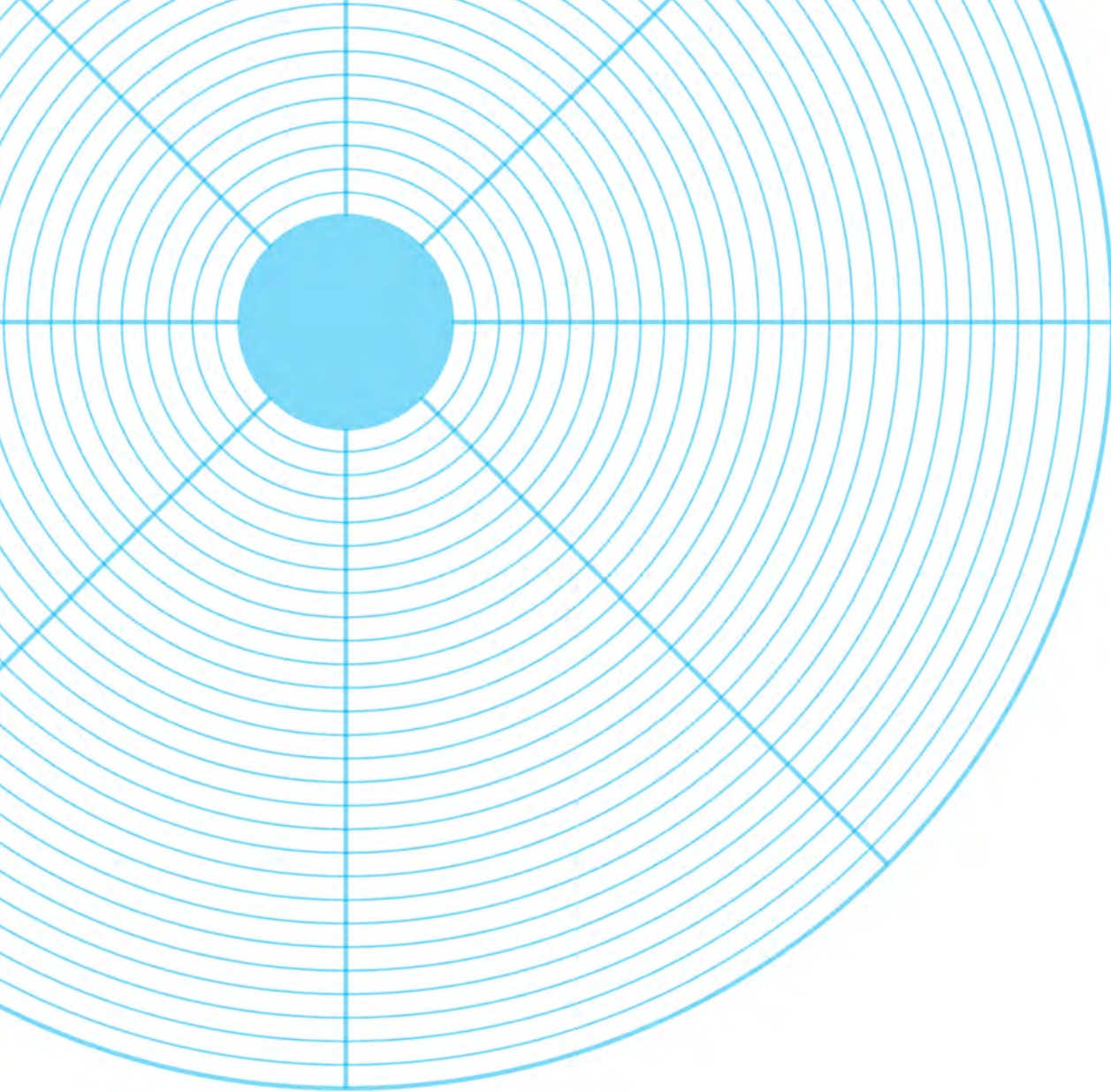




HEAT PUMP RETROFIT BEST PRACTICES GUIDE FOR CONTRACTORS

Version 2



Acknowledgements

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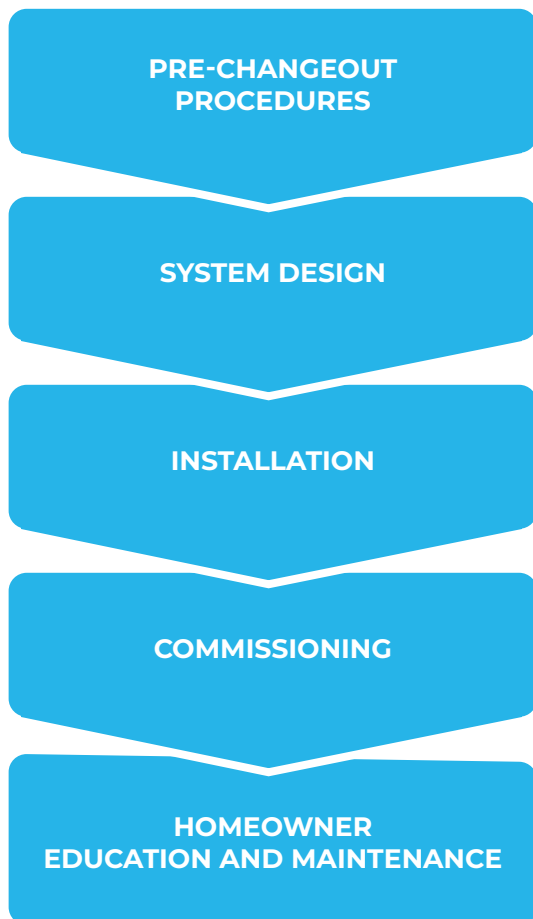
Introduction

This guide is an update to the Heat Pump Best Practices Installation Guide for Existing Homes published by the Home Performance Stakeholder Council (HPSC) in 2019. The guide supports the ongoing training of retrofit contractors toward high-quality heat pump installations. It serves as a standalone best practice document as well as a companion guide to HPSC's contractor training "Quality Installation of Forced Air Furnace and Air Source Heat Pump Retrofits in BC Homes." The guide is not intended to replace other residential heat pump training materials developed for heating, ventilation, and air conditioning (HVAC) contractors.

The content of this guide focuses on air source heat pump (ASHP) solutions, reflecting advances in the industry. It provides you with best practices for pre-changeout procedures, system design (sizing and selection), installation, commissioning, and homeowner education and maintenance.

GUIDE ORGANIZATION

The best practices in this guide support a planned approach to heat pump retrofits. The core steps of this approach are outlined below (**Figure 1**) and provide the organizing principle for this guide. Through proper sizing, installation, and performance verification, a heat pump retrofit can achieve significant benefits such as occupant comfort, energy savings, and carbon reduction.



TYPES OF HEATING SYSTEMS

The heating system types covered in this guide are summarized below.

Ductless all-electric heat pump:

Often referred to as a 'mini-split' or 'multi-split' system, this is an all-electric ASHP with one or more indoor units that directly condition a space (without ducting). Some systems may have small sections of ducting to connect smaller spaces with a single indoor unit (sometimes called a concealed duct system).

Centrally ducted all-electric heat pump:

This is a centralized all electric ASHP consisting of a single outdoor unit and single indoor unit that, in a retrofit application, typically connects to existing distribution ductwork (previously connected to a forced air furnace).

Centrally ducted dual fuel heat pump:

Sometimes referred to as hybrid heat pumps, these systems replace an existing forced air furnace with an electric ASHP coupled to a supplementary gas furnace, controlled by a single thermostat.

Figure 1 Steps for Installation Best Practices

Pre-Changeout Procedures

This section provides guidance on best practices for pre-changeout procedures. You can use these best practices to understand a home's existing HVAC system and overall performance, and thereby inform your approach to proper heat pump sizing and equipment selection.

Two commonly overlooked steps to support informed decision-making and recommendations for a new heat pump are homeowner discovery and a system performance assessment.

HOMEOWNER DISCOVERY

Homeowner Discovery is a process of gathering information from homeowners to better understand their expectations and needs. When asked the right questions, homeowners can share useful insights on their existing HVAC system performance, and their motivations for investing in an upgrade.

When you are gathering input from homeowners, consider asking the following questions:

QUESTIONS FOR HOMEOWNERS	RELEVANCE TO CONTRACTOR
☒ Have you completed or are you planning other energy upgrades?	The answer to this question will help the contractor understand the building's overall performance and may influence heat pump sizing.
☒ What is your existing heating and cooling system and what is your experience with that system?	This question allows the contractor to explore whether the homeowner has experienced hot or cold rooms, noisy ductwork, equipment short cycling, or other issues.
☒ What are your motivations for upgrading to a heat pump?	A homeowner might be interested in upgrading to a heat pump due to environmental considerations, interest in home cooling options, accessing rebates, or other reasons. This information helps shape the contractor's approach to their proposal. For example, a homeowner whose top priority is reducing emissions might prefer a different solution to a homeowner whose top priority is minimizing heating costs.
☒ Have you considered or identified potential locations or limitations for heat pump outdoor unit placement?	It can be challenging to find a suitable location that does not compromise outdoor living space and meets municipal requirements (e.g., setbacks and noise considerations). The opportunity to collect feedback on potential locations from the homeowner's perspective will help inform the contractor's installation options.
☒ For those without a centrally ducted existing system: Do you have any preferences for the appearance, style and location of indoor equipment (e.g., floor-mounted, wall-mounted, concealed, etc.)?	This can be a good opportunity for the contractor to help homeowners understand the options available and any associated considerations (cost, aesthetics, space constraints, maintenance access, future flexibility etc)

HOUSE AS A SYSTEM

A house is considered a multi-component system where all components are connected (**Figure 2**). Components include the heating system, the building enclosure (also called the envelope), and other electrical and mechanical systems. Any change to one of these systems in the building will have an impact on the other systems. For example, adding insulation or improving the airtightness of a home will reduce its heating and cooling load.

Enclosure improvements may include adding insulation to the exterior walls, roof, basement, or crawl space; air-sealing the attic or known gaps; or upgrading the windows. These improvements may reduce the required size of a new heat pump, and ideally, they would be made prior to selecting and installing the new heat pump. They may also enable a home to avoid an electrical service upgrade where capacity is identified as a concern.

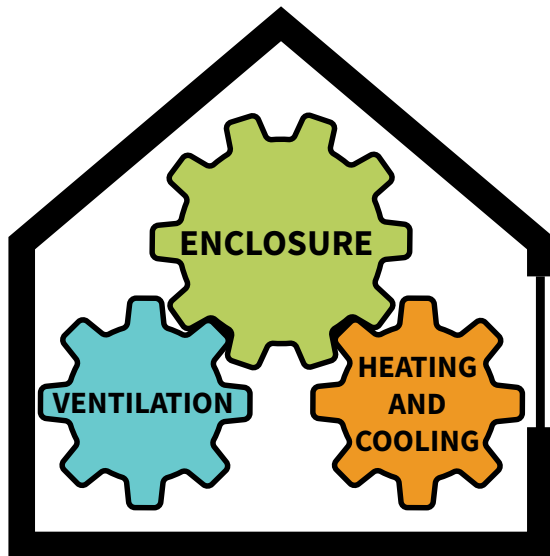


Figure 2 Interacting Systems in a House

PERFORMANCE ASSESSMENT

A performance assessment of the existing equipment is critical for gathering the empirical data to inform heat pump options and potential limitations. Several types of performance assessments are described below.

ASSESSING ELECTRICAL CAPACITY

Prior to installation, the electrical contractor will assess the home's electrical loads to determine whether the existing electrical system has sufficient capacity to support the new heat pump system, including any supplementary heating. If the results indicate that the new electrical load would exceed the current capacity of the home, a service upgrade may be required.

These two procedures can be used to evaluate electrical loads:

- Meter Data Method* (preferred method, approved by Technical Safety BC):** This method uses the actual maximum electricity demand of the home over a 12-month period. The demand is approximated as the maximum hourly consumption (kWh) plus an intermittent peak safety factor of 25%. New loads are added to the existing load to calculate the new demand.
- Traditional Method:** If a homeowner moved into the home within the last 12 months, the required utility data will not be available. In this case, a standardized calculation may be used. This method estimates how much electricity the home uses based on the square footage of the home and industry averages of electricity usage for all. This estimate is then compared to the current electrical service capacity of the home.

* Instructions for homeowners on how to download electrical demand information can be found on BC Hydro's website:

<https://app.bchydro.com/accounts-billing/rates-energy-use/home-electrical-capacity-data.html>

PLANNING FOR NON-DUCTED AND CONCEALED DUCT SYSTEMS

Homes that do not already have a centrally ducted system will likely be suited to non-ducted or concealed duct heat pump systems:

- **Non-ducted systems** – systems that include either single or multiple indoor units connected to an outdoor unit.
- **Concealed duct systems** – systems that serve multiple spaces with a single indoor unit by connecting spaces with short duct runs.

During your pre-changeout evaluation for these types of systems, you can assess potential locations for indoor units and duct runs as applicable. For example, you might consider whether the home has any dropped ceilings that could accommodate ducts. Your pre-changeout evaluation must include an assessment of zone-by-zone or room-by-room heat load analysis. This analysis will determine how zones can be effectively heated without significant oversizing of indoor heads or the outdoor unit.

EVALUATING CENTRALLY DUCTED EXISTING SYSTEMS

A key step in planning for a heat pump retrofit is evaluating the existing ductwork condition and capacity. The existing furnace in a home may have been oversized and/or the ductwork may have been undersized. Other changes, such as enclosure upgrades may have been implemented, and a heat pump may operate at a different cubic feet per minute (CFM) of air flow than the equipment being replaced.

Your ducting performance assessment is also an opportunity to propose improvements to the distribution system through accessible ductwork modifications such as improved transitions, duct sealing, etc. You may also propose enhancements, such as adding return-air, improved filtration (e.g. 50 mm (2") or greater thickness pleated filter), etc.

As part of the performance assessment, best practice is to complete external static pressure (ESP) testing and calculations. These calculations will determine whether the existing ductwork and fittings are adequate for system distribution. They will also give you insight into whether the new

heat pump will have enough air flow to operate effectively. This practice is especially important when homeowners have concerns with heat distribution, or when other potential issues have been identified around equipment capacity, duct capacity, or available electrical service.

Air flow testing technologies such as the True Flow Grid allow HVAC contractors to gather CFM readings using a device that provides an accurate measurement of airflow through a residential air handler. CSA C750:25 - Airflow and static pressure measurements in residential ductwork systems provides guidance on how to complete these tests.

The combination of static pressure testing, ductwork measurements, and air flow testing (**Figure 3**) is the most comprehensive approach to understand existing ductwork capacity and to inform heat pump sizing and selection.



Figure 3 Testing Existing Ductwork Capacity - Static Pressure Test (Supply Only Location)

Best practice procedures for assessing ductwork are detailed in CSA C750: Airflow and static pressure measurements in residential ductwork systems.

DETERMINING DUCTWORK CAPACITY – GENERAL TESTING INFORMATION

As air flow increases, the static pressure increases exponentially. Therefore, it is critical for you to understand ductwork capacity for equipment sizing and selection. Equipment manufacturers publish the maximum Total External Static Pressure (TESP) for installed systems on the rating plate of air handling equipment. A typical manufacturer range for TESP could be 13 mm (0.5") to 20 mm (0.8") water column (W.C.) to allow proper equipment performance. Since ductwork is a fixed size, it limits how much air will flow through it.

To accurately evaluate duct capacity, take static pressure readings at a known air flow (usually in CFM). Three methods are available to determine the CFM from existing forced air equipment:

METHOD #1 (RESEARCH)

Review the equipment installation manual and look up the blower CFM based on the model, dipswitch settings, static pressure information, and blower setting.

METHOD #2 (TEMPERATURE RISE)

Use the sensible heat formula:
 $1.08 \times \text{CFM} \times \Delta T = \text{BTU/h output}$

Identify the furnace BTU/h output, take the temperature rise measurement, and then rearrange the above formula to:
 $\text{BTU/h output} / (1.08 \times \text{temperature rise}) = \text{CFM}$

Example: 56,000 BTU/h output / (1.08 * 52.9°F temperature rise) = 980 CFM



Figure 4 Testing Existing Ductwork Capacity
- Air Flow (Flow Grid)

METHOD #3 (MEASURE)

Measure the CFM of a forced air heating system using available tools and devices with one of these three options:

- **Option 1: Filter Slot Airflow Grid Method**
 A filter slot airflow grid temporarily replaces a filter in a filter slot to measure airflow (**Figure 4**). Measurements of static pressure in the supply side of the system are used to correct the actual measured airflow to include the impact of the filter. This correction may be done automatically by the measurement device or may need to be done manually.
- **Option 2: External Blower Method**
 This method requires an external blower that is often used for duct leakage testing. The external blower concurrently generates and measures airflow. The external blower is connected to the air handler cabinet and the return ducting is blocked such that all airflow must travel through the external blower and then through the supply side of the system. Both the existing blower and external blower are used to generate airflow. In normal operating conditions, the airflow measurement is determined by adjusting the airflow through the external blower until the supply static pressure matches that in normal operating conditions.
- **Option 3: Duct Traverse Method**
 A duct traverse is completed in the return or supply side of the system in accordance with ANSI/ASHRAE 41.2-2022. Air velocity measurements at different points across a duct cross section are used to determine the airflow measurement.

WORKED EXAMPLE: EXISTING DUCTWORK CAPACITY EVALUATION

This worked example evaluates the existing ductwork capacity and sizing options of a home in Burnaby.

This home has an existing **mid-efficiency gas furnace** rated for **70,000 BTU/h (21 kW) (input) / 56,000 (16 kW) (output)** that covers 100% of the heated floor area.

The contractor has completed a heat loss calculation (using CSA F280-12) and made a preliminary selection of a new 3.5-ton electric heat pump with a rated output of **42,000 BTU/h (12 kW)**.



F280-12 DESIGN HEAT LOSS (DHL)
33,362 BTU/H

F280-12 DESIGN HEAT GAIN (DHG)
18,949 BTU/H

HOME CHARACTERISTICS

LOCATION: BURNABY
(CLIMATE ZONE 4)

YEAR BUILT: 1980

The existing ductwork capacity is measured using the Filter Slot Airflow Grid Method, with the following results:

LARGE DUCTWORK	MEDIUM DUCTWORK	SMALL DUCTWORK
980 CFM @ 0.30 in. W.C. (current furnace on high-fire)	980 CFM @ 0.40 in. W.C. (current furnace on high-fire)	980 CFM @ 0.50 in. W.C. (current furnace on high-fire)

Now that the CFM and Static Pressure (SP) are known, a simple calculation based on the new equipment's rated full-load CFM will show the expected SP of the existing ductwork system.

- Fan Law #2: $SP_2 = SP_1 * (CFM_2/CFM_1)^2$
 - Example using medium ductwork: $CFM_1 = 980 \text{ CFM at } 0.40'' \text{ W.C.}$
 - New heat pump: $CFM_2 = 3.5 \text{ tons at } 400 \text{ CFM/ton} = 1,400 \text{ CFM}$
- Calculation example: $0.4 * (1,400/980)^2 = 0.816'' \text{ W.C. (SP}_2)$

WORKED EXAMPLE, CONTINUED

This calculation provides the following results:

LARGE DUCTWORK	MEDIUM DUCTWORK	SMALL DUCTWORK
1,400 CFM @ 0.612 in. W.C. (new heat pump full output)	1,400 CFM @ 0.816 in. W.C. (new heat pump full output)	1,400 CFM @ 1.020 in. W.C. (new heat pump full output)

From the pre-changeout air flow testing for this home, the existing ductwork could therefore accommodate a **3.5-ton heat pump** with large ductwork and medium ductwork but not small ductwork (without further modifications). The options to address a heat pump retrofit with smaller ductwork may include:

- Ductwork modifications to reduce static pressure.
- Split system added with centrally ducted 3-ton heat pump and one ductless head.
- Supplemental electric heat kit added to the heat pump.
- Switch to a dual fuel system with gas furnace + heat pump (in colder conditions, the furnace can provide heating at a similar CFM to the existing system, and in warmer conditions, the heat pump does not need to supply its full-load CFM).
- Larger 100-125 mm (4-5") sealed filter cabinet (**Figures 5 and 6**) to provide comparable air filtration with less airflow resistance.



Figure 5 Example of Larger Filter

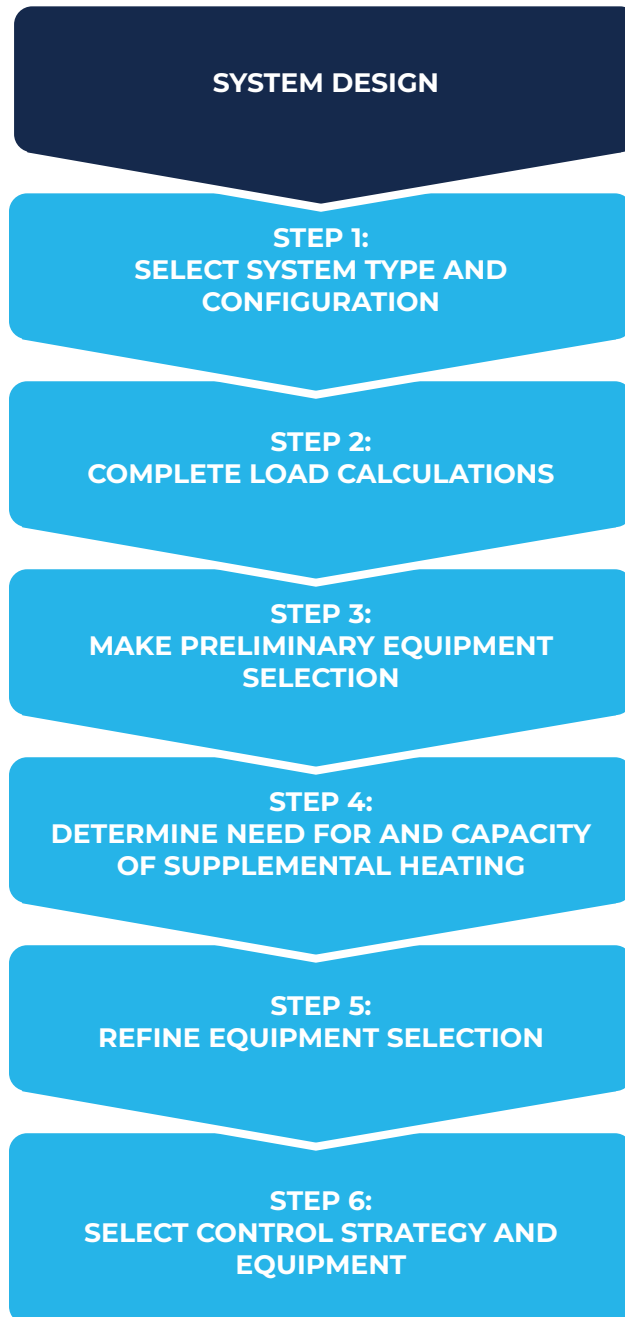


Figure 6 Filter Inside a Cabinet (left) and Sealed Cabinet (right)

System Design

Heat pump system performance and occupant comfort depend on proper system design. This process includes proper system sizing, equipment selection, and consideration of how the new system will interact with any existing systems. System design is an iterative process. The key steps are outlined below (**Figure 7**) and discussed on the following pages .

Figure 7 Steps for ASHP System Design



STEP 1: SELECT SYSTEM TYPE AND CONFIGURATION

Based on the pre-changeout evaluation, make a preliminary selection of the system type and configuration. The information you gathered about the home and the homeowner will likely point toward a centralized vs. decentralized vs. semi-centralized/mixed approach, and single vs. dual fuel. **Table 1** shows suitable heat pump options for existing heating systems and regions. Consider these options in concert with the homeowner's preferences and desired outcomes.

TABLE 1: HEAT PUMP OPTIONS FOR EXISTING HEATING SYSTEMS AND REGIONS			
EXISTING HEATING SYSTEM	REGION/LOCAL WEATHER CONDITIONS	SUITABLE HEAT PUMP APPROACH	SUPPLEMENTARY HEATING SYSTEM
Electric Baseboards	Lower Mainland and Vancouver Island (Moderate Winter, Design Temp > -8°C (18°F))	Ductless or Concealed Duct	Not required when installing a cold climate heat pump that is sized for the home's design heat load and has an operating range that covers the lowest temperature expected for the area (i.e., the 20-year minimum). May be needed for rooms not adequately served by the new indoor head(s).
	Southern and Northern Interior (Cold Winter, Design Temp < -8°C w(18°F))	Cold Climate Ductless or Concealed Duct	Existing heating system, where necessary.
Forced Air Central Heating (Gas/Oil/Electric Furnace)	Lower Mainland and Vancouver Island (Moderate Winter, Design Temp > -8°C (18°F))	Centrally Ducted (combined with Ductless), Ductless (Multi-Head or Multiple Units), Concealed Duct, or Dual Fuel	Can use existing heating system; electric resistance coil in air handler, or dual fuel system.
	Southern and Northern Interior (Cold Winter, Design Temp < -8°C (18°F))	Cold Climate Centrally Ducted (combined with Ductless), Ductless (Multi-Head or Multiple Units), Concealed Duct, or Dual Fuel	Existing heating system; electric resistance coil in air handler, or dual fuel system.

STEP 2: COMPLETE LOAD CALCULATIONS

Correct sizing of the heat pump system is critical to its efficiency and performance. The overall system, including any supplementary heating, needs to provide the required heating and cooling capacity at the local outdoor design conditions. If the heat pump capacity is too low, the system will likely need to defrost more frequently during heating operation. A home with an undersized heat pump may also rely too much on the supplementary heating system during colder weather, increasing overall operating costs.

The extra running costs of an undersized ASHP system generally outweigh the additional cost of installing a larger unit. However, an oversized heat pump system can present significant issues as well, such as excessive cycling and poor performance at warmer temperatures. **A better practice is to select equipment that most closely meets the calculated load.** However, in cases where duct capacity is an issue that is not easily addressed through duct improvements, an effective solution may be a smaller capacity, centrally ducted ASHP coupled with mini-split (ductless or concealed duct) systems. A dual fuel approach may also be suitable in these cases.

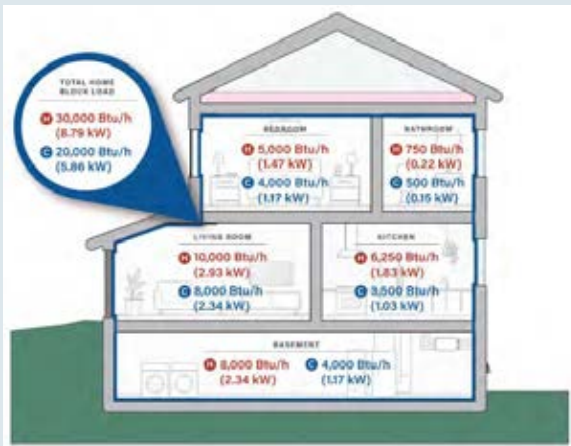
Current best practice and the prescribed approach to access provincial rebate programs is to follow the heat load calculation methodology and associated tools described in CSA F280-12: Determining the required capacity of residential space heating and cooling appliances. Any rule-of-thumb approach to equipment sizing without an actual load calculation. This approach could be problematic because the existing space heating equipment may not have been sized correctly and existing home conditions may have changed.

HVAC Designers of Canada has published a list of verified software tools¹ that are compliant with CSA F280-12. By using verified software, both the HVAC contractor and those who rely on the software outputs will have confidence that the results will be in line with the CSA standard.

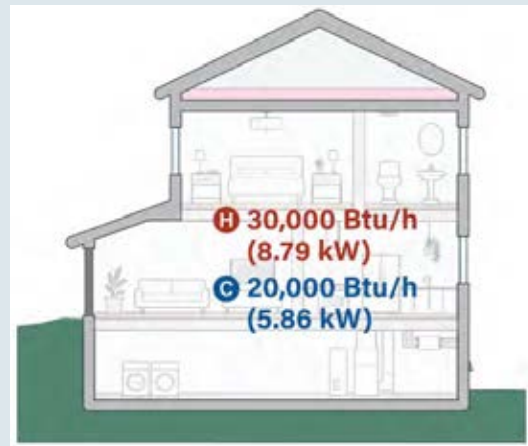
A CSA F280-12 compliant load calculation can be completed using a room-by-room or whole-house approach.

¹ HVAC Designers of Canada maintains a list of verified software: <https://hvacdc.ca/f280-12-software/>

Room-by-room calculations provide the heating and cooling requirements for the individual rooms along with a total design heat loss and heat gain for the home. This approach is appropriate for retrofits with major ducting modifications, homes with identified “problem” areas to be addressed, and/or homes using distributed (ductless) or concealed duct systems.



Whole-house calculations provide the total heating and cooling requirements for the entire conditioned space of the home. This approach is appropriate for retrofits to central ducted systems with adequate existing distribution. This approach is not to be confused with BTU/h per sq. ft. calculations which is a rule-of-thumb approach.



An accurate heat load calculation requires attention to detail on key components that contribute to the design heat loss and gain. This includes building location, indoor design conditions, orientation, and building construction. The use of F280-12 verified software to calculate heating and cooling loads simplifies the process. **Table 2** lists critical inputs for HVAC contractors to ensure an accurate load calculation:

TABLE 2: LOAD CALCULATION KEY INPUTS	
COMPONENTS	DETAILS
Design Conditions	• Building location • Building orientation • Building construction • Outdoor design temperature • Indoor design temperature and humidity
Building Conditions	• Insulation (R-values) of walls, ceilings, and floors • Window size and performance (U-values and solar heat gain coefficient) • Infiltration (air leakage) rates • Ventilation • Interior and exterior shading

CONTRACTOR TIP

Natural Resources Canada's Local Energy Efficiency Partnerships team has developed an Air Source Heat Pump Sizing and Selection App. The app helps HVAC designers and contractors identify important factors that should be considered to determine potential heat pump solutions in both new-builds and retrofits of existing homes.

https://heatpump-tool-outil-thermopompe.nrcan-rncan.gc.ca/?_gl=1*ix58hg*_ga*MTA0MjE1ODU4My4xNjc4NDkwODM4*_ga_C2N57Y7DX5*cze3NTc0MzY0NjAkbzU0JGcwJHQxNzU3NDM2NDYwJGo2MCRsMCRoMA

STEP 3: MAKE PRELIMINARY EQUIPMENT SELECTION

The pre-changeout procedures will inform your initial selection of system type and configuration. At this stage, you may have narrowed your equipment options to those within range of meeting the design heating load. From here, an evaluation of the balance point and the need for/extent of supplemental heating will allow for selection refinement.

CALCULATION OF THE CAPACITY BALANCE POINT

For you to properly size and select equipment, and determine the need for supplementary heating, it is critical to understand the capacity balance point.

The following definitions will help you understand the capacity balance point calculation.

Set temperature is the setting defined by program requirements as the maximum temperature that can be used as the set point for the high ambient temperature switch-over, or the setpoint for simple switch-over control.

Thermal balance point is the temperature below which the heat pump does not have enough capacity to meet the heating needs of the building on its own. The thermal balance is calculated using inputs from a heat load calculation of the home and the capacity ratings of the installed heat pump.

Economic balance point is the temperature below which the ratio of electricity to natural gas means that using the supplementary gas furnace is more cost effective. The economic balance is calculated using the efficiency of the heat pump and the furnace, and the cost of electricity and gas.

High ambient temperature switch-over, also known as auxiliary or furnace lock-out temperature, is the maximum outdoor temperature that the auxiliary heat source is programmed to operate at; above this temperature only the heat pump will operate (except during defrost cycles).

Low ambient temperature switch-over, also known as the compressor lock-out temperature, is the minimum outdoor temperature that the heat pump is programmed to operate at; below this temperature, only the furnace will operate.

Heat pump minimum operating temperature is the minimum ambient temperature that the heat pump can operate, as specified by the equipment manufacturer. The minimum operating temperature of a heat pump is typically between -15°C (5°F) to -25°C (-13°F), although some cold climate heat pumps can work down to -30°C (-22°F).

You can calculate the capacity balance point by plotting the heat loss of the home against the performance curve of the heat pump*. This plot will ensure the equipment meets the necessary heat load at the outdoor design temperature where the home is located. The performance curve of a heat pump will vary between various technologies, brands, and models of heat pumps. This means **there is no such thing as a universal balance point**.

For dual fuel solutions, it is **not** best practice to size both the heat pump and the furnace to full-load. Several balance point examples are shown on the next pages.

* A toolkit for air source heat pump sizing and selection can be found on Natural Resources Canada (NRCAN)'s website:

<https://natural-resources.canada.ca/energy-efficiency/toolkit-air-source-heat-pump-sizing-selection>

WORKED EXAMPLE: BALANCE POINT CALCULATION

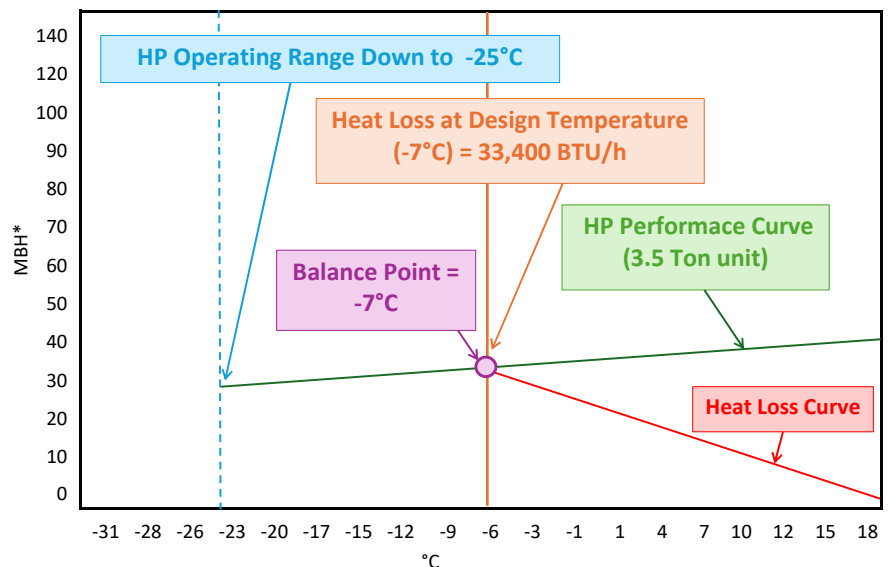
The table below summarizes the design heat loss (DHL) and design heat gain (DHG) for the home in the worked example, along with the balance point plots for two design options in each of three climate zones (Design Temperature, DT).

	BURNABY	KAMLOOPS	PRINCE GEORGE
DHL	33,362 BTU/h	48,362 BTU/h	64,772 BTU/h
DHG	18,949 BTU/h	24,832 BTU/h	19,249 BTU/h
DT	-7°C (19°F)	-23°C (-9°F)	-31°C (-24°F)

Burnaby (Climate Zone 4)

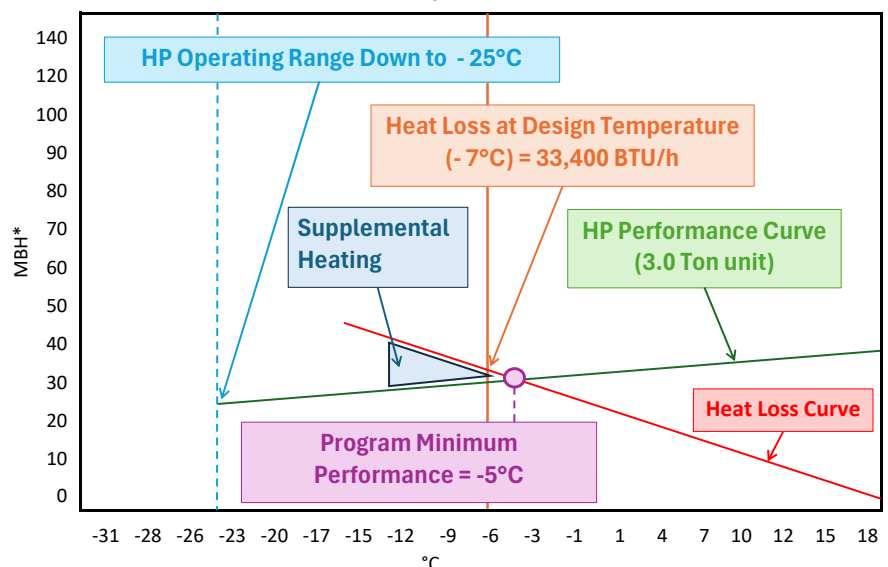
OPTIMIZED HEAT PUMP SYSTEM

- Heat pump achieves 100% of capacity at design temperature.
- No supplemental heating needed



PROGRAM MINIMUM

- Heat pump is selected to meet the heating load at -5°C
- Modest supplemental heating needed with smaller heat pump



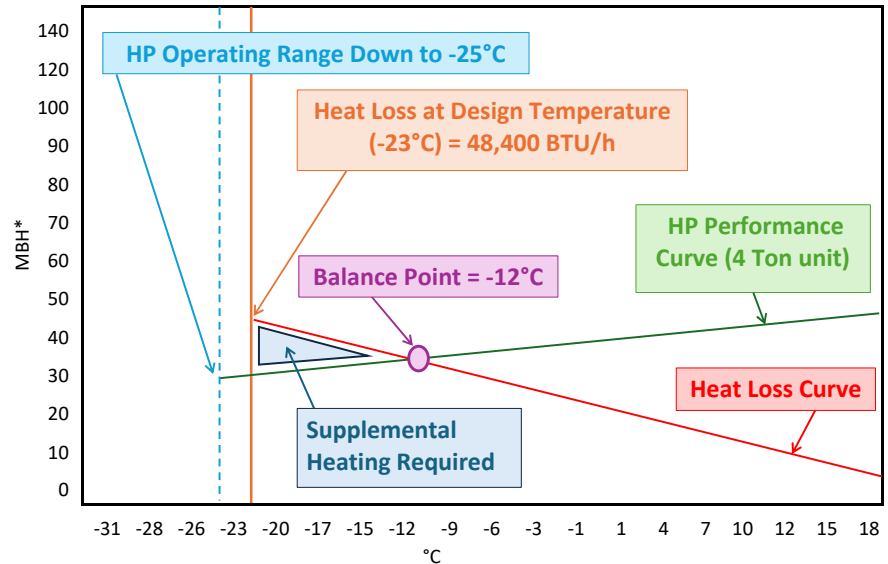
* 1 MBH = 1000 BTU/h

WORKED EXAMPLE: BALANCE POINT CALCULATION, CONTINUED

Kamloops (Climate Zone 5)

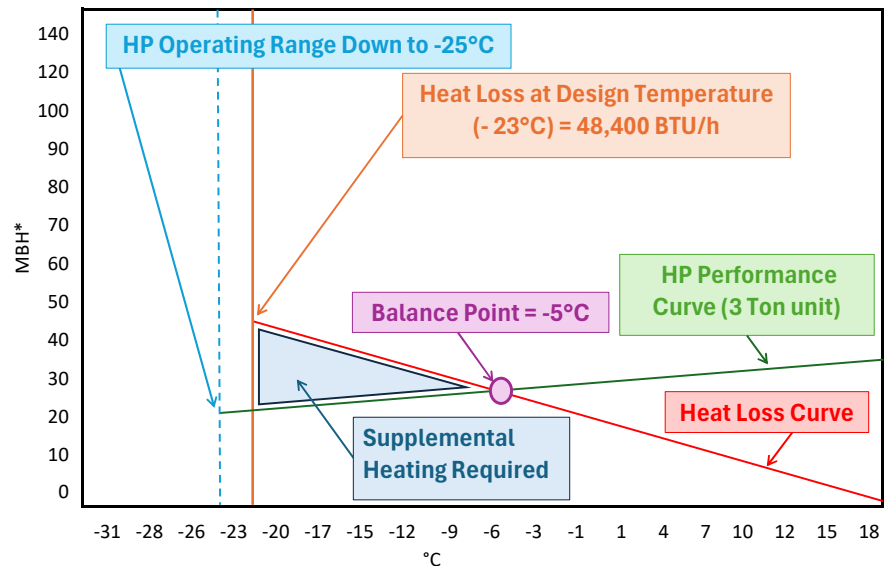
OPTIMIZED HEAT PUMP SYSTEM

- Heat pump achieves ~70% of capacity at design temperature.
- ~5 kW (17,000 BTU/h) of supplemental heating required (could be met by an electric heat kit, or other).



DUAL FUEL SYSTEM

- Heat pump achieves ~50% of capacity at design temperature.
- Heat pump component sized to meet the design load down to -5°C
- ~7 kW (24,000 BTU/h) of supplemental heating required.
- Gas furnace will typically be sized for the full heating load at winter design temperature.



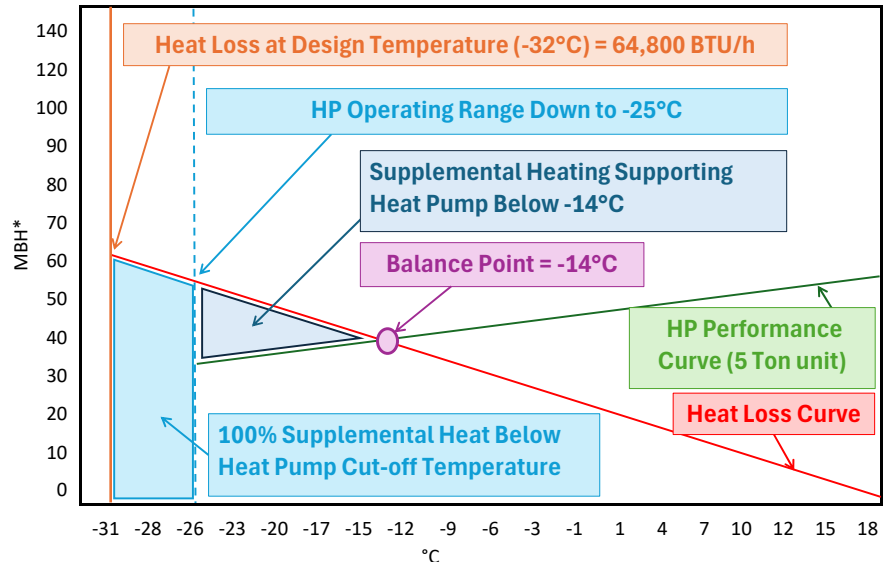
* 1 MBH = 1000 BTU/h

WORKED EXAMPLE: BALANCE POINT CALCULATION, CONTINUED

Prince George (Climate Zone 6)

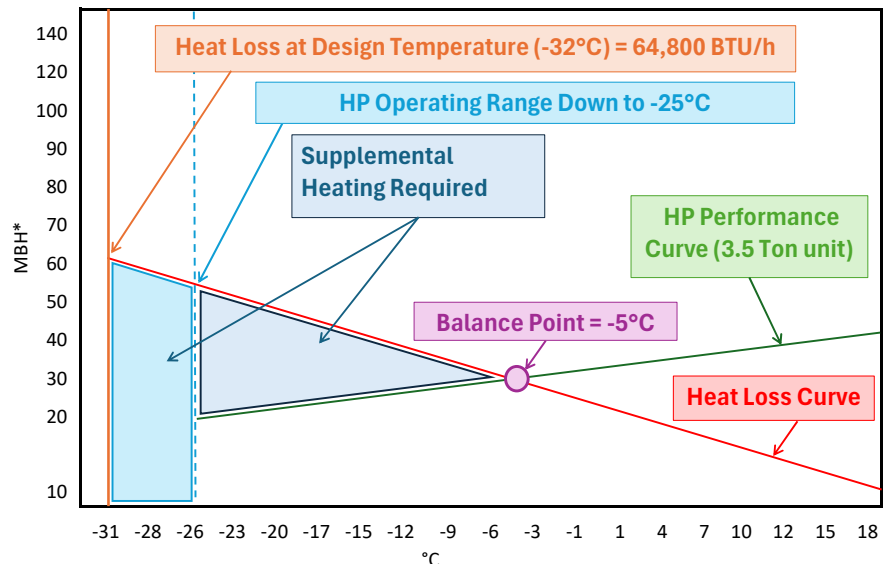
OPTIMIZED HEAT PUMP SYSTEM

- Heat pump achieves ~50% of capacity until the equipment is beyond its operation range @ -25°C (-13°F).
- ~20 kW (68,000 BTU/hr) of supplemental heat required for the coldest days. Increments of resistance heat will be staged with the heat pump until outdoor shut-off temperature.



DUAL FUEL SYSTEM

- Heat pump achieves ~33% of capacity until the equipment is beyond its operation range @ -25°C (-13°F).
- Heat pump component sized to meet the design load down to -5°C
- ~20 kW (68,000 BTU/hr) of supplemental heat required for the coldest days.
- Gas furnace will typically be sized for the full heating load at winter design temperature.



* 1 MBH = 1000 BTU/h

STEP 4: DETERMINE NEED FOR AND CAPACITY OF SUPPLEMENTARY HEATING

Supplementary heating is the additional heat that is added if the heat pump is not able to keep up with the heating needs of the home during peak cold conditions. Do not confuse this terminology with “back-up” or “emergency” heat, which is a heating source that only turns on if the primary heating system fails. Refer to the definitions in the side panel.

It is only after you have completed the CSA F280-12 heat load and balance point calculations, that you have the information needed to appropriately size the supplemental heating system. By using these calculations, you will avoid any unnecessary default practices of installing 100% backup heat.

For milder-climate locations in British Columbia (typically climate zones 4 and 5), a properly sized cold climate rated heat pump will run efficiently down to (or below) the design temperature. Homes may still require some supplemental heat, but this will be significantly less than full back-up/emergency heat. In the coldest locations, the heat pump will shut off below a certain temperature (varying by manufacturer). In these cases, you will size the supplemental heating system to meet the full heating design load.

For colder locations and dual fuel systems that use a heat pump for primary heating and a furnace for supplemental heating, the control strategy will dictate the approach to sizing the two components. If the control strategy follows a switchover temperature approach, the heat pump would be sized to operate down to a selected compressor cutout temperature, with the furnace meeting the full heating load below that temperature. While a less typical approach, the heat pump could be sized to meet the load in most conditions, with the furnace sized (for less than full load) to supplement at the coldest temperatures with both components operating simultaneously.

For all-electric central heat pumps, supplementary heating can be provided by electric resistance heater elements. As part of pre-changeout planning and design, it is important to size any electric resistance heating to match the requirements of the home. Oversizing the supplementary heating system may lead to additional costs for the homeowner, including potential upgrades to the electric panel and/or service.

DEFINITIONS

Primary or principal heating system refers to the heating system that has been designed to accommodate the heating load of the building and may include supplementary heating equipment.

Supplemental/auxiliary/secondary heating equipment refers to the heating equipment that is used to supplement the principal heating system when the capacity of the primary equipment has been exceeded. Examples include a central ducted ASHP with supplementary electric heat kit, an air-to-water heat pump with supplementary gas boiler, or a packaged dual fuel system (electric heat pump with supplementary gas furnace). The primary and secondary components are controlled by an integrated controller.

Supplementary electric heat kit is an electric resistance element that is installed in an all-electric heat pump air handler and is controlled by the heat pump thermostat. A supplementary electric heat kit is sized to meet the difference between the heat pump capacity and the design load, or if required by the installation, to temper the air during the defrost cycle or provide 100% of design heating requirements.

Redundant, backup, or emergency heating equipment refers to independent heating equipment that is not relied upon to provide primary space heating to a home. It typically has its own (and often manual) controls. Examples include gas fireplace heaters, wood fireplaces, and wood pellet stoves.

Electric resistance heater elements (**Figure 8**) typically come in 5 kW (17,060 BTU/h) increments. As an example: a 5-kW resistance heater will use just over 20 amps at 240 volts and will require a 30-amp, 240-volt breaker. A 10-kW resistance heater will require a 50-amp, 240-volt breaker. Any larger electric resistance heater elements for backup/emergency heating will typically use multiples of 5-kW and 10-kW elements, which has the potential to add significant panel loads and may trigger panel upgrades.

WARNING

Sizing a supplementary electric heat kit to provide 100% heating requirements is only required where the temperature may drop below the minimum operating temperature of the heat pump and the home does not have redundant or backup equipment. A supplementary electric heat kit sized for 100% of heating requirements may require an electrical service upgrade, may increase the home's energy bills, and may exacerbate the peak demand on the electrical grid.

CONTRACTOR TIP

If a heat pump and/or the listed electric resistance heating loads exceed the electrical panel capacity (when calculated per the Canadian Electrical Code), load share devices or a smart electrical panel might be an option. These technologies may avoid an electrical panel and service upgrade. To learn more about these technologies, see the Building to Electrification Coalition article titled: **"Home Electrification: Service Upgrade Not Required!"**

<https://b2electrification.org/home-electrification-service-upgrade-not-required>

The following considerations may influence your supplemental or backup heating strategy:

- Type(s), quantity, and size of external supplemental heating (e.g., gas or wood fireplace, electric baseboards, etc.) in the home outside of the heat pump system.
- Ductwork capacity and potential ductwork modifications and improvements.
- Potential sizing for extreme weather events that may occur every 20 to 50 years.
- Available heat pump and electric resistance heater sizes from the manufacturer and large incremental jumps from one size to another.
- Maximum size limitation for 240-volt, single-phase heat pumps. Some equipment has a maximum 5 tons whereas others have a maximum 4 tons.
- Cold ambient locations where the outdoor temperature drops below the heat pump lock-out temperature.
- Occupant-specific requirements/preferences.
- Electrical panel capacity and ability to install additional supplementary resistance heating.

In all cases, review the approach to supplemental and/or back-up heating with the homeowner to inform your strategy based on your assessment and the individual needs of the home.

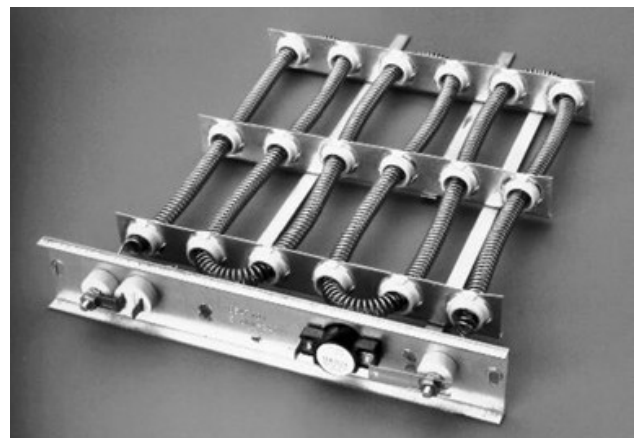


Figure 8 Supplementary Electric Resistance Heating Coil (Image from Heat Pump Practices Installation Guide for Existing Homes Version 1.0)

STEP 5: REFINE EQUIPMENT SELECTION

After you have established the capacity balance point and the need for supplemental heat, you can refine your equipment selection, along with any options. Items you can check at this stage include the following:

- Confirm the performance ratings at various temperatures for the selected equipment. For example, if you are selecting a heat pump to meet the winter design load in a milder climate, check that the rated capacity at the “cold climate” temperature meets the load at that temperature.
- For dual fuel solutions, confirm the outputs and sizing for the two components and check that the sizing aligns with the intended control strategy.
- For ductless multi-split systems, confirm with the equipment manufacturer that the proposed layout and selection of heads works with the equipment capacity, and that heating is provided to every occupied room.

STEP 6: SELECT CONTROL STRATEGY AND EQUIPMENT

An important part of optimizing the performance of a heat pump is to specify an integrated control strategy between the thermostat and equipment. Full interoperability between the thermostat and heat pump system will achieve the desired home comfort and energy savings while limiting the use of the supplementary heating system. Control strategies and thermostat options are described below.

Dual Fuel Simple Switch-Over Control

This control strategy uses a set change-over point based on the outdoor temperature. The set point defines the outdoor temperature, below which the heat pump shuts off and the supplementary gas furnace takes over. In switch-over control, the set point is always at or above the thermal balance point.

Dual Fuel Extended Operation (“True Hybrid”) Control

This control strategy allows the heat pump to work below its thermal balance point while the remaining load is supplied by the supplementary gas furnace. Extended operation can be implemented on thermostats that have settings for a high temperature and low temperature switch-over. At outdoor temperatures between the high temperature and low temperature switch-over points, the thermostat will alternate between the heat pump and the furnace to meet the load. Some thermostats may also facilitate extended operation by using indoor temperature control.

CONTRACTOR TIP

Modulating condensing gas furnaces and heat pumps are both at their most efficient when running at steady state, i.e. not cycling on and off. This means that a consistent setpoint or much smaller night setback than what might be used for a conventional furnace is the preferred setpoint strategy for these systems.

All-Electric Control

This control strategy refers to thermostat control that turns on various stages of an electric heat kit, in addition to the heat pump heating cycle, as the outdoor temperature drops progressively lower. An all-electric heat pump control has these two characteristics:

1. The low ambient temperature switch-over is set to the heat pump minimum operating temperature to ensure the heat pump is not turned off unless the outdoor temperature drops below the minimum operating temperature.
2. The high ambient temperature switch-over is set to prevent excess use of the supplementary electric heat kit when the heat pump can cover the load. The high ambient temperature switch-over should be at the thermal balance point or slightly higher if required for comfort.

Deviation from Setpoint Control

This control strategy can be used for dual fuel and all-electric control (**Figure 9**). With this approach, the controller will switch over to supplemental heating when the interior temperature drops below setpoint by a specified amount for a specified duration.

CONTRACTOR TIP

In existing homes with gas furnaces, two wires are typically run from the furnace to the thermostat. Heat pumps require more wires to operate. Some manufacturers (e.g., Honeywell and BC-based Tekmar) have developed technology that uses the existing two wires which connect to a relay box next to the heat pump. The multiple wires then run from the relay box to the heat pump to provide control. These systems allow the use of the existing two wires but they are not always compatible with fully communicating thermostats.

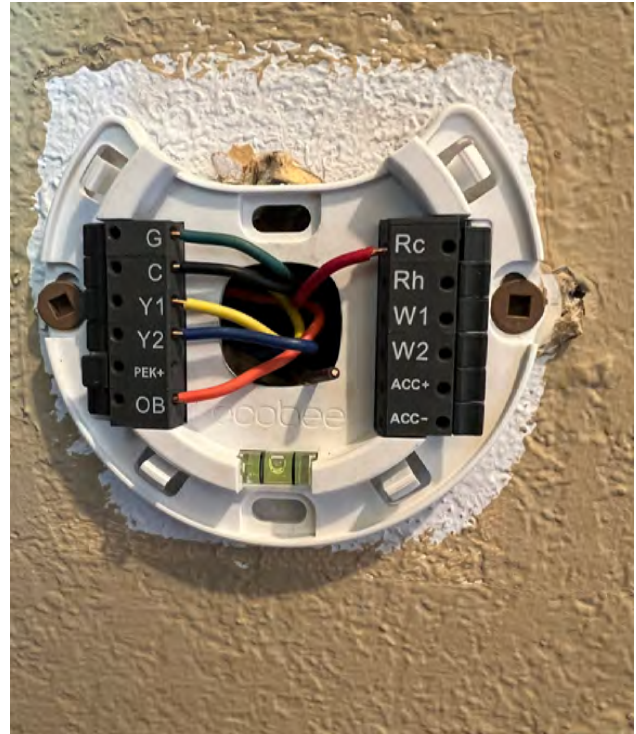


Figure 9 Examples of Controllers; Tstat Wiring (top) and Sample Controller that can Manage Multiple Units (bottom)

THERMOSTAT OPTIONS

Three types of thermostats, and when to use them, are outlined below:



Existing Thermostats (Low Performance - Not Suitable)

In retrofits, using the existing thermostats is typically **not** an option. An electric baseboard thermostat is line voltage (240 volt) and not compatible with new heat pump installations. An existing gas furnace thermostat (24 volt) may or may not be compatible. Additionally, many older thermostats are “heating-only” operation and the generic thermostats include only basic settings with one or two stages of heat and one or two stages of cooling.



Heat Pump Thermostat (Minimum Performance)

A basic heat pump thermostat provided by the equipment manufacturer or third-party control/smart thermostat manufacturer is relatively inexpensive. These thermostats provide scheduling and remote access (in some cases) along with on/off control of the heat pump in heating and cooling. Typically, the manufacturer programming in the heat pump will determine how quickly the heat pump ramps up and down. These thermostats may overshoot and undershoot the desired setpoint with a small penalty for comfort and efficiency (due to cycling losses).

This category includes thermostats manufactured by Honeywell, Nest, and Ecobee, and any thermostat that is not receiving information from the heat pump.

These thermostats should not be used with variable speed systems because they cannot control the compressor speed.



Heat Pump Thermostat (Optimized Performance)

The heat pump manufacturer’s proprietary, fully communicating thermostat provides optimized performance when used with fully modulating and inverter technology. These communicating thermostats incorporate full functionality for comfort and efficiency.

Heat pump thermostats can determine the thermal characteristics of the home to efficiently maintain set temperatures and run times. Fully communicating thermostats include other functionality like self-diagnostics, the ability to communicate a problem directly to the installer, and in some cases the ability to provide energy usage data. Communicating thermostats will usually require a factory wiring harness to go from thermostat to fan coil.

For dual fuel systems: Third-party or proprietary controllers can talk between the heat pump and the furnace, including the capability to set different switch-over temperatures for the furnace and the heat pump (e.g., the heat pump can continue to operate in its efficient range supplemented by the furnace).

Installation

A high-quality installation is as important as appropriate system selection and sizing to achieve the intended performance and homeowner satisfaction. This section covers best practices for several aspects of the installation process that can have a significant impact on the project outcomes.

EQUIPMENT LOCATION AND INSTALLATION

To support optimum performance of a heat pump system, it is important to select appropriate locations for both outdoor and indoor units. Poorly selected locations can result in performance degradation, comfort issues, and customer complaints, see **Figure 11**.

OUTDOOR UNITS

Locate outdoor units in accordance with the manufacturer's instructions, with consideration given to the following items:

- Install outdoor unit where it is accessible for cleaning and repairs.
- Maintain sufficient access around the unit to clear any blockages such as from leaves or snow.
- Keep outdoor units away from fences, walls, and other surfaces and out of enclosed structures like doghouses to allow unimpeded air flow around the unit. This practice will avoid creating a microclimate that would negatively impact heat pump performance and efficiency.
- Avoid locations where sound could cause a disturbance, such as under a bedroom window or close to a neighbour's window.
- Install vibration isolators to avoid sound resonance issues.
- Locate the units above anticipated snow levels with due regard for defrost water drainage (i.e., do not place a unit directly on the ground).
- Minimize refrigerant pipe run lengths and bends (follow the manufacturer's instructions if given).
- Minimize the length of refrigerant lines outside the conditioned space.
- Ensure easy drainage of condensate.
- Determine where the defrost runoff will terminate during winter conditions to ensure it does not run onto a pathway and freeze, creating a slipping hazard.
- Protect the units from winter winds using trees or other vegetation, wind baffles, or its positioning relative to the home.
- Locate units at a safe distance from any gas sources or appliances.
- Protect the units from the sea spray in coastal areas and from frost and strong winds. Strong winds can cause the condenser fan to spin in reverse and burn out the motor, which is a particular concern when a unit is located on a roof. Many manufacturers make optional wind block panels that can be installed for outdoor units in areas with excessive wind.
- If homeowners have pets that may urinate on outdoor units, it is recommended that the units be protected with a section of low garden fencing that will not restrict airflow or service access. This issue can also be addressed by elevating the unit above the anticipated snow line.
- Where the manufacturer's literature does not provide clearance recommendations, ensure enough clearance based on the site and system type. For example, the following minimum distances from obstructions are suitable for mini-split systems:
 - 500 mm (20") between air inlet and outlet faces
 - 600 mm (24") above the unit
 - 600 mm (24") service access
 - 150 mm (6") to other faces
- Select locations with full winter sun exposure if possible.

OUTDOOR UNITS, CONTINUED

The outdoor unit can be fixed on:

- A specified base in accordance with the manufacturer's instructions.
- A concrete pad cast in place or a single-piece, pre-cast concrete or composite slab and installed with anti-vibration mounts (**Figure 10**).
- A concrete patio or balcony and installed with anti-vibration mounts.
- A timber slatted deck and installed with anti-vibration mounts.
- Brackets fixed to a foundation or wall with anti-vibration mounts.
- A roof where the installation has been specifically designed (engineered) to accommodate live loads and wind forces acting on the roof and installed with anti-vibration mounts.



Figure 10 Heat Pump Installed on a Concrete Pad with Anti-Vibration Isolation Mounts



Figure 11 Example of Installation with Inadequate Clearance (left) and Adequate Clearance (right)

WHEN INSTALLING OUTDOOR UNITS, CHECK FOR THE FOLLOWING:

- ✓ The unit sits level (**Figure 12**), both side-to-side and front-to-back, and cannot fall over.
- ✓ The unit's weight is fully supported to prevent sagging.
- ✓ The unit has an unobstructed gap under it.
- ✓ A suitable clearance underneath the unit allows for hosing, clearing of leaves and dirt, and clearance for snow.
- ✓ Components used for fixing the unit are corrosion-resistant (typically requires stainless steel).
- ✓ Any ground-mounted units are placed on a pad on soil that is well drained and will not heave with frost.
- ✓ Wall brackets are designed for attachment to a foundation wall where ground clearance allows.
- ✓ Anti-vibration isolators are used.
- ✓ Surge suppressors are installed at the service disconnect (**Figure 13**) to protect sensitive electronics. Alternatively, suppressors may be installed at circuit breaker boxes if the devices are approved for such application. Follow the device manufacturer's instructions and all applicable codes and standards.
- ✓ Any penetrations through the building envelope are properly detailed to maintain continuity of environmental separation.



Figure 12 Heat Pump Installed on Level Deck



Figure 13 Protected Electrical Wiring and Disconnect

INDOOR UNITS

Indoor equipment includes zone level distribution units (**Figure 14**) and/or the air handler section (**Figure 15**).

Ductless Heat Pump Heads

- Maintain adequate clearances for making all connections and to allow future servicing of the unit (including filter access).
- Install wall-mounted indoor units with adequate clearance for making all connections, for servicing the unit, and for replacing filters and any other maintainable components.
- The manufacturer's ceiling side clearance for wall-mounted units is considered a minimum. If possible, install the unit with a minimum additional clearance of 300 mm (12") from the ceiling. Best practice is 30-45 cm (1-1.5 ft) from the ceiling.
- In rooms with higher or vaulted ceilings, install the units at such a height (where possible) that the air discharge is no higher than 2.5 m (8 ft) from the floor.
- Direct the airflow to the coldest point in the room (but not toward a window).
- Maintain a clear airflow path.
- Minimize refrigerant pipe run lengths and bends (each 90° bend causes approximately 1% reduction of heating/cooling capacity).



Figure 14 Indoor Unit with Adequate Ceiling Clearance of a Mini-split

- Plan condensate drainage piping to drain by gravity to avoid the need for a condensate pump.
- Confirm that the wall is structurally strong enough to carry the load of the unit.
- Confirm that the wall space where the unit is being installed is free from electrical cables, plumbing, and cross bracings.
- Confirm that the unit is securely seated.
- If space allows, install floor-mounted units in larger living areas and lower levels of two-story homes.

Central Indoor Air Handlers

Locate all indoor units in accordance with the manufacturer's instructions with consideration given to the following:

- Maintain adequate clearances for making all connections and to allow future servicing of the unit (including filter access).



Figure 15 Indoor Unit of a Central Heat Pump

DUCTING FOR CENTRAL HEAT PUMP SYSTEMS OR CONCEALED DUCT SYSTEMS

While most central system retrofits will re-use existing distribution ductwork, some new ducting may be required (**Figure 16**). New ducting may be needed to tie into the new central equipment, to add ducted components, and/or to rectify pre-retrofit performance issues (hot or cold spots, rooms with inadequate air delivery, leaky ducts, etc.).

For any new ducting, consider the following:

- Duct system design must follow the National Building Code (Section 9.33.6) and the Thermal Environmental Comfort Association (TECA) Forced Air Guideline, HRAI Residential Air System Design manual (SAR-R2), or ACCA Manual D.*
- Pay close attention to available static pressure, especially with concealed duct air handlers.
- New supply and return ducts must be sealed with suitable long-life material to minimize air leakage. Duct sealing materials are to be rated to UL181A or UL181B specifications and used in accordance with the manufacturer's instructions.
- Avoid ducts in unconditioned spaces. Where this cannot be avoided, thoroughly seal all joints and seams with duct mastic and insulate the ductwork to a minimum of above-grade wall building code requirements.



Figure 16 Mechanical Room Duct Transitions that are Properly Sealed and Minimize Static Pressure

* For ductwork design guidance see Sheet Metal and Air Conditioning Contractors National Association's HVAC Systems Duct Design:

<https://store.smacna.org/hvac-systems-duct-design-5th-Edition/>

REFRIGERANT LINE SET AND TUBING

Refrigerant line set (pipework) can have a significant impact on heat pump performance. A properly sized and installed line set gives the safe, efficient, and reliable installation necessary for the heat pump system to perform as designed. Install all line sets in accordance with the manufacturer's recommendations. Follow the manufacturer's instruction for pipe sizes, minimum and maximum line set lengths, and height changes, with consideration given to the following:

- Follow Section 5.12, 6.2, and other relevant sections of CSA C273.5-11: Installation of air source heat pumps and air conditioners.
- Design line sets for the shortest runs and minimum number of joints and bends to limit internal friction and reduce risk of leaks.
- Install line sets so that oil return cannot get trapped; i.e. avoid multiple changes in elevation.
- Install insulation to line sets per manufacturer's recommendations.
- Glue insulation joints to prevent condensation from dripping inside the space.
- Protect the outdoor line set from insulation damage with rigid line hide and building code-approved line set protection.
- Protect any remaining exposed line set with ultraviolet (UV)-resistant tape or other mechanical protection (**Figure 17**).
- Protect line set penetrations through the building enclosure with rodent-proof insulation (e.g., with PVC sleeve and cap drilled to the size of the refrigerant lines, metal-wool stuffing, or similar).
- Correctly seal all penetrations through the shell of the home to restore continuity of envelope air barriers. Use gasket material as necessary to properly seal all penetrations.
- Ensure there are no bends or kinks in the line.
- Return any wall insulation disturbed by the installed line set to original (or better) condition.
- Create new flare fittings (where used), using flaring tool and measurement gauge appropriate to the applicable refrigerant (e.g., old R22 flaring tools should not be used for R410A refrigerant systems) and in accordance with the manufacturer's instructions. All flared fittings should be tightened with a torque wrench to the manufacturer's specifications.
- Apply refrigerant oil to the end of each flare.
- Purge brazed connections with dry nitrogen while brazing to prevent oxidization.
- Slope pipes toward the compressor to allow any oil that gets into the pipes to drain back to the compressor sump (some compressor oil will likely get into the pipeline in any system, and if it remains there it will derate the system's pressure and hence its efficiency).
- Make tubing connections using gasketed press/crimp designed for the refrigerant and tubing type (e.g., Sporlan Zoom Lock® or Vulkan LokRing®).
- Use factory-supplied flare adapters where necessary to connect to equipment and avoid field-fabricated tubing flares.



Figure 17 Insulated and UV Protected Refrigerant Lines

REFRIGERANT CHARGE AND ADJUSTMENT

The outdoor units of heat pump systems are factory-charged with the appropriate quantity of refrigerant to allow for the indoor unit and a specified pipe run. Refrigerant charging must be carried out in accordance with CAN/CSA B52: Mechanical Refrigeration Code, Section 8: Maintenance of System. When extra refrigerant charge/adjustment is needed or excess needs to be removed, consider the following procedures:

- Ensure the work is completed by contractors with the appropriate training and certifications.
- Use only the manufacturer's specified refrigerant.
- Pressure test the refrigerant line set using dry nitrogen and triple-evacuated with a vacuum pump per the manufacturer's instructions. The vacuum shall be held at 500 microns or less for a minimum of 15 minutes in each of the three vacuum cycles, and valved off to check for pressure changes that indicate contamination or leaks. Each evacuation shall be alternated with nitrogen under pressure. Pressure test the refrigerant lines only at pressures lower than the pressure rating of service valves,, or per the manufacturer's specifications.
- Measure the additional pipe run length and calculate the amount of refrigerant required according to the manufacturer's instructions.
- Weigh in the required amount of refrigerant by mass using electronic scales.
- Keep the charge lines as short as possible.
- Leak test the pipework before charging, by partially opening, then closing the cylinder valve to pressurize the connecting pipework.
- Charge using liquid refrigerant from the cylinder.
- Check for leaks using the bubble test solution.
- Ensure that the cylinder and unit are at the same height to prevent gravity transfer of the refrigerant.
- Calculate the required charge, then add or subtract refrigerant depending on whether the line set is longer or shorter than the length that the charge is set for.
- Label amount of refrigerant added or removed by type and weight in accordance with CAN/CSA B52 clause 5.11: Marking and Labelling, including the following:
 - Refrigerant type
 - Date of service
 - Lubricant type
 - Refrigerant charge (total including any additional charge)

CONDENSATE DRAINAGE

The condensate that forms on coils of indoor and outdoor units must be collected and disposed of safely. Follow the BC Plumbing Code and consider the following when installing and/or connecting condensate drainage piping:

- Slope drains downhill. Drains can be routed with the line set and run to a suitable termination point, away from crawl spaces, walkways, and outdoor equipment.
- Some units, such as ducted mini-splits and ductless cassette units, have limited vertical lift built in. Do not exceed the manufacturer's specifications for the vertical lift allowed before a continuous downward slope. If this is not possible, a condensate pump may be required.
- Wrap the indoor and through-wall section of the drainage pipe in polyurethane foam insulation.
- Use smooth, hard PVC-U drainage pipe if drainage pipe runs laterally (**Figure 18**). Flexible, ribbed drainage pipe can be used for vertical drainage (**Figure 19**).
- Where pipe traps are recommended by the manufacturer to reduce negative pressure, install them in accordance with the manufacturer's specifications.
- Use mechanical connectors (jubilee clips) to connect the hoses.
- Locate indoor units to avoid the need for a condensate pump. Where unavoidable, install a condensate pump in accordance with the manufacturer's specifications. Advise the owner of the maintenance requirements of the pump and that it may make noise. In addition, ensure that the pump has a system cutoff switch if it fails or doesn't drain properly.
- Tie condensate drains upstream of a trap and not tied into a vent.



Figure 18 Condensate Management for Lateral Drainage Pipe

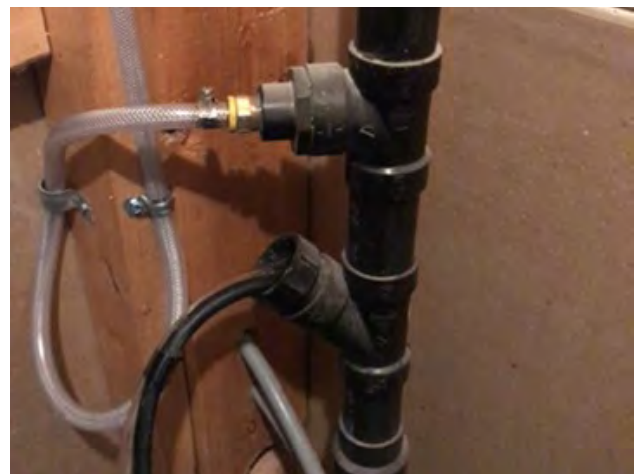


Figure 19 Ribbed or Braided Flexible Tubing

ELECTRICAL CONSIDERATIONS

A qualified contractor or electrician will have assessed the building's existing electrical system and capacity as part of the pre-changeout activities. In cases where additional capacity is required, separate dedicated circuits (i.e., wired back to the main switchboard) are best practice. Install new electrical wiring following all codes and standards, including CSA Standard C22.1: Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations and all manufacturers' recommendations. All electrical work must be carried out by an individual having proper qualifications and certification to perform this type of electrical work in British Columbia. An Electrical Certificate of Compliance (CoC) is typically required on completion.

The qualified individual will check that:

- Each piece of equipment is supplied with correct voltage.
- Overcurrent protection is properly sized to protect the load and the circuit (i.e., circuit breaker or fuse) and the mains wiring is sized correctly (i.e., minimum circuit ampacity).
- There is phase balance on three phase circuits (where applicable).
- The electrical service can supply all of the system's power requirements.
- A lockable isolating switch for the outdoor unit is installed and attached to the house (not to the outdoor unit).
- Waterproof protection to the electric connection is installed as required.



Figure 20 Heat Pump Outdoor Unit Installation in Progress

CONTROLS INSTALLATION

The location and settings of the controller will impact how effectively it responds to interior conditions. Consider the following:

- Place thermostats on interior walls, about 1.5 m (5 ft) high, and away from direct sunlight, appliances, or drafts.
- Locate any outdoor temperature sensors in shady protected areas.
- In larger spaces greater than 28 m² (300 ft²), install a fixed, wall-mounted control in a location that will be representative of the space the unit is serving.
- For smaller rooms or isolated zones that have no significant thermal/comfort problems, return-air temperature sensing with a handheld remote may be sufficient.
- Temperature sensing may need adjustment, especially for wall-mounted indoor units. Adjust the sensing offset settings for 2-4°C (36-40°F) ("more heating" and "less cooling") for high-wall installations and other situations where air distribution to the space may be compromised. Further adjustments might be required based on occupant feedback.
- Check the installer settings, including the following, as applicable:
 - Retain the installer settings during a power outage.
 - Use "efficient home" settings when available to improve cycling behaviour in low load situations.
 - When available and not required due to ventilation requirements, the installer settings shall be set to avoid continuous fan operation, even at low speeds.

CONTROL OF SUPPLEMENTARY HEATING

When installing a control system for supplementary heating, consider the following:

- If supplementary heat is provided by an electric heat kit, configure the thermostat controls so the supplemental heat does not engage when the outdoor air temperature is above the balance point temperature of the heat pump. The exception is if supplementary heating is required during a defrost cycle or when emergency heating is required during a refrigeration cycle failure.
- Do not use a low ambient temperature compressor cutout to limit operation of the heat pump unless there is a specific reason to do so, such as the manufacturer's requirement or in specific cold climate, dual fuel systems at temperatures in which the heat pump's capacity is significantly below the thermal balance point. Where a low ambient temperature compressor cutout is used, set at the lowest temperature of the manufacturer's specified operation range. Cold climate ASHPs typically have a minimum operating temperature of -15°C (5°F), -25°C (-13°F), or -30°C (-22°F).
- Set the controls such that the compressor always operates at temperatures above the thermal balance point temperature.
- Turn down any independent thermostats for supplementary heating systems such as baseboards 3-5°C (37-41°F) lower than usual to maintain the heat pump as the primary heating source. Consider interlock controls that will not allow both the heat pump and electric baseboards to operate together.
- For a dual fuel system in which supplementary heat is provided by a furnace, configure the controls so the furnace does not engage when the outdoor air temperature is above the program- or homeowner-defined switch-over temperature. The exception is if supplementary heating is required during a defrost cycle or when emergency heating is required during a refrigeration cycle failure.

Commissioning

Once the installation is complete, commissioning is a critical step to completing a successful heat pump retrofit. Follow the commissioning instructions provided by the manufacturer and/or reference the guidance of Section 6.3 of CSA Standard C273.5-11: Installation of air source heat pumps and air conditioners. Also consider the following:

- Configure the thermostat control settings within the manufacturer's specifications, to meet program requirements or based on homeowner preferences.
- Check all control and electrical wiring connections before starting the system.
- Clean all ductwork (as requested by homeowners), accessories, and existing air handlers and install a clean filter as per design before start-up.

At a minimum, complete the following operational checks and measurements:

- ☒ **Refrigerant charge:** Use the method approved and specifically stated by the manufacturer to measure the operating pressure and ensure proper refrigerant charge. Refrigerant charge evaluation relies on measurement of operating pressures and comparison to pressures specified by the manufacturer. The specified pressures correspond to measured ambient (and perhaps indoor) temperatures.
- ☒ **Airflow:** The airflow across indoor coils shall be per the manufacturer's specifications. Take airflow readings with the system set to full heating capacity flow. For multiple-stage systems, it may be necessary to test in partial capacity depending on various factors. For major renovations with newly designed and installed central ductwork, balance the airflow to individual rooms to the designed duct system flow.
- ☒ **Power inputs:** Check that power inputs of the circulating fan motor and compressor motor are per the manufacturer's specification. Check that all electrical components are operating below their maximum amperage rating (Rated Load Amperage).
- ☒ **Controls:** Check that the controls are functioning as intended.

COMMISSIONING CHECKLISTS

Both HPSC and FortisBC have developed checklists containing the steps for heat pump and dual fuel system commissioning. These checklists are provided under **HPSC Contractor Resource** and **FortisBC Home Renovation Rebate**.

<https://homeperformance.ca/wp-content/uploads/2025/11/HPSC-Heat-Pump-Commissioning-Report.pdf>

https://www.cdn.fortisbc.com/libraries/docs/default-source/rebates-and-energy-savings-documents/rebates-for-homes/home-renovation-rebate-comissioning-sheet.pdf?sfvrsn=6637d173_3

Homeowner Education and Maintenance

One of the main factors contributing to homeowner satisfaction with their new heat pump system is whether they understand how to operate and maintain the system. You can facilitate this understanding and clarify any owner responsibilities once the installation is complete. This activity also provides you an opportunity to propose a service plan for the new heat pump system, which is beneficial to the continued optimal performance of the equipment and your future business.

HOMEOWNER CHECKLIST

Provide the homeowner with all heat pump-related documentation and demonstrate basic operation and maintenance procedures to build the homeowner's confidence in operating their new equipment. The following list provides a summary of documentation to be provided and topics to be discussed and/or demonstrated with the homeowner before you leave the site:

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| <ul style="list-style-type: none"> ☒ Original equipment manufacturer (OEM) equipment performance information and the Owner's Manual . ☒ Model and serial numbers of all equipment. ☒ Operation instructions for the system, including programming of the indoor temperature controller(s), i.e. thermostat(s). ☒ Explain the proper service and maintenance requirements. Include the following topics: <ul style="list-style-type: none"> • Filter replacement: frequency, how to, acceptable products (size, efficiency, etc.) • Annual equipment servicing requirements • Establish a maintenance schedule • Benefits of a maintenance contract versus callouts as required ☒ Discuss other common maintenance items. For example: Copy of installation record and commissioning checklist <ul style="list-style-type: none"> • Watch for snow buildup that blocks the outdoor unit. • The cloud of water vapour that looks like smoke upon defrost termination and indications of improper defrost cycling (buildup of frost on the outdoor unit coils). | <ul style="list-style-type: none"> ☒ Warranty documents covering the system and controls, including servicing requirements for compliance with warranty policy. ☒ Copy of installation record and commissioning checklist. ☒ Copy of applicable permits: electrical and mechanical as required by jurisdiction. ☒ Proper labelling of circuit breakers and heat pump disconnects . ☒ Explain the following heat pump heating characteristics: <ul style="list-style-type: none"> • Longer runtimes • Lower supply air temperature • Implications of using setback • Where applicable, additional details on how heat pumps are different from the combustion appliances (e.g., furnaces) being replaced • For dual fuel systems, how the two systems are meant to operate together ☒ Explain Emergency Heat setting; how it is controlled and reset. Once activated, the homeowner may need to manually switch back to normal operation. |
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Additional Resources

ACCA Manual H, Heat Pump Systems: Principles and Applications, Second Edition. ISBN 978-1-892765-07-9

Air-Source Heat Pumps, National Renewable Energy Laboratory, U.S. Department of Energy (DOE), June 2001. Available at: <https://www.nrel.gov/docs/fy01osti/28037.pdf>

Assessment of Residential and Small Commercial Air-Source Heat Pump (ASHP) Installation Practices in Cold-Climates, Northeast Energy Efficiency Partnership (NEEP), June 2017. Available at: <https://neep.org/sites/default/files/AssessmentofResandSmallCommASHPInstallationPracticesinCold-Climates.pdf>

CAN/CSA-A440-00 (R2005) – Windows

CAN/CSA-A440.2-09 – Fenestration energy performance

CAN/CSA-C273.5-11 – Installation of air source heat pumps and air conditioners

CAN/CSA-C750 - Airflow and static pressure measurements in residential ductwork systems

CAN/CSA-F326-M91 (R2010 – Residential mechanical ventilation systems

CSA Group - SPE17:23 - HVAC Guide for Part 9 Homes

Cold Climate Ductless Heat Pump Specification and Recommendations, Guidance for Northwest IECC Climate Zones 5 and 6 (RTF Heating Zones 2 and 3), Version 2.0-August 2022. Available at: <https://neea.org/wp-content/uploads/2025/03/NEEA-Cold-Climate-DHP-Spec-and-Recommendations.pdf>

Cold Climate Heat Pump Development and Demonstration, Natural Resources Canada (NRCAN), Mar. 31, 2015. Available at: <https://natural-resources.canada.ca/sites/nrcan/files/energy/pdf/CEF-Outreach-Report.pdf>

Controls for a Heat Pump with Secondary Heating for Contractors, Consortium for Energy Efficiency (CEE), Jan. 16, 2024. Available at: https://cee1.org/images/pdf/CEE_Controls_for_a_HP_with_Secondary_Heating_for_Contractors_TRC_01.16.24.pdf

Consortium for Energy Efficiency - Heat Pump Tools: <https://cee1.org/program-resources#res>

Demand Factors and Use of Rule 8-106 8) for a Detached Single Dwelling, Technical Safety BC, 2025. Available at: <https://www.technicalsafetymc.ca/regulatory-resources/regulatory-notices/information-bulletin-demand-factors-use-rule-8-106-8-for-a-detached-single-dwelling>

Duct Retrofit Decision Guide, Consortium for Energy Efficiency (CEE), Jan. 16, 2024. Available at: https://cee1.org/images/pdf/CEE_Duct_Retrofit_Decision_Guide_TRC_01.16.24.pdf

Getting The Most Out of Your Heat Pump, Northeast Energy Efficiency Partnership (NEEP). Available at: <https://neep.org/sites/default/files/GettingTheMostFromYourHeatPumpConsumerGuideFINAL.pdf>

Good practice guide: Heat pump installation, New Zealand Energy Efficiency and Conservation Authority, March 2022. Available at: <https://www.eeca.govt.nz/assets/EECA-Resources/Good-Practice-Guide-Heat-Pump-Installation-March-2022.pdf>

Guide to Installing Air-Source Heat Pumps in Cold Climates, Northeast Energy Efficiency Partnership (NEEP). Available at: <https://neep.org/sites/default/files/Installing%20Air-Source%20Heat%20Pumps%20in%20Cold%20Climates.pdf>

ADDITIONAL RESOURCES

Guide to Sizing & Selecting Air-Source Heat Pumps in Cold Climates, Northeast Energy Efficiency Partnership (NEEP). Available at: <https://neep.org/sites/default/files/Sizing%20%26%20Selecting%20ASHPs%20In%20Cold%20Climates.pdf>

Heating and Cooling with a Heat Pump, Natural Resources Canada (NRCan), February 2025. Available at: <https://natural-resources.canada.ca/energy-efficiency/energy-star/heating-cooling-heat-pump>

High-Efficiency Furnace Installation Guide for Existing Houses, FortisBC. Available at: <https://www.cdn.fortisbc.com/libraries/docs/default-source/rebates-and-energy-savings-documents/rebates-for-homes/furnaceinstallationguide.pdf>

Home Electrification: Service Upgrade Not Required!, Building to Electrification Coalition (B2E), 2021. <https://b2electrification.org/home-electrification-service-upgrade-not-required>

HRAI Residential Air System Design Manual

HRAI Residential Commissioning Manual

HRAI Residential Heat Loss & Heat Gain technical manual (SAR-R1)

Installation of air-source heat pumps and air conditioners, CSA Standard C273.5-11 (reaffirmed 2020).

System Design with Existing Heating, Consortium for Energy Efficiency (CEE), Feb. 5, 2024. Available at: https://cee1.org/images/pdf/CEE_System_Design_with_Existing_Heating_TRC_02.05.24.pdf

Understanding Your Homes's Electrical Capacity, BC Hydro, 2025. Available at: <https://app.bchydro.com/accounts-billing/rates-energy-use/home-electrical-capacity-data.html>

Weatherization for Heat Pump Contractors, Consortium for Energy Efficiency (CEE), Jan. 16, 2024. Available at: https://cee1.org/images/pdf/CEE_Weatherization_for_Contractors_TRC_01.16.24.pdf



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