Air-source heat pump pilot project: Lessons learned

Note: This document refers to ducted air-source heat pumps installed under this pilot project. In some cases, ductless systems may be more suitable. There are ductless systems being installed and monitored as part of this pilot project and we will report on their performance in the future.

The Government of Yukon's Energy Branch, in conjunction with Natural Resources Canada (NRCan), is coordinating a three-year pilot project on air-source heat pumps and their performance in a cold climate.

During the pilot project's first year, there were five cold-climate air-source heat pump systems installed.

All five systems:

- are Mitsubishi Zuba models with two rated at 36,000 BTU/hr and three rated at 42,000 BTU/hr;
- are installed with built-in electric auxiliary heating systems;
- are centrally ducted systems;
- are installed in single detached homes.

Four indoor units were installed vertically with single side return (see Figure 1) and the fifth indoor unit was installed horizontally (see Figure 2).

Here are the lessons learned from the five participants and from the air-source heat pumps' operations during the winter 2020-2021 heating season.

Figure 1: Mitsubishi Zuba (42,000 BTU/hr) indoor unit with single side return installed

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Lessons learned

Lesson 1: Take the necessary time to size your heat pump and your duct work.

Know your home's heating demand.
Prior to installing an air-source heat pump, get an NRCan-Certified Energy Advisor to complete an energy assessment of your home to identify the heating and cooling loads. Accurately identifying a home's heating demand is essential to correctly identifying the best corresponding heat pump size. Oversized heat pumps will have significantly reduced efficiency.


Figure 2: Mitsubishi Zuba (36,000 BTU/hr) indoor unit installed horizontally in a crawlspace.

Size your heat pump appropriately by using the NRCan's sizing tool. Don't be afraid to select a smaller heat pump, rather than a bigger one.
Correctly sizing a heat pump system to both the home heating demand and to existing or new ductwork is tricky, but important. A heat pump that is properly sized to a home's heating demand will operate efficiently. For ducted systems, a heat pump properly sized to the ductwork allows for sufficient airflow, operates efficiently, and is relatively quiet.

An oversized heat pump can lead to issues such as:
- reduced operating efficiency. The heat pump will operate in short bursts of heat, called short cycling. The heat pump will ramp up and down over shorter time periods, which is inefficient;
- more ice build-up on the compressor coil because of the short cycling;
- potentially more water run-off to manage;
- the units require more space and need larger ducts for the higher airflow; and
- equipment costs and long-term electricity costs are higher.

When installing an under-sized heat pump, a homeowner can expect that the heat pump will run more frequently and for longer at colder temperatures. The backup heat may also operate at a warmer temperature compared to a properly sized heat pump.

IMPORTANT: For ducted systems, ensure the ductwork can handle the air flow of the unit, otherwise size down.

A ducted heat pump that is oversized for the ductwork can lead to issues such as:
- limited return airflow;
- Increased airflow noise; and
- lower operating efficiency with greater electricity consumption.

You can improve your system's airflow by:
- upgrading your ductwork to ensure that airflow will meet the heat pump's requirements;
- installing the indoor unit horizontally;
- ensuring a dual side air return on the indoor unit; or
- raising the indoor unit off the ground.

Regardless of the mitigation strategy, follow the manufacturer's recommendations and guidelines.

It may not be immediately obvious what heat pump size to use with your home, even with the results of a home energy assessment. A heat pump rated for a certain heat output level, for example, 36000 BTU/hr (10.5 kW), will actually be able to produce more heat (greater than 36,000 BTU/hr) for short periods of time. We recommend asking your installer, or the Energy Branch, to use the NRCan sizing tool to confirm the heat pump size needed to match your home's heating demand.

The NRCan sizing tool requires:
- the home's heating loads identified in by the energy assessment;
- if you are considering a ducted system, the size of your ducts; and
- the manufacturer's data for the specific heat pump model (refer to the Northeast Energy Efficiency Partnerships (NEEP) product listing).

When selecting a heat pump, focus on cold-climate heat pumps listed by Northeast Energy Efficiency Partnerships (NEEP)(neep.org/ASHP-Specification). Then choose a brand that you and your installer prefer.
There are different brands and models of heat pumps that are capable of operating in cold climates. Local installers who participated in phase one of the pilot project preferred to install Mitsubishi heat pumps.

A product listed by Northeast Energy Efficiency Partnerships (NEEP) means it meets a certain standard for operating in cold climates. NEEP-listed systems must meet a minimum heating season performance factor, have a variable compressor, and meet a minimum coefficient of performance at -15°C.

Ask your installer questions.
Get informed about your heat pump. Ask questions prior to the installation to know what to expect when operating and maintaining your new heat pump system.

The Energy Branch has a Homeowner's guide to installing an air-source heat pump (ASHP) on yukon.ca. This guide outlines the steps and considerations to follow when retrofitting your home's heating system to an air-source heat pump. It includes a list of important questions to ask installers throughout the installation process.

Get in touch with the Energy Branch.
The Energy Branch is able to review and provide advice on heat pump selection and things to consider for your heat pump installation project. We do not offer recommendations on specific products. You and your installer are responsible for the project and installation work completed.

Lesson 2: Manage your expectations when embarking on a retrofit project.

Expect the installation to take longer than the estimated timelines.
The heat pump installations for the pilot project took between five and seven days.
Note that there is typically a 24-hour period when the system is energized prior to being activated.

Get estimates on installation costs and seek out multiple quotes.
For centrally ducted systems installed in Yukon in 2020, the quotes ranged from $25,000 to $32,000 depending on the following variables:

- upgrades to the home's electrical panel;
- removal of existing heating systems such as an old furnace;
- upgrades to existing ductwork or full installation of new ductwork;
- cost of the heat pump's indoor unit, outdoor unit, and associated components such as the thermostat and/or auxiliary heat;
- cost of the platform and stand for outdoor unit;
- costs of freight; and
- costs of labour.

Good Energy rebate can help lower installation costs.
Ensure that you apply for the Government of Yukon's Good Energy rebate for heat pumps. The rebate can cover 40% of eligible costs up to $8,000. The rebate is only offered for Northeast Energy Efficiency Partnerships-listed heat pumps. You may also be able to get money back under the Government of Canada's Greener Homes Grant. Check the qualifying terms and conditions carefully before proceeding with your project.

Lesson 3: Finding and hiring installers can be challenging.

There can be many contractors involved in installing a heat pump. Consult the Energy Branch's Good Energy Network for a list of local installers.

There is no single qualification required of heat pump installers in Yukon (nor in Canada). There are only a few heat pump contractors in Yukon who do residential installs. They are in high demand and have limited availability.

A heat pump's refrigeration and electrical components must be installed by certified professionals:

- a certified electrician is required to do the wiring and work under an electrical permit.
- a general refrigeration technician or mechanical technician is required to install the heat pump's refrigerant lines.

A homeowner can hire these certified professionals directly or hire a contractor to manage the installation and subcontract these required professionals. Consult the Energy Branch's Good Energy Network for a listing of installers that are knowledgeable about Good Energy rebates.

The type of installer you choose may affect your system's warranty length.
A general refrigeration technician can install heat pumps and is often able to purchase products from multiple companies and brands. A typical warranty period for a heat pump installed by a general refrigeration technician is five to six (5-6) years.

A manufacturer-certified contractor is typically able to complete the entire installation process (electrical work, refrigeration lines). However, these installers typically work with a limited number of manufacturers. A typical warranty period for a heat pump installed by a manufacturer-certified contractor is eight to ten (8-10) years.

Some homeowners have chosen to install heat pumps that come with pre-assembled refrigeration lines. This is problematic because these heat pumps may not meet the NEEP requirements for cold-climate units. While this avoids the need to hire certified professionals, installing a heat pump by oneself typically violates and nullifies the warranty on the unit.

Lesson 4: Think through the design and expect adjustments.

Expect design changes during the installation.
During the pilot project, homeowners experienced unexpected changes to the system design during its installation. Most were due to unforeseen issues such as:

- there was less room for the ducts than anticipated which lowered the ceiling;
- additional electrical work was needed to the electrical panel; and
- an HRV was already installed resulting in a second set of ducts being installed in the home.

Outdoor unit placement matters for efficient operation and comfort.
It is important to ensure that the outdoor unit is appropriately located for optimal operational efficiency:

- install it away from walkways and driveways to prevent winter ice from draining defrost water that turns into a hazard on pathways in the winter;
- ensure that there are no house vents nearby to exhaust moist air onto the outdoor unit;
- install both the outdoor and indoor unit in low to no traffic areas; and
- ensure the refrigerant lines are as short and as straight as possible.

Lesson 5: Be prepared for winter maintenance

Defrost cycles means water run-off.
During the winter months, the centrally ducted systems installed for this pilot project underwent multiple defrost cycles due to frost build-up on the outdoor units.

The defrost cycle causes the system to temporarily operate in reverse. This activates the cooling cycle to melt the frost build-up on the compressor coil. This results in water draining off the outdoor unit (see Figure 3).

Figure 3: Mitigation measures taken to manage the defrost water coming off the Mitsubishi Zuba (42,000 BTU/hr) outdoor unit included putting bins and sandbags under and around the unit.

Several homeowners reported that the winter maintenance tasks were substantial and for some, required daily attention.

Their maintenance mitigations to deal with the water runoff included:

- emptying buckets or bins placed under the outdoor unit to collect defrost water;
- chipping of ice that accumulates under the outdoor unit from the defrost water;
- placing sand bags around the outdoor unit to avoid the spread of defrost water;
- ensuring there is no excessive frost buildup on the outdoor unit;
- ensuring that when the heat pump turns off due to low temperatures that the system properly switches and activates the auxiliary heating system.

These maintenance considerations are important factors to consider, particularly in situation where you may need to leave your home for a period of time during the winter.

During high humidity, monitoring ice build-up is essential.
In December and January, some outdoor units experienced a large amount of ice-build up. One unit was completely covered in ice, including on the blades due to an unusually high humidity in the air (see Figure 4 and Figure 5).

The ice weighs the blades down and is not good for the system's long-term operating health. If the unit's defrost cycle is no longer sufficient to self-melt the ice, it will continue to build-up. The solution was to clear the ice on the outdoor units with warm water and heaters. Wind baffles were also added to four of the outdoor units.

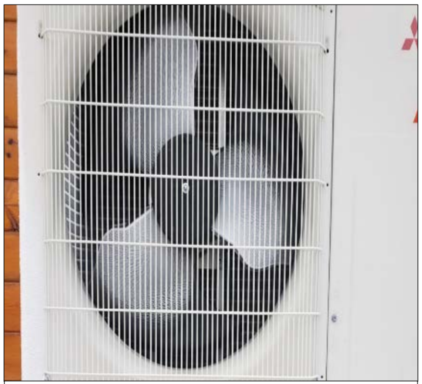

Figure 4: Accumulated frost on blades of Mitsubishi outdoor unit (42,000 BTU/hr).

Figure 5: Overly iced-up Mitsubishi outdoor unit (42,000 BTU/hr).

Watch the transition to the auxiliary heating system to ensure your system is working smoothly.
Air-source heat pump units are set to lock out at around -27.8 °C. This means the outdoor unit will automatically turn off and switch to the auxiliary heating system below this temperature.

In January and February 2021, Yukon experienced a three-week cold snap with temperatures ranging from -25 °C to -40 °C. The heat pump systems automatically locked out but the integrated auxiliary heating systems did not kick-in as expected.

From our feedback and data measurements, Mitsubishi discovered a previously unidentified defect in the outdoor unit. The thermistors were improperly reading the outdoor temperatures. A thermistor is a sensor that detects the temperature of air and liquid. The system's control board uses this information to adjust the heat pump's compressor and blower speeds to compensate for the changing temperature conditions.

The factory defect was in the outdoor unit's computer board. Mitsubishi replaced the computer boards with new units under warranty and at no extra cost. The Energy Branch is carefully monitoring these units to confirm performance.

Lesson 6: Costs to operate heat pump are to be determined.

Higher than expected electricity bills.
Homeowners switching from wood heating saw an increase in their monthly electrical bills and overall heating costs. The highest electrical bill participants received was in February 2021, during the extreme cold when the auxiliary heat issue was occurring. Because of the factory defect, we do not believe this is reflective of future system performance.

Operational costs analysis is forthcoming.
The Energy Branch is completing an analysis of the system performance data collected to determine operational costs and energy savings for the installed heat pumps. This technical report will be publicly available.

Next steps

Under *Our Clean Future*, the Government of Yukon will install 25 heat pumps with backup heating systems by 2023. The Energy Branch will continue to monitor and review how the first five installed heat pumps operate and perform during the next heating seasons. In the coming years, the Energy Branch hopes to be able to help install other brands and models of air-source heat pumps and monitor their performance in Yukon's climate. The Energy Branch will produce a technical report on the heat pump pilot project including data on performance, operational costs and energy savings.