3.0 Identifying House Issues, Avoiding Creating Them, and Finding Solutions

by HPSC Admin

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3.0 Identifying House Issues, Avoiding Creating Them, and Finding Solutions

Learning Objectives of this Section

- Identify common house problems, pre-existing or unintended consequences of isolated retrofits, their complex causes, and reasons for concern
- Explain the HAAS considerations and solutions to avoid unintended consequences for each major retrofit type, and identify and solve existing problems

Overview

Homeowners trust contractors as the expert in home retrofits. Practically applying a HAAS approach to projects will increase customer trust and satisfaction in your services. Remember - retrofit contractors should strive to "do no harm", meaning the work of retrofitting a home should not cause, or worsen, issues in a home. Understanding the concept of HAAS and the potential for unintended

consequences is key for contractors work to contribute to their clients' homes being more efficient, comfortable, durable, safe and healthy.

3.1 Common House Problems and their Potential Contributing Causes

You have now learned that HAAS is an important approach to retrofitting; let us now understand why it is important in further detail.

When a contractor assesses a home prior to retrofitting, they may find pre-existing issues, either from their inspection or from an interview with the occupants. Similarly, these same problems may arise as unintended consequences of isolated retrofits. The HAAS approach is useful for solving these problems and avoiding them in either scenario. This section explores three common problems, their potential contributing causes, and the reasons for concern. This is not an exhaustive list of problems, further issues and interconnections can be explored using online tools such as the Sustainable Traditional Buildings Alliance's Responsible Retrofit Guidance Wheel.

Excess moisture

Moisture problems have a variety of causes and can result in major damage to a home. Excess moisture concerns include precipitation (wind driven rain), water vapour (transported by diffusion or air movement), and ground water leaking into the home.

Home energy retrofits can have negative impacts on occupant safety and health and home durability if contractors do not understand the pre-existing moisture issues in a home and the potential moisture related unintended consequences that can be created by retrofitting a home. Excessive moisture can be triggered by several potential causes and cumulative effects. Once contractors are familiar with the common causes of excess moisture, it is relatively straight forward to identify solutions for specific homes.

Potential Contributing Causes

The following is a list of potential causes that can contribute to excessive moisture. These may be pre-existing factors when you arrive on site or become contributing factors after an isolated retrofit.

Building Envelope

- Openings around windows, patio doors, doors that when installed or replaced have not been property integrated with the building envelope and allow for water penetration.
- Cracks or gaps in the building envelope (interior or exterior) leading to water leakage or air leakage (carrying water vapour) through the building envelope
- Roof leaks
- Improper grading of soil around home, leading to water flow into home
- Poor drainage systems leading to intrusion of water through basement
- Plumbing water pipe leaks
- Capillary action causing moisture from the ground to rise up through concrete, masonry, or

other building materials
- Construction material moisture from renovations (e.g., cement, wood, etc.)
- Ineffective rain downspouts or clogged rain gutters

Mechanical Systems

- Inadequate ventilation, especially if the home is airtight, resulting in accumulation of moisture from indoor sources becoming trapped inside.
- Oversized, or improperly specified, cooling system short cycling (turning off and on too quickly) failing to remove humidity from home.
- HVAC penetrations into home have not been properly sealed allowing for water penetration. Improperly vented bathroom and dryer exhaust systems expelling moisture into the envelope or an unintended location.

Occupants

- If exhaust fans are inefficient, not working properly, or are not used:
  - Daily activities such as showering or bathing, washing clothes, cooking, hanging clothes to dry indoors, exercising, and even breathing
  - The presence of aquariums, fountains, or plants indoors
- Sprinklers or irrigation systems contacting the building envelope
- Occupants not keeping up with general maintenance e.g., checking caulking around bathtub and showers
- Occupant use/miss use of ventilation controls
- Occupants opening basement windows in summer and letting humid air inside

Environment

- Rain penetration, through roofs and walls, in particular wind-driven rain
- High outdoor humidity levels, especially if the home is not airtight
- Flooding due to weather conditions (e.g., snow melt, storm surges, prolonged or heavy rainfall)

Reasons for Concern

Health

- Health Canada recommends that your home's relative humidity be kept between 30 and 55 percent in winter[6]. Lower levels aggravate skin allergies and respiratory infections, and higher levels increase the spread of mould, bacteria and viruses[7].
- Moisture allows mould and mildew to grow posing health risks such as eye, nose, and throat irritation, coughing and phlegm build-up, wheezing and shortness of breath, and worsening of allergies and asthma symptoms[8].
- Dust mites, which thrive in warm and humid indoor environments (when humidity is above 50%), causing problems with allergies.

Comfort

- For optimal health and comfort, Natural Resources Canada recommends indoor relative humidity is kept between 30 and 55% in winter[9].
- Mould, mildew, and excess moisture can cause musty, unpleasant odours in the home.

Durability

- Moisture can cause serious structural and aesthetic damage such as wood rot, staining and discolouration of surfaces, moisture damage to drywall, and peeling of paint.
- Freeze-thaw deterioration of concrete, stone, and masonry.
- Electrochemical corrosion of metal components.
- Structural failure due to expansion/shrinkage.
- Insulation that has become wet will be breeding ground for mould and mildew and will loose its insulating capacity.

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[6] As cited in "Moisture Problems" Natural Resources Canada, [2007]. URL: 2PP_eng.qxd (publications.gc.ca)

[7] "Addressing Moisture and Mould in your Home" Government of Canada, [2020]. URL: https://www.canada.ca/en/health-canada/services/publications/healthy-living/addressing-moisture-mould-your-home.html

[8] As cited in "Moisture Problems" Natural Resources Canada, [2007]. URL: 2PP_eng.qxd (publications.gc.ca)

[9] As cited in "Moisture Problems" Natural Resources Canada, [2007]. URL: https://www.canada.ca/en/health-canada/services/publications/healthy-living/addressing-moisture-mould-your-home.html URL: 2PP_eng.qxd (publications.gc.ca)

Poor indoor air quality

Indoor Air Quality (IAQ) refers to the air quality within homes. IAQ can be affected by pollutants, temperature, humidity, and other factors in the surrounding outdoor environment. These factors can affect the safety, health, and comfort of the occupants, and the performance of the home.

Retrofits can improve or degrade the IAQ in a home and have the potential to cause serious and life-threatening health and safety issues. A challenge for contractors is that IAQ issues in homes can be triggered by cumulative effects, including the retrofits that they complete.

Retrofits with the potential to affect IAQ include those that impact:

- Air tightness through air sealing
- Insulating envelope components
- Modifying existing building envelope
- Ventilation and air flow
- Temperature and humidity

Most energy retrofits impact one or more of these factors and, therefore, IAQ. This is an important issue for contractors to understand and avoid creating.

Potential Contributing Causes

Building Envelope and Home

- High levels of air leakage in home resulting in infiltration of outdoor contaminants or contaminants from within the building envelope.
- High levels of air leakage is a potential contributor to moisture accumulation in envelope components potentially resulting in mould and fungal grown.
- High levels of air tightness in the home, without adequate ventilation, creating issues with high humidity, condensation, moisture, and mold.
- Indoor contaminants, such as volatile organic compounds, used in building and consumer products building up in concentration within the home.
- Asbestos in home insulation or other building materials that is disturbed through renovations.
- Carbon monoxide from vehicles in attached garages.
- Improper, poorly functioning, or inadequately maintained heating systems, including leaky ducting.
- Improper, poorly functioning, or inadequately maintained ventilation and filtration systems.

Mechanical Systems

- Dirty or damp ventilation or ducting systems.
- Back-drafting causing combustion spillage.
- Unvented, or insufficiently vented, fuel-burning appliances, wood or gas fireplaces, and natural gas stoves.

Occupants

- Incorrect use of home ventilation systems
- Chemical build up in the air caused by products brought into the home (e.g., paints, varnishes, dry cleaned laundry, deodorizers, cleaning agents, ozone from office photocopiers, perfume, etc.).
- Dander from pets living in home.
- Second-hand smoke in homes of smokers.
- Lack of regular cleaning leading to dust mites or build up of other contaminants.
- Using gas stove burners without properly using venting range hoods.

Environment

- Proximity to highway or other sources of outdoor pollutants.
- High levels of pollen.
- Rodents having lived in attic or within home.
- High outdoor humidity.
- Radon entering the home.
- Mildew, mould, or bacteria.
- Wood smoke from wood stoves/rural fires in the community.
- Wildfire smoke.

Reasons for Concern

Health and Safety

- There are numerous potential health and safety concerns with poor IAQ. The issues vary widely depending on the type and concentration of pollutants in the air, the length of time a person is exposed to the pollutant, and a person's age, pre-existing medical conditions, and

individual susceptibility. IAQ issues can range from physical irritation to life threatening. Major health and safety concerns include[10]:

- Combustion spillage, a dangerous phenomenon where negative air pressure in homes with combustion appliances causes their gases to leak into the home, including carbon monoxide, which can be deadly.
- Radon gas entering the home.
- Serious disease or cancer from exposure to unsafe airborne particles and chemicals such as asbestos and volatile organic compounds.

Other health and safety concerns caused by IAQ issues include: eye, nose, throat or lung irritation, headaches, dizziness, fatigue, shortness of breath, sinus congestion, coughing and sneezing, vision problems, nausea, aggravated allergy problems, worsening asthma conditions[11.]

Comfort

- Stale air/lack of fresh air.
- Lingering odours.
- Occupant discomfort from aggravated health issues such as allergies or headaches.

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[10]"Indoor Air Quality" United States Environmental Protection Agency, [2018]. URL: https://www.epa.gov/report-environment/indoor-air-quality

[11]"Indoor Air Quality" United States Environmental Protection Agency, [2018]. URL:https://www.epa.gov/report-environment/indoor-air-quality

Overheating

Overheating is generally understood to be the increase in temperature within a building to an extent where it causes discomfort to the occupants. Research shows that people typically begin to feel 'warm' at 25ºC, 'hot' at 28ºC, and 35ºC has been identified as the internal temperature above which there is a significant danger of heat stress[12]; and this is simply the average, many people are more sensitive to temperature changes and could experience discomfort or health issues at lower temperatures. Additionally, warm temperatures at night can cause discomfort, leading to lower quality of sleep and subsequent health impacts.

A challenge for contractors is that overheating in homes can be triggered by many potential causes and cumulative effects, including the retrofits that they complete. Additionally, some of the retrofits that contribute to the benefits of an energy efficient home in winter (i.e., retaining heat and keeping the occupants comfortable) can result in, or contribute to, overheating in the summer. This is why, as more homes undergo multiple deeper retrofits, a HAAS approach is so important for avoiding the unintended consequence of overheating.

Potential Contributing Causes

The following is a list of potential causes that can contribute to overheating. These may be pre-existing factors when you arrive on site or become contributing factors after an isolated retrofit.

Building Envelope

- Design of home: e.g., insufficiently sized overhangs (roof eves) above windows, inadequate shading.
- Windows:
    - Large number and/or size of windows with high solar exposure.
    - Type of window installed allow too much solar heat gain to enter the home.
- Air sealing retrofit of home, without adding ventilation, may result in higher temperatures in the home.
- Under-insulated home allows more heat to pass through the building envelope and to overheat the home, especially through attics, roofs, and south- and west-facing facades.

Mechanical Systems

- Insufficient, or ineffective, ventilation and lack of air movement in home.
- Oversized heating system, resulting in overheating in winter (heating season) months.
- Ineffective, insufficient or non-existing cooling system.

Occupants

- Occupant use of heating, cooling, or ventilation controls Internal heat gains in the home caused by lighting, appliances (e.g., stoves, fridges, dishwashers, washing machines, TVs, computers and electronics), mechanical systems (e.g., hot water tanks), and occupants (people in the home give off heat in the form of metabolic gains).
- Occupants keeping blinds and windows open during hot summer days allowing heat and humidity to enter home and impact occupant comfort.
- High level of humidity in home created by occupant activities like cooking, bathing, or opening windows bathing or other home features such as aquariums.

Environment

- Orientation of home to sun exposure.
- Warm summer climate and/or high humidity levels.
- Increases in summer temperature caused by climate change.
- The heat island effect, which is more common in dense urban areas.
- No natural shading from summer sun (e.g., buildings, trees).

Reasons for Concern

Health

- Risk to occupants and pets, especially young children and seniors, from heat related stress or inappropriate humidity levels.
- Uncomfortably warm nighttime temperatures leading to compromised sleep with subsequent health issues.

Comfort

- Uncomfortable temperatures and humidity levels leading to unhappy homeowners.

Energy bills

- Potential or increased energy bills from increased need for home air conditioning.

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[12] "Understanding Overheating - Where to Start" NHBC Foundation, [2012]. URL: zerocarbonhub.org/sites/default/files/resources/reports/Understanding_Overheating-Where_to_Start_NF44

3.2 Complex Interactions

We have now explored examples of common house problems with their potential contributing factors. That is not to say, however, that there is a simple cause and effect relationship between the components of a house, retrofits, and problems or consequences. A HAAS approach is less a formula (e.g., factor A + factor B = consequence C) and more a set of guiding concepts to help improve performance in a complex home system.

Consider yourself as a detective arriving on scene. You arrive to each house with knowledge, expertise, and examples to call on but still, you must treat each project as unique; you gather the evidence of the home's current state, learn information from occupants to get the full picture, and deduce your appropriate next steps from the information you have.

This may seem daunting or like too much responsibility for a single contractor. Remember, your job is not to personally solve all the home's problems. Your job is to "do no harm" with your work. This means avoiding creating issues and identifying existing issues in the home to either fix them directly, recommend the homeowner to have a different qualified contractor fix them, or to understand their potential impact on your work to avoid unintended consequences.

3.3 HAAS Considerations and Solutions

We have now learned some of the reasons why the HAAS approach is important for successful retrofits. This section will now introduce considerations to avoid common house problems and solutions for fixing pre-existing ones. It begins with an overview of HAAS considerations for retrofitting to avoid house problems and concludes with more detailed examples which can be used as reference either for fixing existing issues or unintended consequences of isolated retrofits and avoiding creating them.

Note that this course is not designed to provide comprehensive training on how to install products, but instead to help different contractors identify when it is appropriate to consider other aspects of the house in parallel with their specific retrofit service/product. The HPSC has developed more technically advanced training for some retrofit sectors and these are referenced accordingly in this section. The final section of this course, Creating a Reciprocal Referral Network, will elaborate on the suggestions made in this section to refer to other contractors as needed.

In the following pages, HAAS considerations are explored for the following six types of HAAS solutions:

- Energy Evaluations
- Air Sealing
- Ventilation
- Insulation
- Fenestration (Windows and Doors)

- Heating and cooling Systems

Energy Evaluation

Definition

An investigation performed by a specialist to examine a home's air leakage, insulation, heating and cooling systems, and ventilation to "determine the suitability of the house for improvements and prioritize different energy efficiency measures"[13].

Description

During an energy evaluation an energy advisor will measure and collect data on all the elements of the home that impact its energy performance and then enter that data into an energy simulation software program that calculates the home's EnerGuide rating. The energy advisor collects data such as[14]:

- Airtightness readings and recommendations on air sealing from blower-door tests, visual inspections, and possibly infrared thermography and using smoke pencils/puffers.
- Level of insulation in the walls, basement, and ceiling.
- The number, type and location of all windows and exterior doors.
- The size and efficiency ratings of the space heating, space cooling (air conditioning) and water heating equipment.
- Information about any ventilation equipment.

In Canada, the energy advisor is usually a Natural Resources Canada (NRCan)-registered Energy Advisor who will perform an assessment called an EnerGuide Home Evaluation. According to NRCan, "following the audit, the energy advisor will provide the homeowner with a personalized report with recommendations for upgrades that will have the most impact in improving that particular home's overall efficiency. The report will also include the home's efficiency rating, which the homeowner can use to compare to similar homes in the area, as well as a comparison against their post-upgrades rating"[15].

Benefits

Homeowner

- Comprehensive picture of improvements that can be completed on their home.
- Unbiased recommendations for priority retrofits.
- Baseline data to compare their home's performance before and after retrofits.
- Eligibility for some federal and provincial programs that offer incentives exclusively for homeowners that complete an energy evaluation.
- Access to an energy label and rating that confirms the efficiency of the home and provides a customized comparison of how much energy the home uses compared to a typical new home built to code of the same size, location and design.

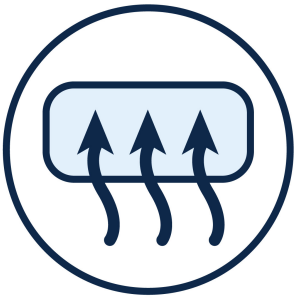
Contractor

- Energy advisors are trained to walk homeowners through the big picture of energy efficiency retrofits explaining the HAAS approach and recommending next steps; this can reduce the time you spend selling the "why" behind your product and services and make it easier for your

company to 'make the sale'.

- An initial home energy evaluation can quantify energy savings for the homeowner; this makes it easier for your customer to see the savings your retrofit has contributed to, increasing their satisfaction and likelihood to recommend/give you a positive review.
- Contractors can ask the homeowner to see their EnerGuide Report, which provides valuable information about energy retrofit potential in the home, including the air leakage rate in the home, where the air sealing is recommended and information to inform heat load calculations and insulation and window retrofits.

HAAS Considerations for Energy Evaluations by Sector



AIR SEALING

An energy evaluation can help identify if the home requires air sealing, how much, and where. Many homeowners do not know about air sealing or understand its importance and might otherwise fail to plan or budget accordingly including air sealing in their retrofit plan.

INSULATION

An energy evaluation can help identify areas of the home where insulation will be most effective for improving comfort and lowering energy use. It can help you make an informed recommendation for each unique home.

VENTILATION

An energy evaluation will typically identify a need for upgrades to ventilation. Ventilation should always be a consideration regardless of the air tightness levels in the home. Air leakage should never be relied on for ventilation purposes as it is inconsistent and incontrollable and may cause moisture accumulation in the building envelope.

WINDOWS & DOORS

An energy evaluation can help the homeowner understand the effectiveness of the home's current windows or doors. If window or door upgrades are recommended, the homeowner will see them in a prioritized order of retrofits.

HEATING & COOLING

An energy evaluation can help identify if the home requires air sealing or insulation, how much, and where. This helps you recommend whether the homeowner should consider air sealing and insulation work first to avoid over or under sizing the heating and cooling systems.

Energy evaluations typically make recommendations for upgrading to more efficient heating systems.

It can also identify if the home should have new energy efficient windows installed which can affect the heating and cooling needs.

REFERRAL OPPORTUNITY

Energy Advisors provide homeowners with a detailed report that outlines recommendations for HVAC, insulation, air sealing, fenestration, and general renovation upgrades based on the energy assessment results. Energy Advisors will be able to direct homeowners to the Home Performance Contractor Network to hire contractors for this work, however, as part of their registration with NRCan they are not permitted to recommend a specific company or contractor's name.

Many contractors have often recommended that a homeowner starts with an energy assessment, as they know that having a third party recommend an energy upgrade can help them make their sale. When rebate programs require an energy evaluation for the homeowner to access a rebate, there is even higher value in contractors referring to an energy advisor.

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[13]"Best Practices Guide for Air Sealing and Insulation Retrofits" BC Housing Research Centre, [2020]. URL: https://www.bchousing.org/publ...

[14] "EnerGuide energy efficiency home evaluations", Government of Canada, [2021]. URL: https://www.nrcan.gc.ca/energy-efficiency/energuide/energuide-energy-efficiency-home-evaluations/20552

[15]"Get an EnerGuide Home Evaluation", BC Hydro Power Smart, [2021]. URL: https://www.bchydro.com/powersmart/residential/building-and-renovating/get-a-home-energy-audit.

html

Air Sealing

Definition

Air sealing is the systematic identification and sealing of air leakage paths (as many as reasonably possible) using materials such as weather stripping, caulking, acoustic sealant, spray foam, polyethylene plastic, backer rod, sheet metal, house wrap, gaskets, and tapes. The intent of air sealing is to limit uncontrolled air infiltration (movement of air into a building) and uncontrolled air exfiltration (movement of air out of a building).

Description

There are two types of air sealing: direct and indirect. Direct air sealing is planned and implemented by the contractor (i.e. spray foaming a plumbing penetration or installing door weather stripping). Indirect air sealing is what occurs when another retrofit is completed (e.g., windows or insulation) and it results in a reduction of air infiltration or exfiltration. Direct air sealing is often the best place to start on home renovation retrofits, unless an energy assessment informs otherwise (e.g., if it is determined that the home is already sufficiently airtight, or if there are other issues to resolve first, such as Radon leaks). Whether or not direct air sealing has taken place, the impacts of indirect air sealing must also be considered for any retrofits.

In all cases, when air sealing has occurred, careful consideration should focus on whether or not there is a need to also upgrade the home's ventilation system (see HAAS Considerations of Air Sealing below).

Benefits

Homeowner

- Improved indoor air quality as air sealing reduces the potential pollutants, allergens, and microbes that can infiltrate into the building from outdoors or from within the building envelope (from air leaks that pass through attic spaces, crawlspaces, walls, etc.).
- Reduced risk of moisture damage (mould or rot) within the building envelope caused by uncontrolled air infiltration or exfiltration.
- Reduced heat loss/heat gain through air leakage means there is less use of HVAC systems, less energy waste, and lower energy bills.
- Increase thermal and acoustic comfort: no drafts, more consistent occupant comfort, quieter home.
- Less dusty and fewer insects due to the elimination of the gaps and cracks that allow the elements from the outdoor to enter the home.
- Shrinks the carbon footprint of the home by reducing the consumption of energy to heat and cool the home.

Contractor

- Greater overall home performance allowing other retrofits such as insulation, HVAC systems, and windows to operate at peak performance, improving customer satisfaction.

Identifying if a Home Needs Air Sealing

Almost all homes, in varying degrees, can benefit from air sealing. Common signs that a home needs air sealing include[16]:

- Customer complaints: occupants identify they are uncomfortable in the home or feel drafts.
- Ice dams: homeowner identifies a history of ice dams in the winter (an indication of air leaks, and/or under-insulated or improperly vented attic).
- High energy bills: occupants identify that they are paying high energy bills
- Visual gaps or cracks: many air leakage locations can be discovered by completing a thorough visual inspection of the building interior, particularly at interfaces in the building envelope (doors, windows, roofline, foundation) and penetrations (plumbing, electrical). On a windy day it is often possible to feel air leakage with your hand around leakage areas.
- Visible signs of air leakage: if you see an accumulation of dirt or dust on the surface of or in insulation (above recessed lighting or top plates in the attic) this is indicative or air leakage. The insulation functions as a filter to capture airborne dust as the air flows through it. Similarly, air leakage around exterior doors, or around exterior walls and floor joists may cause dirt or dust to accumulate on the door frames or in the carpeting near the wall. Dust tracks are a common sign of air leakage.
- Garage attached to home: if there is a garage attached to a home this is a critical area to ensure that there is no air leakage as air leaking into the home from the garage can carry carbon monoxide and other particulates from vehicle exhaust.
- Energy evaluations: more comprehensive techniques such as a blower door test and infrared technology, can be completed by an energy advisor. As noted previously, an energy evaluation identifies and lists the locations where air leakage is found and provides an air leakage per hour quantification how much air is leaking from the home. After air sealing is completed, a second blower door test should be conducted to verify the effectiveness of the retrofit.

HAAS Considerations of Air Sealing

The following are examples of unintended consequences from air sealing retrofits that a HAAS approach can help avoid:

UNSAFE OR POOR INDOOR AIR QUALITY

Increasing the air tightness of a home, without ensuring adequate functioning and use of ventilation systems, may lead to an accumulation of indoor air pollutants and an increase of humidity levels that can impact indoor air quality and occupant health. Further, increasing the air tightness in a home that does not have proper supply ventilation can lead to changes in indoor air pressure. Negative air pressure in a home can cause "back-drafting" where combustion gases (combustion spillage), Radon gas, and other pollutants can be sucked into the home, leading to poor, unsafe, or dangerous indoor air quality.

Moisture

In reducing the amount of air escaping homes, air sealing also prevents the moisture produced inside the home from escaping. Occupants produce a large amount of moisture within homes through activities like cooking, cleaning, washing, or simply breathing. Historically, in older homes, moisture would escape through draughty windows, doors, and chimneys into other (un- or under-insulated) parts of the home that were able to dry out. As airtightness and insulation levels increase in new BC homes, and as air sealing with retrofits becomes more common, all retrofit contractors will need to consider how their work may affect moisture levels in the home due to air tightness.

The solution to addressing moisture issues that can be created by air sealing is to verify the home has adequate ventilation and/or recommend homeowners to consult a ventilation expert. Well planned air sealing retrofits, combined with ventilation retrofits, can help avoid the unintended health and home durability impacts of excessive moisture in the home.

HAAS Solutions for Air Sealing by Sector

Air sealing should always occur before or with insulation retrofits particularly in the attic where air sealing will be impossible after insulating is completed. Air sealing is critical to limit moisture transport into insulated part of the home potentially leading to mould and rot issues.

It is important to note that a reduction in air leakage can be an indirect result of installing insulation. Although most insulation types (cellulose, fiberglass) do not stop airflow they can reduce air leakage. Filling an uninsulated wall with insulation may reduce the amount of air that can easily pass through it. Adding R-30 to an attic space may reduce the amount of air leakage but it is important to acknowledge that the insulation does not stop the air leakage, and that warm, moist, air will still pass through the insulation.

As moist air passes through blown-in or batt insulation, the temperature drops as it gets closer to the outside. It can eventually reach the dew point and lead to the water vapour condensing on the inside of sheathing of walls or on the underside of the attic roof decks potentially leading to moisture damage, mould and rot.

Insulators quoting on attic insulation in homes that have non-airtight recessed (pot) lights, can recommend that homeowners contact lighting contactors or electricians to upgrade their lighting to modern airtight, and insulation contact, recessed lighting. If the homeowner is doing a larger renovation, the recommendation should be to consider removing the recessed lighting and replacing with another type of lighting. The fewer the number of penetrations through the ceiling and into the attic the better for reducing potential for air leakage.

Air sealing in a home, without addition of appropriate balanced ventilation, can create issues with moisture accumulation in the home, indoor air quality issues and, if combustion appliances are in the home, critical issues with combustion spillage.

WINDOWS & DOORS

Replacing a window or door can either positively or negatively impact air leakage in the home depending on the quality of the installation. Contractors should become familiar with proper installation and air sealing techniques around windows and doors to prevent negative impacts. Air sealing in a home, without addition of appropriate ventilation, can create issues with condensation on windows. Recommend the homeowner have their ventilation system inspected or upgraded to ensure appropriate levels of ventilation.

HEATING & COOLING

Ideally, air sealing is completed before replacing the heating system so that the home's heating load is reduced, allowing for a more efficient and potentially smaller sized heating system.
When installing heating systems be sure that any new envelope penetrations created are effectively air sealed.

REFERRAL OPPORTUNITY

Unfortunately, the air sealing industry in BC is not very robust, but with rebate programs increasingly focusing on the HAAS approach and encouraging more deep energy retrofits, air sealing will become an essential retrofit service. There is a business opportunity for contactors to add air sealing into their services or for new specialized air sealing businesses to emerge. The HPSC is developing an air-sealing course if you are interested in becoming trained; more information to come.

Otherwise, make use of your referral network to build relationships with the other trades with air sealing expertise. Many air sealing tasks in a home can fall into the category of general renovations or home maintenance.

Home maintenance companies can be recommended for caulking and sealing, installing weather stripping on doors, sealing and insulating attic hatches and so on.

Painting companies can provide air sealing services as they caulk and seal gaps, cracks and openings on exterior or interior surfaces. Likewise, painting companies that are quoting on exterior painting of homes would be savvy to inform homeowners that if their walls are not insulated, it would be wise to have their wall insulation completed prior to having their home repainted; this way the holes drilled in the stucco or siding can be patched and repainted at the same time as the home is painted.

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[16]"Best Practices Guide for Air Sealing and Insulation Retrofits" BC Housing Research Centre, [2020]. URL: https://www.bchousing.org/research-centre/library/residential-design-construction/best-practices-air-sealing-insulation-retrofits

Insulation

Definition

Insulation is a material used to reduce heat transfer and improve sound proofing in cavities of the exterior walls, foundations and exposed floors.

Description

Insulation slows the transfer of heat between the interior and exterior of a home. By increasing insulation in the building envelope (i.e., walls, floors, roof, foundation, etc.), the rate of heat transfer is slowed down and the more efficient the home becomes. There are priority areas of a home where retrofitting insulation is commonly most effective such as in uninsulated walls, under-insulated attics (under R-30) and crawlspaces. Regardless of whether the homeowner has interest or budget to complete a full home insulation retrofit, best practice is to retrofit insulation as needed whenever other retrofits or general renovation work requires the building envelope to be opened up.

Benefits

Homeowner

- Consistent comfort: a well-insulated home provides for even temperatures throughout a home, keeping occupants warm in the winter and cool in the summer.
- Quiet comfort: insulation also reduces unwanted outdoor noise.
- Smaller heating system: better insulation allows for the use of a smaller and more efficient heating system.
- Save money: reduced energy consumption results in lower utility bills.
- Climate friendly: reduced heat loss means less energy is needed to heat and cool the home, resulting in a smaller carbon footprint.

Contractor

- Upgrading insulation in under or uninsulated areas of the home can significantly reduce heat loss in a home greatly improving homeowner comfort and satisfaction.

Identifying if a Home Needs an Insulation Retrofit

Common signs that a home could benefit from insulation upgrades include:

- On-site inspection or customer interviews revealing:
    - Occupants identify they are not comfortable in their home in winter and/or summer.
    - Walls feel cold to the touch in winter.
    - Occupants identify that they feel their energy bills are too expensive.
    - Occupants have reviewed their energy consumption information (using, for example, the online tools below) and compared their energy use to similar homes nearby and have identified their home is using more energy than it should be.
        - BC Hydro Track Your Electricity Tool
        - FortisBC Track your Natural Gas Consumption
        - Pacific Northern Gas - Understanding your Bill
- On-site inspection revealing:

- Low, uneven, or no attic insulation and/or uninsulated attic hatch.
- Wall check: after turning off the breaker, contractors can remove electrical outlet covers and attempt to visually verify insulation between the electrical box and the drywall. A chop stick, or other non-conductive item, can be carefully poked into the gap to assist identification of insulation. Do not use a metal item for this probing to determine if there is insulation in the wall.

HAAS Considerations of Insulation Retrofits

The following are examples of unintended consequences from insulation retrofits that a HAAS approach can help avoid:

Attic condensation:

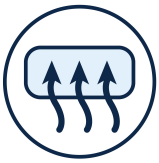
Adding attic insulation can cause, or increase, condensation in the attic. Although under-insulated attics are inefficient and allow for high levels of heat loss, the heat being lost into the attic space also has the unintended benefit of keeping the attic space warm and dry.

When insulation is added to the attic, it will reduce heat loss between the living area and the attic – the desired effect – and consequently, also the space between the insulation and underside of the roof will become colder. Without air sealing in the attic, this can lead to attic condensation when warm, moist air from the main living area rises, through air leakage, into the attic space. When the warm, moist air meets the cold underside of the roof's deck, condensation can occur. When condensation forms in an attic space it makes everything it touches wet - wood framing, rafters, roof sheathing and attic insulation. Moisture in that attic space will potentially lead to wetness, causing mould and rot, further leading to structural damage and possible roof leaks.

Wall moisture

One of the functions of the walls in a home is to provide a barrier against moisture from entering the home from wind driven rain penetration, water due to leaks, or as water vapour via diffusion or air leakage. Although uninsulated walls are inefficient and contribute to heat loss, uninsulated walls are full of air and have the capacity to dry out if they become wet (from the sun warming the walls from the outside or the heating system warming the walls from the inside). When a wall that is insulated becomes wet, from water vapor carried by air leakage, rain penetration, or other causes, it is much more difficult for this area to dry out. Moisture may become trapped in the walls which can lead to expensive repairs to remove dampness, wet insulation, rot, and mould and address structural problems that may have been created[17].

HAAS Solutions for Insulation by Sector



Ideally, air sealing should always occur before insulating. Although challenging any air sealing that can be conducted in the attic prior to insulating should be tackled as it will be impossible to air seal after insulating. Air sealing, on the interior and exterior of a home, is critical to protecting all the components of the building envelope from moisture intrusion which can lead to mould and rot issues.

Ideally, insulation retrofits should take place after air sealing and before and heating system retrofits. This way the home's heating load will be reduced, increasing the effectiveness of subsequent retrofits.

An assessment of appropriate ventilation should be considered with all retrofits.

WINDOWS & DOORS

If the homeowner is residing the exterior of the home and replacing windows, it is best to do it all together as a single retrofit. This is an opportunity to undertake extensive air sealing, add exterior insulation, add a rain screen and reintegrate the new windows and window flashing into the new thicker wall system. Insulation and fenestration contractors will be required to undertake training related to this work to qualify for the HPCN.

Ideally, insulation and air sealing retrofits (if required) are completed before replacing the heating system. This way, the home's heating load is reduced, allowing for a smaller sized and more efficient heating system.

HEATING & COOLING

REFERRAL OPPORTUNITY

Insulation contractors will be required to undertake advanced training to qualify for the HPCN.

Non-insulation contractors can connect with qualified companies in their service region using the contractor directory on the HPSC's Hub.

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[17]"Best Practices Guide for Air Sealing and Insulation Retrofits" BC Housing Research Centre, [2020]. URL: https://www.bchousing.org/research-centre/library/residential-design-construction/best-practices-air-sealing-insulation-retrofits

Ventilation

Definition

In this course, the term "ventilation", which has many different interpretations, describes the natural or mechanical movement of air into or out of a house. The following text from Health Canada summarizes ventilation well:

> "*Natural ventilation describes the air flow caused by pressure differences between the inside and the outside of the house through intentional openings in the building envelope* [e.g., open windows at opposite sides of the house to allow effective cross ventilation]. *Infiltration is also due to pressure differences but occurs unintentionally through cracks in the building envelope. The amount of air movement from natural ventilation and infiltration is usually hard to predict. Mechanical ventilation refers to air flows intentionally created through the use of fans, ducting, and designed openings in the house envelope. These include devices such as exhaust fans, range hoods, and heat or energy recovery ventilators.*
>
> *A century ago, Canadian houses had excessive natural ventilation* [i.e., infiltration/exfiltration] *in winter, resulting in drafts, dry air, and high fuel consumption. Due to an increased focus on reducing heat loss, buildings in Canada have become more airtight. Natural ventilation is generally no longer sufficient and building codes now require some form of mechanical ventilation.*"[18]

Description

Ventilation in a home is important for both occupant comfort, health, and safety and for the proper functioning of the home's other systems.

There are several types of ventilation systems, but this course will only focus on three types: exhaust-only, existing air handler whole-home ventilation, and balanced heat recovery ventilation systems[19].

1. Exhaust-only systems, such as bathroom fans and kitchen range hood fans are the most commonly used ventilation systems in older homes in BC. Exhaust-only ventilation is a one-sided system that typically relies on fans to get rid of stale air and moist air but does not provide any dedicated, controlled, source of fresh air.
2. Existing air handler whole-home ventilation integrates ventilation into an existing heating system. When the furnace circulation fan is turned on, it draws out-door air through the outdoor air duct. This air is then mixed with return air in the return air plenum in order to increase its temperature before it reaches the furnace heat exchanger and the living areas of the house (very cold air passing over the heat exchanger can cause premature deterioration). The outdoor air is then distributed throughout the house by the regular heat-distribution (duct) system.
3. A heat recovery ventilator (HRV) is a type of air-to-air heat exchanger that uses the air being exhausted to warm the incoming outside air, recovering 60 to 90 percent of the heat from exhausted air.

Benefits

Each type of ventilation system has its benefits and drawbacks[20].

Exhaust-only systems

Benefits	Drawbacks

• Simple and relatively inexpensive and easy to install or retrofit to a more efficient model. • Generally, the most cost-effective ventilation system to operate. • Remove indoor-generated pollutants at the source. • Better quality exhaust fans can be quiet, discreet, and more effective than standard exhaust-only systems. • Low maintenance requirements.	• Depressurize the house, which may lead to the infiltration of soil gases (such as radon) and/or back-drafting of combustion appliances. • Replacement air will enter the house through uncontrolled and unintended pathways such as cracks and holes which may introduce pollutants from outdoors or from within the walls or attic. • Moisture from outdoors can be introduced into the building envelope leading to degradation - rot, mold, moisture damage. • Incoming air is not filtered or distributed through the house. • Only provide exhaust ventilation in the areas they are located (bathroom and kitchen areas). • Ventilation rates are difficult to predict due to the variability of the sources of incoming air. • Exhaust-only appliances are not recognized by occupants as a ventilation system, they are only used sporadically in most houses, not sufficiently removing moisture within the home and leading to under-ventilation in tighter homes. • In colder weather, excessive operation of exhaust-only systems can lead to increased heating costs.

While exhaust only ventilation fans may work moderately well in many older homes, a whole-house ventilation system is more effective at providing adequate ventilation[21]. As homes are retrofitted to be more airtight and efficient, a balanced heat or energy recovery ventilation system is the recommended approach.

Existing air handler whole-home ventilation

Benefits	Drawbacks

• Uses existing furnace, heat pump, or AC air handler and existing ductwork, which reduces additional purchase and installation costs. • Provides opportunity to filter and/or temper incoming air. • The system pressurizes the home so outdoor pollutants are not pulled into the home (radon, pollen, vehicle exhaust, etc.). • Can be paired with an HRV/ERV to improve efficiency and provide a balanced system.	• Increases electrical use and system costs, as air handler operates for ventilation when no heating or cooling is needed. • Air handler wattage is usually 300-500 watts. Use of electronically commutated motor (ECM) or other retrofit motor can reduce energy use by up to 80%, but adds to system cost. • Because the system pressurizes the home, in cold climates there is risk indoor moisture can be driven into walls - potentially creating moisture damage, mold and rot. • On the return air side, the system relies on negative pressure to pull in the required amount of outdoor air. This approach is difficult to control and verify air flows. Multi-speed air handlers complicate this problem, since the intake of outdoor air varies with fan speed. • Bathroom and kitchen fans are still needed for localized exhaust. • Requires applying ASHRAE 62.2's Effective Ventilation Rate formula for intermittent ventilation. • Requires homeowner awareness and education on proper operation and maintenance.

Heat Recovery Ventilator (hrv)

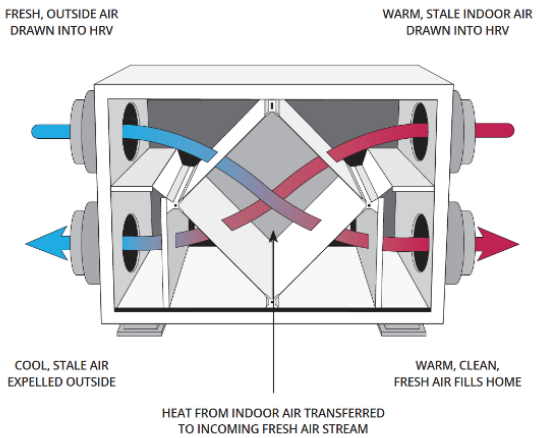

Figure 4 Heat Recovery Ventilator (HRV)

HRV System Benefits	HRV System Drawbacks

• Recovers heat normally lost through conventional ventilation systems, reducing energy costs and the household carbon footprint.
• Stale air is replaced by a supply of fresh air in the home. Air filtration also significantly reduces the particulate concentration in indoor air caused by climate change events such as forest fire smoke.
• Enhanced indoor air quality by exhausting indoor pollutants and introducing filtered fresh air.
• More even temperatures through improved air circulation enhances occupant comfort.
• Minimized pressurization or depressurization of home because of balanced air flow.
• Removes lingering odors from the home.
• Less condensation on windows.
• Protects interior from moisture damage, mold, mildew.

• Generally, HRV retrofits are the most expensive home ventilation option.
• Installation in an existing home can be challenging. Whole home systems required ducting to all (or most) rooms. Air flow must be measured and balanced.
• Needs regular maintenance (changing or cleaning filters) which requires access to the unit and homeowner awareness and education.
• Unfamiliar system for occupants. May not use it accurately.
• Most effective in very tight homes.

Identifying if a Home Needs a Ventilation Retrofit

Common signs that a home could benefit from ventilation upgrades include:

- You (or another contractor hired by the homeowner) are undertaking direct air sealing or completing other retrofits (e.g., window) that may result in indirect air sealing, causing the home to become more airtight.
- On-site inspections or customer interviews revealing:
    - Kitchen or bathroom exhaust fans are not installed or not used regularly or adequately (note: if a fan is too loud, occupants are unlikely to use it regularly).
    - Shaking, rattling, whistling or other noises from ventilation ducts.
    - Hot and colds spots or uneven temperatures in the home.
    - High energy bills. Ventilation systems that ventilate at too high a rate or for too long will increase energy costs for occupants.
    - Condensation on windows and cold surfaces.
    - Visible mould growth, mildew, or musty smells.
    - Poor indoor air quality.
    - Signs of combustion spillage such as health symptoms and discolouration or soot on combustion appliances.
    - Ventilation ductwork is visibly not sealed, kinked, damaged, unconnected, too long, or with too many elbows (see figures 5 and 6 for examples). Even the best ventilation fan will not function effectively if the ductwork is not installed correctly.
- The toilet paper test: while not an accurate test of the effectiveness of a ventilation fan, a simple method to verify if the fan is working is to place a single square of toilet paper on the fan vent. If, when turned on, the fan does not hold up the toilet paper - the fan should be either cleaned, maintained, have ductwork revised or replaced. Note, if the ventilation fan does hold up the toilet paper it still might not be efficiently sized and functioning.

Figure 5 Example of disconnected and leaky ventilation fan ducting (and the ineffectiveness of duct tape for connecting ducts)

Figure 6 Example of disconnected and leaky ventilation fan ducting (and the ineffectiveness of duct tape for connecting ducts)

HAAS Considerations of Ventilation Retrofits

An ideal approach to ventilation retrofits is to have a system that can change the total household air once every three hours, plus providing separate combustion air for fuel-burning heating systems and appliances or consider moving the home to a combustion free system using all electric systems and appliances[22].

The following are examples of unintended consequences from ventilation retrofits that a HAAS approach can help avoid:

Poor indoor air quality

An airtight home without appropriate ventilation (under ventilated) can lead to indoor air quality issues including insufficient air circulation, a lack of fresh air, excessive moisture and humidity, and

increased occupant exposure to a build up of indoor air pollutants and allergens.

Negative Air Pressure

An airtight home with too much ventilation can become depressurized (have negative air pressure) and can create the conditions for back-drafting. If there are combustion heating systems or appliances in the home, back-drafting can lead to combustion spillage. Combustion spillage is an extremely dangerous and potentially life-threatening situation where negative air pressure can cause combustion gases, such as carbon monoxide*, to be sucked into the home[23].

Back-drafting can also lead to radon gas leaking into a home. Radon is a naturally occurring invisible, odourless, and tasteless gas that can be released from the ground. In enclosed spaces, like homes, the gas can accumulate to high levels and cause serious health risks[24].

**IMPORTANT NOTE*

Carbon Monoxide (CO) is an invisible, odourless, tasteless gas. Exposure can lead to serious illness or death. CO is produced from the burning of fuel such as natural gas, propane, wood, oil, gasoline, and coal. This quote from Residential & Commercial Security Company Canada summarizes the risk well:

> *"Normally, the small amounts of CO released by heating equipment in the home are vented outside and do not build up inside, but when the air circulating the rooms and heating systems is not properly vented, or when there is a leakage that causes the rate of CO buildup to be greater than that of the venting, the high levels of carbon monoxide displace oxygen in the blood, resulting in CO poisoning - a blockage of normal oxygen delivery to the tissues. CO poisoning is very dangerous and is often called the "silent killer" because it is hard to detect it until it is too late. Though many victims of CO poisoning recover with treatment, severe cases can cause death or permanent brain damage."*[25]

Air Leakage

Homes with high levels of ventilation and low levels of air sealing can experience air leakage as the negative pressure inside pulls outside air through gaps and cracks in the building envelope. This reduces the efficiency of heating and cooling systems and raises energy bills.

Comfort and Cost

A home with too much or too little ventilation can be unpleasant and uncomfortable, and homes with too much ventilation can be expensive to heat.

Moisture/condensation

Improving the air tightness of the home, without adding or recommending the inspection of appropriate ventilation, can allow excess moisture to accumulate inside the home and condense on cold surfaces such as windows. Additionally, disconnected or leaking ventilation fan ducting will introduce moisture into the building envelope, insulation, or attic space- creating the conditions for mould, rot, and moisture damage.

HAAS Solutions for Ventilation Retrofits by Sector

When any retrofit is completed, contractors can support homeowners by explaining the importance of adequate ventilation and how to operate their ventilation system. The existence and use of effective ventilation systems can positively or negatively impact the success of your product or service. Homeowners with exhaust-only systems should be advised to run bathroom and kitchen fans during showering or cooking and for 15-20 minutes afterward to ensure proper ventilation of moisture. Timers or humidistats are often used on bathroom fans to allow the homeowner to turn it on and have it automatically turn off.

When air sealing, recommend that the homeowner have their ventilation system inspected and upgraded as/if required. Explain the safety concerns behind the recommendation.
Air sealing to reduce uncontrolled air infiltration allows ventilation systems to work more effectively and pull incoming air from a controlled source. In a more air tight exhaust-only home a more effective option can be to install a passive make up air vent so incoming air is not filtered through the building envelope. When homes are made air tight, the recommended system is a balanced heat or energy recovery ventilator.

If homes are needing a ventilation retrofit it is ideal to have this identified prior to attic insulation retrofits, as ventilation retrofits need access to the attic area for addressing ducting and electrical work.

Become familiar with the areas of high or elevated potential for radon exposure in your service areas. Make it standard practice to search for the radon potential for each home you assess using resources such as the Government of Canada and Radon Aware.
Natural Resources Canada identifies that "bathroom and kitchen exhaust fans that vent to the outside are recommended **as a minimum** [for ventilation] to remove odours and moisture produced in those rooms."[26]
For these fans to be effective they must:
• Be quiet. If fans are loud, homeowners will likely turn them off too soon.
• Work! Many older bathroom and kitchen fans make noise but do not actually remove much air or moisture.
• Be properly sized for the space they are ventilating. Care should be taken not to oversize ventilation fans, which is common with modern kitchen exhaust fans.
• Be properly connected to ductwork that is sealed, in good working order, and installed to best practices (ventilation fan ductwork with long runs, or with too many joints are bends may significantly limit the effectiveness of the unit).
• Include a strategy for providing make up air if an exhaust fan over 400 CFM is installed.
• Have the appropriate ventilation exhaust airflow rates (see figure 7). Note these rates are the minimum recommended rates and this level of airflow may not be maintained after installation.

From ASHRAE 62.2 - Table 5-1 Demand-Controlled Local Ventilation Exhaust Airflow Rates

Application	Airflow
Enclosed Kitchen	• Vented range hood (including appliance-range hood combinations): 100 cfm (50 L/s) • Other kitchen exhaust fans, including downdraft: 300 cfm (150 L/s) or a capacity of 5 ach
Non-Enclosed Kitchen	• Vented range hood (including appliance-range hood combinations): 100 cfm (50 L/s) • Other kitchen exhaust fans, including downdraft: 300 cfm (150 L/s)
Bathroom	50 cfm (25 L/s)

From ASHRAE 62.2 - TABLE 5.2 Continuous Local Ventilation Exhaust Airflow Rates

Application	Airflow
Enclosed Kitchen	5 ach, based on kitchen volume
Bathroom	20 cfm (10 L/s)

Figure 7 Appropriate Ventilation Exhaust Airflow Rates
Source: 2019 Building Energy Efficiency Standards - Reference Ace v23

WINDOWS & DOORS

The installation of new windows and doors may, and should, result in a home that is much more air tight (through the installation of better quality products with less air leakage and through quality installation that reduces air leakage at the connections between the new product and the building envelope). Improving the air tightness of the home, without adding or recommending the inspection of appropriate ventilation, may create issues related to condensation and indoor air quality.

HEATING & COOLING

Before installing a heating or cooling system, inspect, or ask the homeowner about, the existing air sealing and ventilation systems. Recommend that they complete air sealing and a ventilation upgrade if necessary.
When conducting maintenance on a home with natural draft combustion heating systems, recommend an upgrade to a high efficiency direct vented heating system or a high efficiency heat pump.
Educate the homeowner on the importance of regular maintenance for all heating systems.
When the homeowner is not willing or able to replace natural draft equipment, they should be advised to have a combustion spillage test to verify the ventilation equipment will not create issues with back-drafting.

REFERRAL OPPORTUNITY

HVAC contractors will be required to undertake advanced training to qualify for the HPCN.

Non-HVAC contractors can connect with qualified companies in their service region using the contractor directory on the HPSC's Hub.

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[18]"Ventilation and the Indoor Environment" Health Canada, [2018]. URL: https://www.canada.ca/en/health-canada/services/publications/healthy-living/ventilation-indoor-envir

onment.html

[19] "Current approaches for mechanical ventilation of houses" J.C. Haysom and J.T. Reardon, [1998]. URL: https://nrc-publications.canada.ca/eng/view/ft/?id=96acba7c-afd4-4ea1-94b0-1f8f3500c582

[20] "Ventilate Right: Ventilation Guide for New and Existing California Homes" United States Department of Energy, [2021]. URL: https://homes.lbl.gov/ventilate-right/system-pros-and-cons

[21]"How to get the ventilation you need in your house" Natural Resources Canada, [2018]. URL: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/16-0114%20Home%20Ventilation_access_eng.pdf

[22]"Ventilation and the Indoor Environment" Health Canada, [2018]. URL: https://www.canada.ca/en/health-canada/services/publications/healthy-living/ventilation-indoor-environment.html

[23] "Combustion Gases in Your Home - Things You Should Know About Combustion Spillage" Government of Canada, [2019]. URL: https://www.nrcan.gc.ca/energy-efficiency/homes/combustion-gases-your-home-things-you-should-know-about-combustion-spillage/18639

[24] "Radon: About" Government of Canada, [2020]. URL: https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/radon.html

[25] "10 Signs of a Carbon Monoxide Leak" Residential & Commercial Security Company Canada, [2021]. URL: https://www.apialarm.com/blog/protection/10-signs-of-a-carbon-monoxide-leak/

Also see, "Carbon monoxide poisoning" Government of Canada, [2020]. URL: https://www.canada.ca/en/health-canada/services/air-quality/indoor-air-contaminants/keep-carbon-monoxide-out-your-home.html#4

[26]"How to get the ventilation you need in your house" Natural Resources Canada, [2018]. URL: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/16-0114%20Home%20Ventilation_access_eng.pdf

Fenestration (Windows and Doors)

Description

Windows and doors are familiar enough that they do not require a definition, per say, but they do have important features worth explaining as they relate to energy retrofits. Beyond the practical uses of windows and doors (e.g., providing access to the home, daylight, and the opportunity to open for fresh air), high efficiency windows also contribute to regulation of temperature, air flow, and moisture in a home, and can better insulate the home from exterior noise.

Windows and doors are efficient when the appropriate products are used and property installed. Energy efficient window products will have:

- Double or triple glazing to increase efficiency while reducing exterior noise.
- Low-emissivity (Low-E) coating to reduce the ability of heat to pass through them preventing heat from escaping a home in the winter and keeping cooler air in a home in the summer.
- Inert argon gas between the window panes prevents heat transfer and minimizes condensation[27].
- Insulated spacers and frames to reduce heat loss[28].
- Other performance characteristics as summarized in the table below from the National Fenestration Rating Council[29].

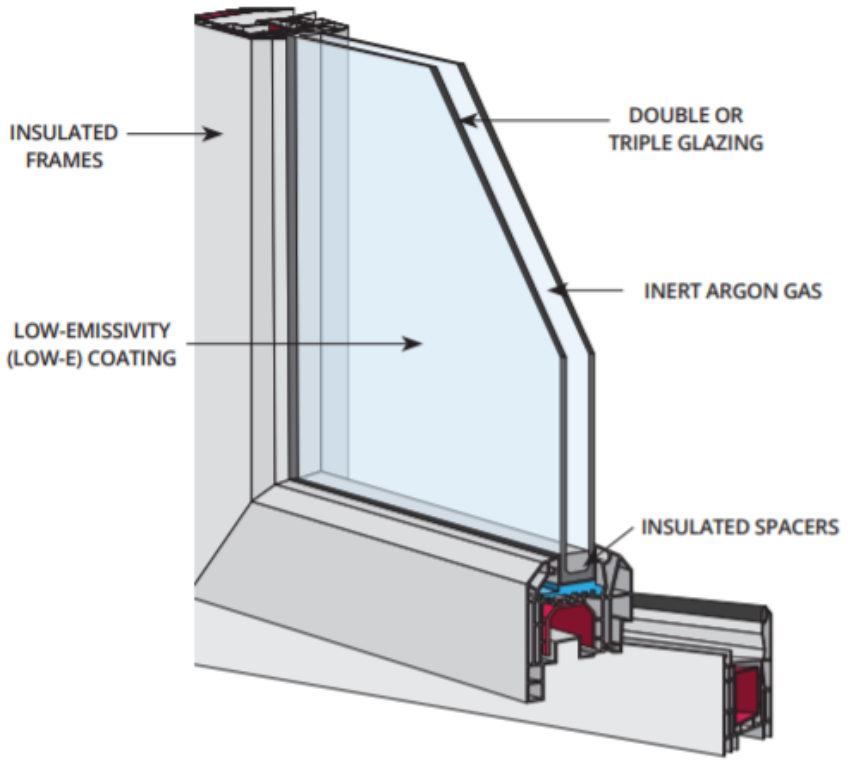

Figure 8 Example of energy efficient window features

Table 1: Other Performance Characteristics of Windows

U-factor	Lower is better	Non-solar heat flow through both glass and frame
Solar Heat Gain Coefficient	Depends on location and orientation of home	Fraction of the sun's energy that hits the window that will enter your home
Visible Transmittance	Higher is better	Fraction of visible light that gets through the window
Air leakage	Lower is better	Measure of the air that can leak through cracks in the window assembly
Condensation Resistance	Higher is better	Measure of water condensing out of air on window surface

Energy-efficient door products may have:

- Double or triple glass panes to reduce heat flow.

- Improved core materials, such as fiberglass, wood cladding and steel with polyurethane foam core.
- A tighter fit and better weather stripping to provide a better seal and reduce air leakage[30].

Benefits of Window Retrofits

Homeowner

Depending on the window installed the benefits can include:

- Improved temperature regulation and comfort.
- Improved aesthetics of the home.
- Decreased need for heating, saving on energy bills.
- Reduced condensation on windows.
- Decreased outdoor noise.
- Protection of furniture, flooring, and artwork from sun damage.
- Enhanced functionality (easier to open and close) and increased security (better locking mechanisms).

Identifying if a Home Needs a Window or Door Retrofit

Common signs that a home could benefit from window or door upgrades include:

- On-site inspections or customer interviews revealing[31]:
  - Single-pane windows.
  - Condensation in between the two panes of glass.
  - Decaying window frames.
  - Air and moisture infiltration around windows.
  - High levels of outdoor noise entering the home through windows.
  - Windows not operating effectively (hard to open or shut).
  - High energy bills.
  - Occupants feel cold next to windows or feel a draft.
  - Hardwood floors, paint, or furniture sun bleached.
  - Deterioration, staining, or mould on materials around windows and doors.
  - Excessive heat gain through windows.
  - Windows outdated and homeowners wanting a 'fresh look'.
  - Windows do not provide the security homeowners are looking for.

HAAS Considerations of Windows and Door Retrofits

Replacing a window or door can either positively or negatively impact the energy efficiency and occupant comfort in a home. The outcome depends on the selection of the appropriate product (previously described) and quality installation. The following are examples of unintended consequences from window or door retrofits that a HAAS approach can help avoid:

Unresolved comfort or energy efficiency issues

Best practice for window and door installations starts with interviewing the homeowner to understand what they are wanting to achieve in their home. If they have overall comfort issues in the home, recommend that the homeowner has an energy assessment conducted, and/or that they consider having their air sealing, insulation, and ventilation checked before the window install.[33] Otherwise, if there are persistent air leaks in the home or inadequate insulation, the homeowner may end up disappointed with the under whelming energy savings or comfort improvements from

high-efficiency windows. Similarly, if they are concerned about condensation on windows, they will not be happy to purchase new energy efficient windows only to have continued issues with condensation because the home lacks adequate ventilation.

Remember that, as discussed earlier, the orientation of a home to solar exposure will also affect how the house operates and the type and placement of windows in these different circumstances can help or hinder the overall temperature control. If your customer is having temperature (comfort) issues, educate them on the possible role their windows and doors may play.

HAAS Solutions for Window and Door Retrofits by Sector

HAAS Solutions for Insulation by Sector

Ideally, air sealing should always occur before insulating. Although challenging any air sealing that can be conducted in the attic prior to insulating should be tackled as it will be impossible to air seal after insulating.
Air sealing, on the interior and exterior of a home, is critical to protecting all the components of the building envelope from moisture intrusion which can lead to mould and rot issues.

Air leakage reductions caused by the installation of new windows may require the installation of additional, or better, ventilation to manage humidity and moisture within the home.

WINDOWS & DOORS

Window and door replacements need to ensure that the gap in the frame between the window or door and the building envelope is insulated and integrated into the air and vapour barrier of the home.

REFERRAL OPPORTUNITY

Fenestration contractors will be required to undertake training to qualify for the HPCN.

Non-Fenestration contractors can connect with qualified companies in their service region using the contractor directory on the HPSC's Hub.

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[27] "Condensation" Government of Canada, [2017]. URL: https://www.nrcan.gc.ca/energy/products/categories/fenestration/18916

[28] "Condensation" Government of Canada, [2017]. URL: https://www.nrcan.gc.ca/energy/products/categories/fenestration/18916

[29]"Energy Performance Label" National Fenestration Rating Council, [2020]. URL: https://www.nfrc.org/energy-performance-label/

[30]"What Makes it Energy Star?" Energy Star, [2021]. URL: https://www.energystar.gov/products/building_products/residential_windows_doors_and_skylights/key_product_criteria

[31]"Best Practices for Window and Door Replacements" Fenestration BC and BC Housing Research Centre, [2021]. URL: https://www.fen-bc.org/resource_details.php?id_resource=8

Heating and Cooling

Definition

Heating systems are systems that generate heat by transforming chemical energy in fuel or electrical energy into thermal energy and transferring that energy to air or water, which then get delivered throughout the home via ducts, piping or distributed zonal heating. Common heating system types include electric baseboards, heat pumps, air furnaces, and boilers.

Cooling systems are systems that reject heat taken from the inside of a home to the outside by utilizing the refrigeration cycle while at the same time dehumidifying the indoor air and actively contribute to air movement in the home. Common cooling system types include air conditioners and heat pump systems.

Some heating and cooling systems can be paired with, or have additional attached equipment, to provide air filtration. Some systems, such as heat pumps, can provide both heating and cooling. Boilers and electric baseboards on the other hand, cannot offer air conditioning, air filtration, or active air movement.

Description

The primary reason for heating and cooling systems is occupant comfort. The type, size, installation quality, maintenance and operation of the heating and cooling systems are important determinants in how efficiently and effectively the systems work in terms of delivering occupant comfort, system durability, and affordable energy bills. For many homeowners, a heating or cooling system retrofit may be an intuitive starting point for their comfort concerns.

However, heating and cooling systems are not the only component in a home's system that affects

occupant thermal comfort. A high-level of air leakage, inadequate insulation, high or low humidity levels, or inefficient windows may also be contributing to the comfort or high energy cost problems and homeowners are likely unaware of these interconnections. Considering this, one of the most important takeaways for a HAAS approach to heating and cooling is the need for homeowner education and for contractors to take the lead in exploring other potential causes for thermal comfort issues.

Benefits

Homeowners

Consumers have many choices and options when selecting a new heating and/or cooling system. Each type of system has distinct benefits. A selection of heating systems and their benefits are provided below:

High Performance air source Heat Pumps

- Year-round comfort: enjoy energy-efficient heating in the winter and cooling in the summer.
- Climate-friendly: in BC, heat pumps are powered by clean electricity and offer efficient heating and cooling.
- Maximum efficiency: heat pumps are the most energy-efficient heating system currently available; they are more efficient than electric furnaces, baseboard heating or natural gas heating systems.
- Indoor air quality: heat pumps provide air filtration that helps rid the home of indoor pollutants, dust, pollen, and other allergens. Heat pumps can provide fresh filtered indoor air, even during period of poor outdoor air quality (e.g., smoke from forest fires). When in cooling mode, heat pumps also provide dehumidification.
- Ease of use: safe, convenient operation, and simple to maintain.

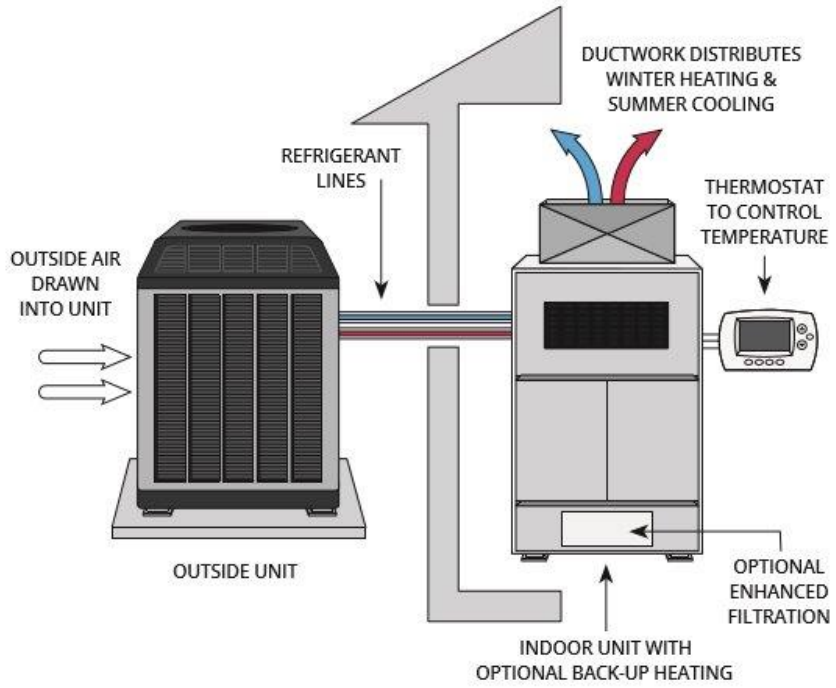

Figure 9 Central Air Source Heat Pump

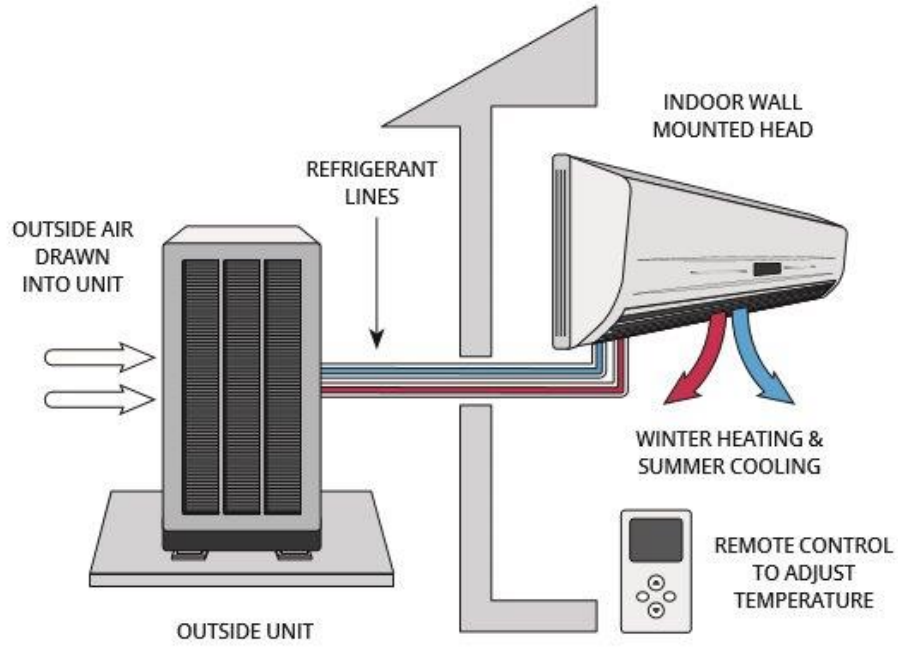

Figure 10 Ductless Air Source Heat Pump

Other types of heat pump systems

- Air-to-water heat pumps, which also extract heat from the outdoor air, but they transfer it into a liquid distribution (hydronic) system. Air-to-water heat pumps can be used for both space and water heating.
- Ground-source heat pumps, which are central heating and/or cooling systems that take advantage of the relatively constant year-round ground temperature and pumps heat to/from the ground. A ground source heat pump circulates a mixture of water and antifreeze through a loop of pipes buried in the ground. In the heating season, the heat from the ground is absorbed into the fluid and then passes through a heat exchanger into the heat pump. In the cooling season, warmth from the home is transferred into the fluid and pumped back into the ground.

Natural Gas Furnaces (Ducted Systems)

- Cost effective home comfort: natural gas heating is typically less expensive than electric heating and can provide cost savings while delivering whole home warmth and comfort.
- Fast heating: brings the home to the desired temperature quickly because the heat produced is hotter than the heat produced by an electric coil or heat pump.

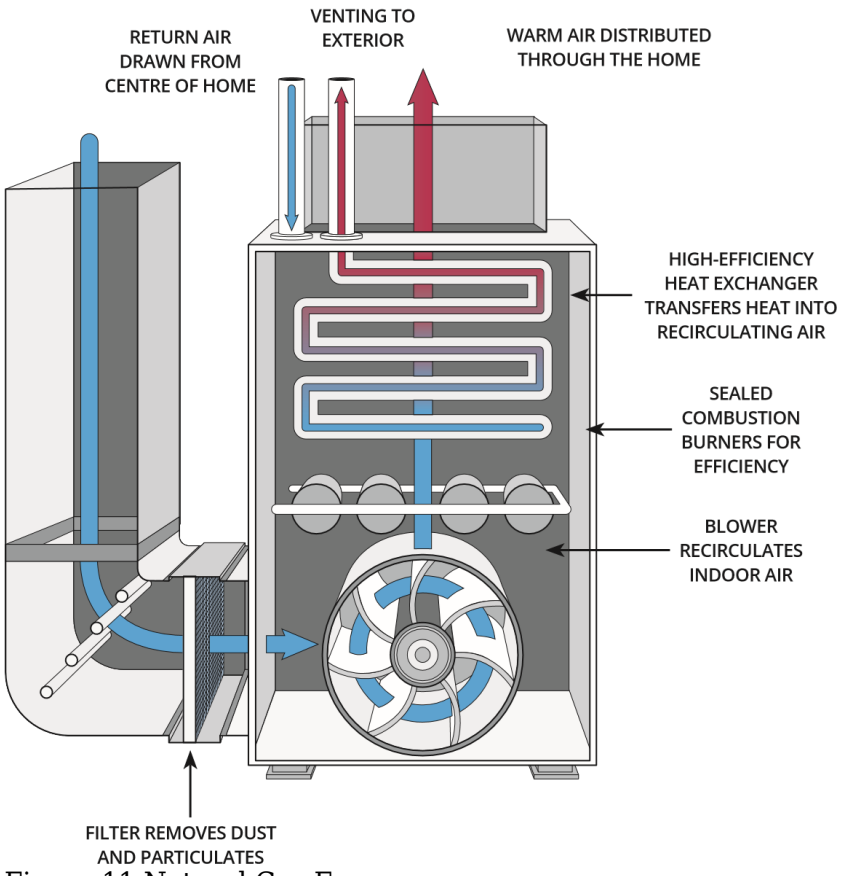

Figure 11 Natural Gas Furnace

Natural Gas Boilers

- Radiant warmth: delivers cost effective radiant warmth evenly and consistently throughout the home, warming occupants' bodies rather than just the air in the room.
- Zonal heating and choice: separate areas or individual rooms can have their own temperature setting, adjusted to occupant preference, with a choice between radiators or radiant floor heating.
- Versatility: options for space and water heating in one system provides versatility and less mechanical equipment in the home.

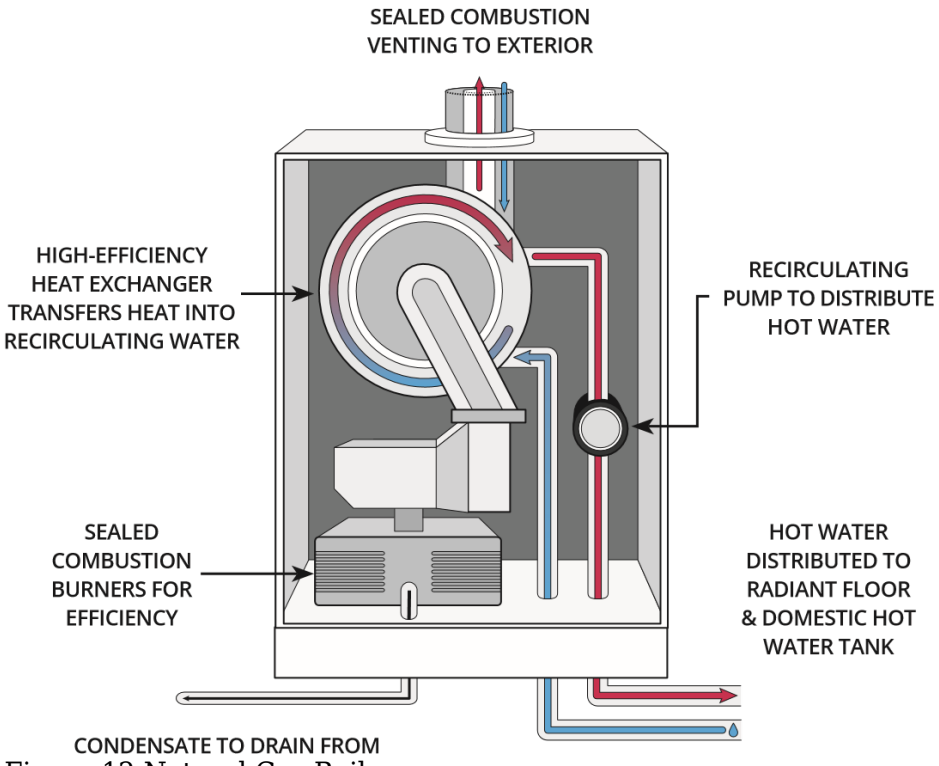

Figure 12 Natural Gas Boiler

Identifying if a Home Needs a Heating or Cooling System Retrofit

Common signs that a home could benefit from a heating or cooling system upgrade include:

- The existence of any oil heating system. Oil heating systems are the most expensive to operate and most carbon intensive heating system on the market. An oil tank leak is a financial and environmental liability for a homeowner and the clean up costs would not be covered by the homeowner's insurance.
- The existence of any naturally drafted combustion natural gas heating system. A naturally drafted system is recognizable by the draft hood. A draft hood serves to isolate the burner from outside pressure fluctuations by pulling varying quantities of heated house air into the exhaust as required and thereby increasing the overall energy consumption of the system.
- For any type of heating or cooling system, an on-site inspection or customer interviews revealing:
    - Annual maintenance inspection identifies the heating system is near end of life.
    - Increasingly frequent repairs are needed.
    - Air sealing, insulation, and window upgrades have been completed and occupants are still too cold in winter and too warm in summer, or there is uneven heat distribution in the home.
    - High energy bills.
    - Heating system is making strange noises.
    - Thermostat needs constant adjustment for the occupants to stay comfortable.
    - Heating system is short cycling.
    - Fluctuations in heat in different rooms of the house.
- Any signs a natural gas furnace is leaking carbon monoxide* which includes:
    - Burner flame for furnace is yellow instead of blue (note: not applicable to natural gas fireplaces that intentionally generate the yellow flame for aesthetic purposes).
    - Streaks of soot around furnace.
    - Absence of upward draft in chimney.

- Rusting on flue pipes or other pipe connections.
- Stale, stuffy or smelly air, like the smell of something burning or overheating.
- The smell of unusual gases in the home; while carbon monoxide is odourless, sometimes it is accompanied by exhaust gas that can be smelled.
- A pilot light that is frequently blowing out.

**IMPORTANT NOTE (reminder from previous section)*

Carbon Monoxide (CO) is an invisible, odourless, tasteless gas. Exposure can lead to serious illness or death. CO is produced from the burning of fuel such as natural gas, propane, wood, oil, gasoline, and coal. This quote from Residential & Commercial Security Company Canada summarizes the risk well:

> *"Normally, the small amounts of CO released by heating equipment in the home are vented outside and do not build up inside, but when the air circulating the rooms and heating systems is not properly vented, or when there is a leakage that causes the rate of CO buildup to be greater than that of the venting, the high levels of carbon monoxide displace oxygen in the blood, resulting in CO poisoning - a blockage of normal oxygen delivery to the tissues. CO poisoning is very dangerous and is often called the "silent killer" because it is hard to detect it until it is too late. Though many victims of CO poisoning recover with treatment, severe cases can cause death or permanent brain damage."*[32]

HAAS Considerations of Heating and Cooling System Retrofits

The following are examples of unintended consequences from heating and cooling system retrofits that a HAAS approach can help avoid:

Oversizing Heating Systems

In homes that are less energy efficient, it may be tempting for HVAC contractors to simply oversize the heating system to ensure there are no customer call backs related to the system not effectively heating the home. However, oversizing heating systems can result in a series of issues. These issues can be made worse, if after the heating system installation, the homeowners also upgrade their windows, insulation, and/or air sealing. Oversized heating systems can lead to a host of problems such as:

- Short cycling: when an oversized furnace, heat pump, or cooling system is too big for the house, it heats or cools the house very quickly and then frequently shuts off and back on, resulting in increased wear and tear and a potentially shorter system life
- Temperature (comfort) issues (inconsistent temperatures and rooms that are too hot or too cold)
- Excessive noise
- More expensive upfront costs and a lost opportunity to buy a smaller and more efficient heating system

Modern variable speed or modulating heating systems can mitigate issues with oversizing but contractor should be focused on ensuring heating systems are properly sized for the home and understanding which equipment will meet the design heat gain/heat loss for the home. Additionally, helping customers understand the HAAS big picture (the importance of the overall efficiency of the

home on heating and cooling systems) rather than simply oversizing the unit, will ultimately result in a better functioning, more efficient home, and a happier customer.

Ducting Issues/Air Leakage

Along with proper heating and cooling system sizing, it is essential that the ductwork be properly sized and installed, or retrofitted, for maximum efficiency, airflow, and indoor air quality. If the indoor air handler is the heart of a heating system, the ductwork are the arteries and veins that deliver heated or cooled air throughout the home and recirculate the air back through the air handler. The duct system has an important role to play in the cost, efficiency, and health of heating and cooling. Sealing ducts, that pass through unconditioned spaces, can also reduce energy consumption by as much as 20%[33] and reduce the amount pollutants that are distributed into the home.

Reduced Air Tightness

When installing heating systems there is potential for the installation process to negatively impact the air sealing of the home. Any penetrations made between the interior and exterior of the home, between the attic space and living space and even into interior walls can increase the air leakage rate in the home. All penetrations made by heating system retrofit contractors into the exterior or interior of the home should be re-sealed and integrated into the drainage plane of the wall system to avoid bulk water leakage.

HAAS Solutions for Heating and Cooling System Retrofits by Sector

Ideally, air sealing (if required) is completed before replacing the heating system so that the home's heating load is reduced, allowing for a smaller sized, more efficient heating system. When new penetrations are created for heating and cooling system retrofit installation, the air sealing needs to be repaired.

Ideally, insulation upgrades (if required) are completed before replacing the heating system. This way, the home's heating load is reduced, allowing for a smaller sized, more efficient heating system. If insulation, and other upgrades, are completed after the fact, there is a potential risk that the newly installed heating system will end up being oversized for the new, potentially smaller, heating load. The risk over a heating system becoming oversized would be dependent on the size of the heating system installed and the efficiency of the home before and after additional, post heating system installation, retrofits.

Before installing a heating or cooling system, inspect, or ask the homeowner about, the existing air sealing and ventilation systems. Recommend that they complete air sealing and a ventilation upgrade if necessary.

To avoid oversizing the unit, consider encouraging the homeowner to also complete an energy assessment and/or air sealing and insulation work. Or ask about their future plans for retrofits and inform them of the potential negative impacts of completing only one upgrade at a time or not taking the future upgrades into the heating system sizing considerations.

HEATING & COOLING

REFERRAL OPPORTUNITY

HVAC contractors will be required to undertake advanced training to qualify for the HPCN. In inefficient homes with many energy retrofit opportunities, installation of a heating or cooling system is the ideal opportunity for HVAC contractors to refer their clients to other contractors for air sealing, insulation and window upgrades.

Non-HVAC contractors: find trained contractors through the network directory to add to your reciprocal referral network.

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[32] "10 Signs of a Carbon Monoxide Leak" Residential & Commercial Security Company Canada, [2021]. URL: https://www.apialarm.com/blog/protection/10-signs-of-a-carbon-monoxide-leak/

Also see, "Carbon monoxide poisoning" Government of Canada, [2020]. URL: https://www.canada.ca/en/health-canada/services/air-quality/indoor-air-contaminants/keep-carbon-monoxide-out-your-home.html#4

[33]"Avoiding Health Pitfalls of Home Energy-Efficiency Retrofits" John Manuel, [2011]. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3040626/

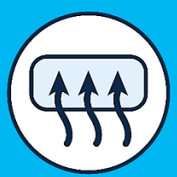
3.4 Putting It All Together

In the previous sections, we have explored why the HAAS approach is important, providing examples of common home problems and their reasons for concern. We then reviewed six key areas of focus for avoiding unintended consequences of retrofits with HAAS solutions for each trade. This information is vital for ensuring the success of retrofits, as BC homes move towards whole-home upgrades.

Now, let us summarize the three major home problems we introduced earlier, provide tools and techniques for identifying them, and practically apply our HAAS knowledge to determine the best

solution to avoid or fix the problem. Where the table explains "how to avoid or fix" the problem, contractors should review to the relevant sections in Section 3.0 Identifying House Issues, Avoiding Creating Them, and Finding Solutions. This is an example of how contractors can take the knowledge from this course and apply it to real-world circumstances.

Table 2: Home Issues and HAAS Solutions

	Tools & Techniques for Identifying Existing Problems Customer interviews or on-site observations, tests, or inspections reveal:				
	• Cold temperature or drafts • Ice dams • High energy bills • Visual gaps or cracks • Visible signs of air leakage • Garage attached to home • Energy evaluation report indicating the need for air sealing • The home is in an area with high or elevated potential for radon exposure	• Kitchen or bathroom exhaust fans are not installed or properly used • Temperature issues • High energy bills • Condensation • Visible mould growth or musty smells • Poor air quality • Signs of combustion spillage • Improperly installed/maintained ventilation ductwork • Failed "toilet paper test"	• Temperature and comfort issues • High energy bills • Walls feel cold to the touch in winter • Low, uneven, or no attic insulation and/or uninsulated attic hatch • "Wall check" identifies need for upgrading wall insulation	• Single-pane windows • Condensation in between the two panes of glass • Decaying window frames • Air and moisture infiltration around windows • High levels of outdoor noise entering the home through windows • Windows not operating effectively (hard to open or shut) • High energy bills • Occupants feel cold next to windows or feel a draft • Hardwood floors, paint, or furniture sun bleached • Deterioration, staining, or mould on materials around windows and doors • Excessive heat gain through windows	• Existence of any oil heating system • Existence of any naturally drafted combustion appliance or natural gas heating system • Heating system is near end of life or increasingly frequent repairs are needed • Temperature issues • High energy bills • Heating system is making strange noises • Thermostat needs constant adjustment for the occupants to stay comfortable • Heating system is short cycling • Any signs a natural gas furnace is leaking carbon monoxide
Problems to Fix/Avoid	Excess Moisture Poor Indoor Air Quality	Excess Moisture Poor Indoor Air Quality Overheating	Overheating	Excess Moisture (less common) Overheating	Poor Indoor Air Quality Overheating
How to Fix/Avoid	 Complete Air Sealing	 Ensure Appropriate Ventilation	 Ensure Adequate Insulation	 Ensure Appropriate Window Selection and Installation	 Inspect or Upgrade Heating or Cooling System

Download a copy of table 2 for easy reference on the job site.