable housing. Shortly thereafter rental vacancy plummeted, and in May of 2021 real estate prices hit record highs across the province (SOURCE). Many of the community members displaced by the 2018 flood could not afford to buy elsewhere in town.

Figure 1:The City of Grand Forks experienced a 200-year flood in 2018.

The need for housing prompted an opportunity to salvage the remaining homes. The relocation, retrofit, and reinvestment of flood damaged homes provides opportunity to create cost-effective housing and satisfy the community's unprecedented need. In relocating homes there is an additional need and/or opportunity to replace outdated and/or damaged building systems with modern higher-performing options.

While it is recognized that every home presents its own challenges related to its vintage, condition, and form, there are underlying principles that are fairly continuous across archetypes. Fundamental principles of building science apply to all buildings, and opportunities to improve buildings tend to follow similar patterns. And while it is easiest to improve a building when already performing construction, or relocating a house, it is certainly not a requirement to making home improvements. The opportunities presented in this manual are not specific to the flood recovery project, nor are they limited to this period in time.

PURPOSE:

To enable opportunities for building performance improvements which are not specific per home nor per era, presented through Retrofit Upgrade Packages at varying tiers for accessibility and ease.

TERMINOLOGY:

Throughout this report the term “Stage” I/II/etc. is used to describe upgrade opportunity tiers with varying levels of commitment (input). Upper stages provide better performance but tend to include more invasive and expensive capital improvements.

The term “Stage” is used to avoid confusion with the BC Energy Step Code which uses “Step” 1/2/etc. and describes a building’s final performance (output). While the measures in this report are chosen to increase your performance with regards to the Step Code, determining results of improvements requires a registered professional to perform analysis specific to the house.

RETROFIT MEASURE UPGRADES/PACKAGES

Note: The following retrofit measures are not suggested to meet any specific performance standard, nor is there any guaranteed increase in home performance. It is suggested you make use of the available resources and consult a NRCan accredited Energy Advisor prior to making any invasive improvements.

Retrofit Measure Upgrades/Packages have been classified based on their ease of implementation. Each of the below summaries include a series of Energy Conserving Measures and an explanation regarding their level of commitment. A flow chart has been provided to aid proponents in identifying the MINIMUM level of upgrade recommended based on their homes condition and their budget. Individuals reinvesting homes are encouraged to improve as much of their home as deem suitable, given the resulting energy savings and home value increase.

Figure 2: Many of the homes are in "shell" state, requiring greater reinvestment effort and creating opportunities for significant upgrades and improvements.

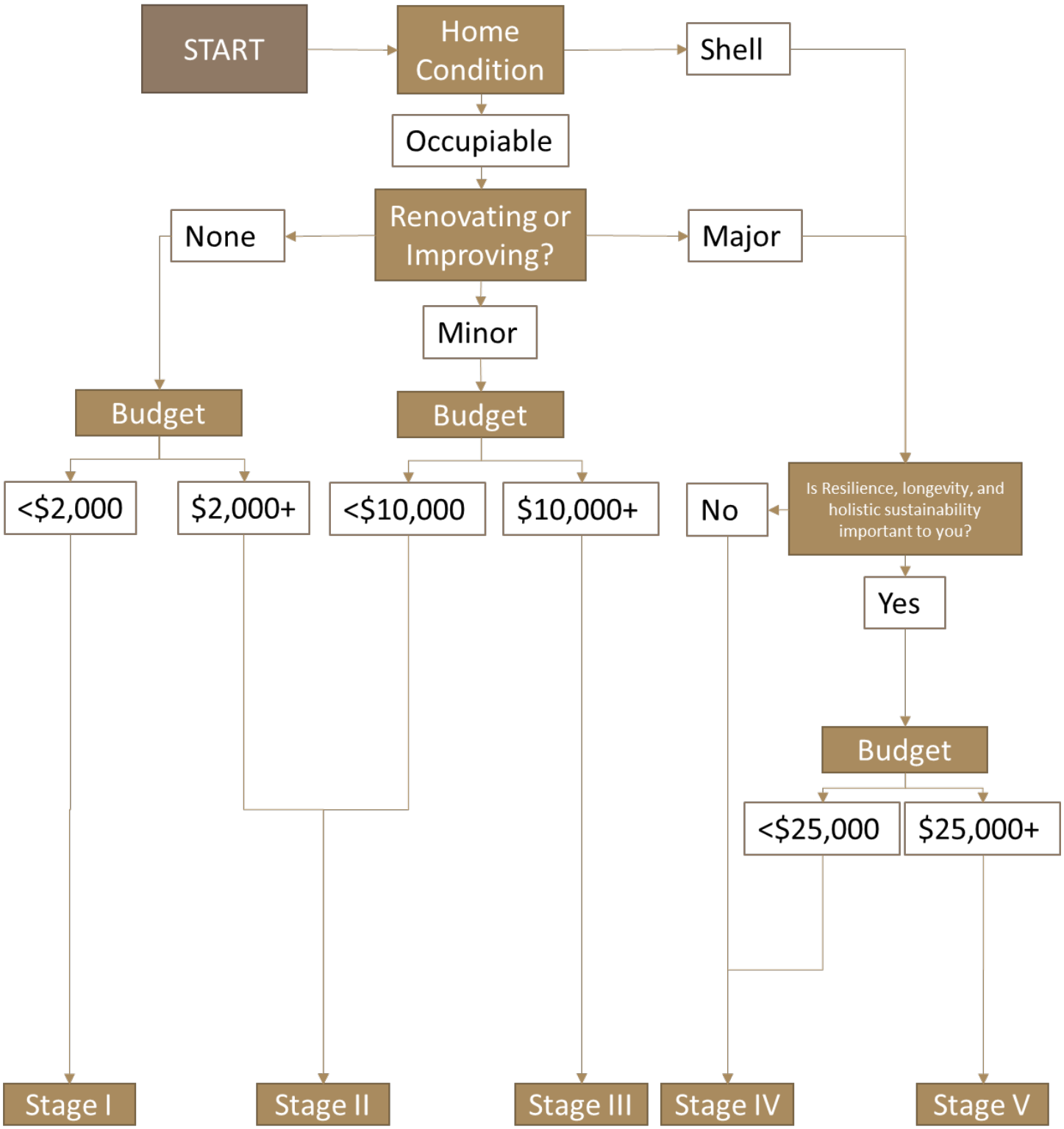


Figure 3: Knowing where to start can be daunting. Different improvements require different levels of commitment. The above flowchart can offer guidance with regards to which tier of upgrades is most suitable.

Stage I – Basic Provisions

Summary:

- Basic maintenance. Typically the least expensive and the least invasive.
- Does not require modification of other building systems to work.
- Little-to-no rebate support available.

Like giving a vehicle an oil change, these are basic provisions that should be made by any new owner to an old home. Often considered the "low-hanging fruit, upgrades of this nature are typically simple enough to be installed by owner. While seemingly minor, addressing failure points like leaky doors and energy hungry lighting can lead to significant improvements in comfort while also reducing energy use.

Energy Conserving Measures:

Lightbulbs:

Cost: $5-$50/fixture

Incandescent lightbulbs are disposable and fail regularly in frequented areas. LED lighting can provide the same lighting for 75% less energy, and with up to 25x the lifespan. LED Lighting is a time and money saving upgrade for spaces with frequent use.

Weatherstripping and Door Adjustments:

Cost: $5-20/exterior door

An air sealing gasket (or weatherstripping) is standard for all doors and windows. As homes age the doors and windows allow more cold wind to travel through them, leading to cold spots throughout the home. Updated weatherstripping improves thermal comfort around exterior doors and saves money by eliminating heat loss.

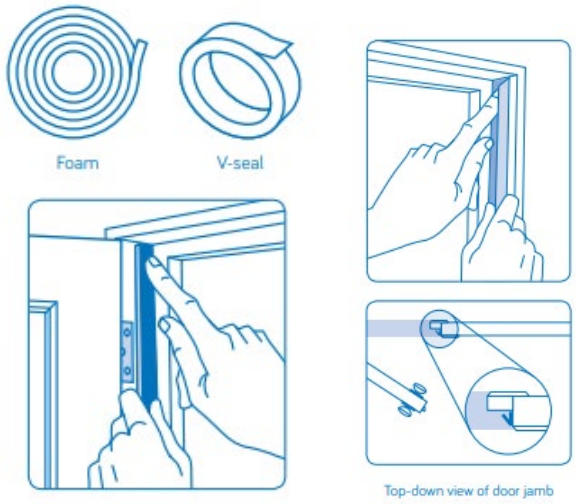


Figure 4: Weather stripping is easy to install and prevents heat loss through unintentional air leakage. [1]

Furnace Filter Replacement:

Cost: $15-45/unit

Furnace filters are the first line of defense against irritants such as dust, pollen, and forest fire smoke. Filters collect dust as they clean your air, protecting both your furnace and your home's occupants. When filters get dirty, they restrict airflow, requiring additional energy and creating additional wear.

Furnace filters should be changed every 3-6 months.

Figure 5: Furnaces will struggle to function when their filters are clogged and restrict air flow. Furnace filters should be replaced every 3-6 months to avoid equipment damage.

Insulating and Low-E Window Films:

Cost: $10-40/window

Windows and doors account for almost 50% of the heat loss in a conventional home. While modern windows can cost hundreds of dollars each, window films are inexpensive and can be bought at most hardware stores. Low-E window films prevent overheating and can last years, whereas thermal films prevent condensation and heat loss and are often seasonal.

Stage II – Component Upgrades

Summary:

- Replacement or upgrade of individual components, not systems.
- Tends to enhance single system performance.
- Can involve the minor addition of a new component to improve a system.

Like superficial upgrades, component upgrades are generally non-invasive yet still enable better performance within bigger systems. Examples include periodic replacement of water heaters or appliances, windows and fenestrations, or increased attic insulation.

Energy Conserving Measures:

EnergyStar Appliances:

Cost: $500 - $5,000 each

Appliances help us save time by providing services like washing our dishes and clothes, at the expense of a significant amount of energy. The mechanical nature of appliances means they see regular wear and tear. Next time you need to replace an appliance look for the EnergyStar logo.

EnergyStar Appliances are tested to strict efficiency standards and are certified to save you money by an independent third party. They perform the same or better than standard products without compromising performance in any way.

Improved Water Heater or Furnace Efficiency:

Cost: $500 - $5,000 each

Providing heat to water and living spaces is the greatest consumer of energy in the home. While older gas furnaces and water heaters wasted almost 40% of their input energy, modern gas systems are as much as 97% efficient, with electric and heat pump equivalents offering efficiencies of 100%-340%.

As active mechanical systems, water heaters and furnaces experience fatigue. Next time your heating equipment needs replaced opt for a high-efficiency model and make sure it’s pre-approved for rebates from local utilities or governments.

Door and/or window replacements:

Cost: $300 - $900 each

Doors and windows are an integral part of the building's enclosure. Combined with the walls, they act as our first line of defense against the elements. Thermal resistance is often measured in R-Value, where a typical wall might have a value of R19 to R29. Windows and doors often only perform as high as R4, and act as highways for heat to escape. Water can condense on these cool surfaces, leading to premature deterioration and rot.

Windows are an effective energy saving and aesthetically pleasing upgrade to any home. High performing windows typically have rebates which bring their price in-line with conventional options.

Figure 6: Windows are highways for heat loss. There are both temporary (films) and permanent (replacement) solutions to managing heat loss through these opening in our walls.

Increasing Attic or Floor Insulation:

Cost: $500 - $3,000 each

Insulation prevents heat loss, keeping your home warm and saving you energy. Upgrading walls can be challenging due to their assembly, whereas attics and crawlspaces are usually easy to access and insulate. Attics are often insulated with inexpensive blown-in cellulose, whereas uninsulated floor systems are typically remedied with inexpensive fiberglass batts between the joists.

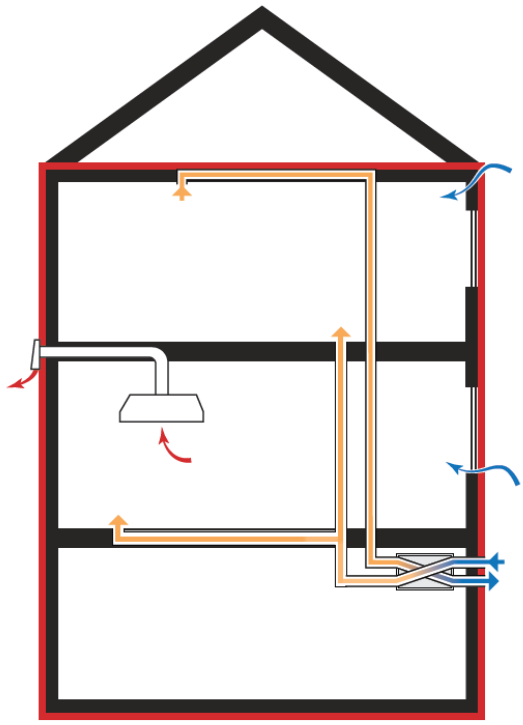
Stage III – Minor System Upgrade or Replacement

Summary:

- Replacement of minor systems or addition of substantial components to existing system.
- Potential for fuel switching
- Enhance performance of house-as-a-system.

A building's numerous parts, including the enclosure, the structure, mechanical equipment, lighting and more, all interact with each other to form a system [2]. The relationship between ventilation, thermal performance, and space conditioning should be evaluated to ensure thermal comfort throughout the year.

When upgrading and/or improving individual systems within the home, it is critical to view the home "as-a-system". Upgrading or replacing a heating system component can impact the building enclosure, and vice versa.



High-Performance Building

Airtight enclosure and mechanical ventilation with or without heat recovery

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High thermal performance

Figure 7: High performance buildings are designed such that their components work together, not against each other. This principle is called the "house-as-a-system" [2]

Energy Conserving Measures:

DWHR:

Cost: $600 - $1200

The amount of energy required to heat water is a function of two variables: starting temperature and flow rate.

Drain Water Heat Recovery (DWHR) routes incoming water through a copper coil wrapped around the greywater outlet. This increases its temperature when hot water from showers or dishwashing exits the building, as seen below in figure 5.

Figure 8: This RDKB home used wraps of conductive copper pipe (inlet water) to recover heat from outgoing greywater (black ABS) This system exchanges heat without mixing.

Thru-Wall HRV

Cost: $700 - $3,000

Ventilation is critical to ensuring a healthy indoor environment as unventilated spaces tend to accumulate CO2 and mold. Conventional exhaust fans do so without heat recovery, constantly wasting the energy spent heating that air, whereas a Heat Recovery Ventilator (HRV) provides constant ventilation while pre-heating incoming fresh air by passing it by the exhausted air without mixing.

While typical HRVs require ducting, simpler “thru-wall” versions offer ventilation and heat recovery while only requiring a power source and single, well-sealed hole through the envelope.

While thru-wall HRVs are a handy and inexpensive solution for small spaces, the greatest benefits are found through ducted systems capable of supplying fresh air directly to living spaces while exhausting contaminated air from kitchens and bathrooms.

Standalone Heat Pump Install:

Cost: $500 - $6,000

Heat-pumps offer both heating and cooling, and are a welcome addition in any Southern BC home without air conditioning. Heat pumps work like a refrigerator or radiator, moving heat from one space to another with a small compressor. The movement of heat this way is incredibly efficient, sometimes as high as 340% when ambient temperatures are ideal.

While standalone models typically only service one or two spaces, the additional low-energy heating and cooling can make a big comfort difference without too invasive of an install.

Want a full-sized HRV to provide fresh air to all your living spaces? Consider a ducted air source heat pump with heat recovery ventilation, discussed in Major Upgrades and Replacements.

Aerobarrier and Airtight Paint:

Cost: $400 - $2,500

Eliminating air leakage is one of the most effective ways of minimizing heat loss. If you've already fixed weatherstripping and adjusted doors (Basic Provisions), the next step is to start sealing holes that are invisible to the naked eye.

Airtight paint and acrylic products like Aerobarrier allow building owners to retroactively seal their homes from the inside, minimizing the loss of conditioned air and lowering the risk of moisture entering the walls from the inside. These are specialized products and are not typically recommended for spaces without active ventilation.

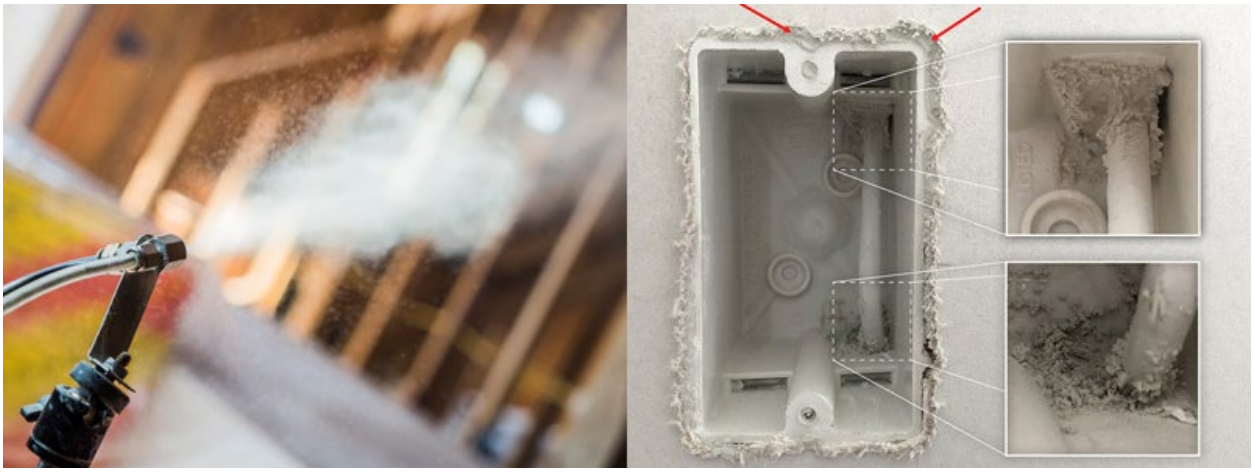


Figure 9: Acrylic products and airtight paints create opportunities for eliminating unintentional air leakage after construction. [3]

Stage IV – Major System Upgrade or Replacement

Summary:

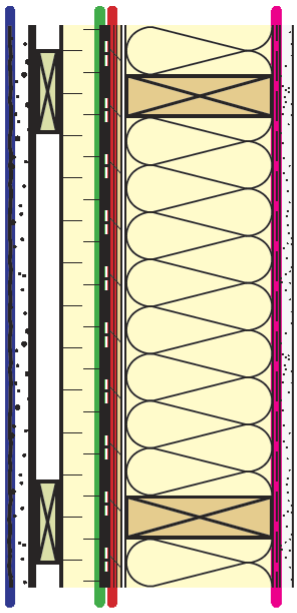
- Major upgrades, like undergoing surgery, require careful consideration of the house-as-a-system.
- Major upgrades may require the replacement of multiple existing components, typically entire systems, sometimes contingent upon each other.
- Major upgrades and replacements are typically eligible for significant rebates or incentives.

Performing major upgrades or replacing entire systems requires a good understanding of how the house's systems work collectively. Some upgrade can have unintended consequences if done without

Energy Conserving Measures:

New Building Enclosure / Re-Enveloping

Cost: $10,000 - $100,000



Water shedding surface

Water-resistive barrier

Air barrier

Thermal insulation

Vapour retarder

Figure 10: The wall assembly is made up of many components, each which serves their own purpose in managing moisture and airflow. [2]

Both **updating a building's exterior** and/or **replacing a building's interior** present critical opportunities to upgrade the enclosure.

While expensive to do on its own, "re-enveloping" a building is cost-effective whenever replacing cladding or fenestrations and can add years of longevity. Re-enveloping is often a necessity in "shell-state" homes.

The building enclosure separates the indoor and outdoor environment. It has the challenging task of managing heat and moisture. Building enclosures have changed greatly over the last hundred years, with some generations performing far better than others.

Performance of a building's enclosure is highly subject to construction quality control. Poorly built enclosures perform poorly and failing prematurely. It is especially critical when designing high-performing enclosures to account for local weather and climate. An enclosure must effectively:

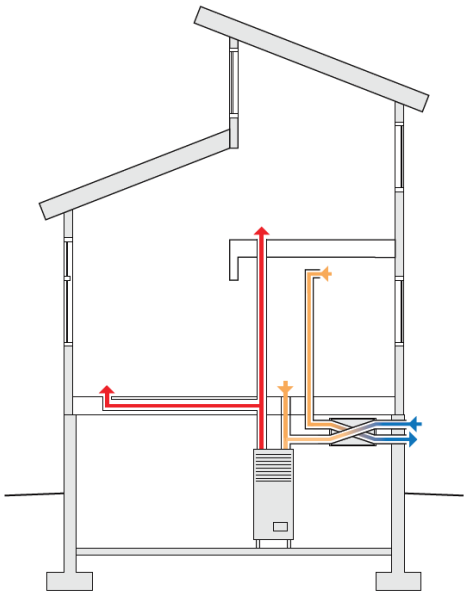
- Mitigate Rain/Water Penetration
- Manage Airflow
- Control Vapour Flow and Mitigate Condensation

Exterior walls are an assembly of materials that perform this task, ensuring moisture doesn't enter the walls from the inside and managing effects of weather on the outside.

A new building envelope, complete with new cladding and updated weather barriers, is one of the greatest improvements you can make to a home.

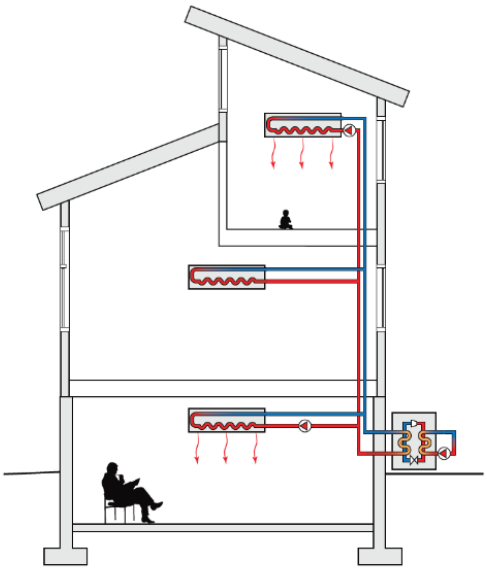
Air Source Heat Pump with Heat Recovery Ventilation

Cost: $2000 - $12,000



Furnace combined with a heat recovery ventilator to improve energy efficiency

Figure 11: HRV's can coupled with furnaces wherever ducting exists. [2]



Air-to-air heat pump system with multiple interior fan-units

Figure 12: Heat pump technology offers the highest heating and cooling efficiencies. It is effective integrated into existing ducting, or as a standalone system. [2]

Modern buildings must be constantly ventilated, meaning fresh air is always being conditioned as it is introduced to the space. A heat recovery ventilator (HRV) provides constant ventilation and recovers heat from outgoing air in the process. Heating, Ventilation, and Air Conditioning, collectively are referred to as HVAC.

Heating and Ventilation can be provided as a single system, in which heat is distributed through ventilated air, **OR, Heating and Ventilation can be provided as independent systems,** in which ventilation air is provided tempered and individual spaces are heated as needed. It is important to understand the nature of your home's HVAC system prior to making upgrades, as some components are application specific.

Full size HRVs require ducting throughout the home to supply fresh air to bedrooms and living spaces. They typically exhaust stale air from bathrooms, and sometimes kitchen spaces. Separate venting is usually required for heavily soiled air, like that from a range hood (grease) or dryer exhaust (lint).

Heat pumps are electrically driven devices that extract heat from a low temperature place and deliver it to a higher temperature place [4]. Rather than moving heat with air, they do so with refrigerant which creates efficiencies as high as 340%.

Heat pumps typically have a compressor unit outside, coupled with one or more heating & cooling coils inside. These fan coils can be wall mounted to treat individual spaces, or they can be placed within the ducting for distributed heating and cooling.

In mild climates, and when decoupled from an active HRV, air source heat pumps can almost eliminate heating and cooling costs.

Stage V: Deep Energy Retrofit (DER)

Summary:

- Improvement of house-as-a-system including replacement and/or upgrade of all major systems, in coordination.
- Requires a registered professional.
    - Energy Advisor
    - Professional Engineer/Architect
    - Registered Builder and/or Program Registered Contractors
- Often involves setting an ambitious goal or using a third-party certification to measure final performance.

With a Deep Energy Retrofit (DER), typically you set a performance goal and then undertake an extensive overhaul of your building's systems that can completely change the nature of its energy use as needed to meet your performance goal. This also offers a clean slate to completely reinvent indoor air quality and thermal comfort in a space.

Performance standards exist for retrofits and building refurbishments. These performance standards offer a pre-approved approach to meeting a specified performance metric. This is helpful, as it can ensure higher quality control and mitigate risk. Refurbishment to meet a predetermined performance standard using approved components for all the relevant systems leads to extensive improvements with respect to thermal comfort, structural integrity, and energy efficiency.

Deep energy retrofits are the work of Energy Advisors, Consultants, and Registered Builders. It is a challenging but rewarding undertaking, involving replacing any systems found detrimental to the building's performance. Ultimately it is expected that the building performs as good or better than most modern buildings when the retrofit is completed. There should be either a measured or modelled confirmation of performance, as well as a registered professional to confirm accordance with universal standards.

Deep Energy Retrofits are deeply rewarding experiences. Not only are they likely to receive the highest subsidies, but they are also the most likely to see significant improvements in livability and occupant comfort.

As deep energy retrofits are likely to be building specific, no explicit energy conserving measures have been recommended but example projects have been provided. They typically involve at minimum new HVAC and building enclosure systems.

Examples:

- Heritage Building Restoration
- Shell Building Reconstruction
- EnerPhit Standard or LEED Standard for Existing Buildings

SUMMARY:

Opportunities exist for home improvements at any scale and budget. While basic maintenance will improve any home, shell state homes and deeper retrofits offer greater opportunities for major improvements. Making major improvements

The Grand Forks Flood Mitigation Program and the resulting home relocations offers an unprecedented opportunity for the creation of sustainable and attainable housing. Due to variation in in size, form, and vintage, it is likely skilled professionals that will make the most of the reinvestment opportunity.

Nonetheless, the opportunities presented in this short manual are not specific to the FMP, nor to homes of any size, vintage, or value. The principles of basic maintenance, of the “house-as-a-system”, and of varying levels of upgrades are universal across residential buildings in BC. While the recommendations provided are done on a professional basis, it is important to remember that every home Is unique, that each has their own unique history, and that anything beyond basic maintenance should be done with the help of a registered professional who can provide warranty for their work. Professionals should also ensure that you get program approved equipment, and that your project gets access to any available rebates at the time.

References

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