Yukon

Heat pump pilot, Yukon 2023 – 2025

simple summary

Introduction

Air source heat pump systems can deliver 1.5 to 3 times more heat energy than the electrical energy they consume, making them an efficient way to heat homes. However, their efficiency is impacted by ambient outdoor air temperatures (lower efficiency at lower temperatures). To confirm heat pumps are an effective and efficient heating system in the territory, RDH Building Science was commissioned by the Government of Yukon to conduct a research study on cold climate air-source heat pumps (ccASHPs)[1] installed in selected existing residential homes in Yukon. The main objectives of this study were as follows:

- assess ccASHP performance in terms of heating energy delivered and heating *coefficient of performance* (COP)[2] against outdoor temperatures;
- compare the measured *seasonal coefficient of performance* (SCOP)[3] of these systems to manufacturer-published data;
- assess potential energy and cost savings from heat pump retrofits in Northern communities;
- identify lessons learned on system operation, design and maintenance of cold climate heat pumps in the Yukon; and,
- develop general recommendations related to overall feasibility and widespread adoption of air-source heat pumps in the Yukon.

[1] Cold Climate Air Source Heat Pump (ccASHP) is a specification which defines characteristics and minimum performance standards for heat pumps in cold climates.
[2] Coefficient of Performance (COP) is the ratio between the rate at which the heat pump delivers thermal energy (in kW), and the amount of electrical power required to do the pumping (in kW). For example, if a heat pump used 1kW of electrical energy to deliver 3 kW of heat, the COP would be 3. Typically, a ccASHP would have a COP of about 3.5 to 4.5 at 8oC, dropping to around 2.0 to 2.5 at -15oC
[3] The Seasonal Coefficient of Performance (SCOP) is a metric that measures the energy efficiency of a heat pump over an entire heating season. SCOP = total thermal energy delivered divided by the electrical energy consumed by the heat pump. By considering the heat pump's efficiency over a range of temperatures, SCOP provides a representation of the system's performance and energy savings potential.

During the summer of 2023, monitoring equipment was installed to measure the performance of air-source heat pump systems in eighteen homes. Monitoring for this project was undertaken over two heating seasons, spanning approximately 19 months from September 1, 2023, to March 23, 2025.

Two detailed technical reports containing a full description of methods and results are available for download here (LINK to be provided by Comms). This general summary contains only an outline of broad results from both years. Additionally, a Technical Summary Report is also available for download here (LINK to be provided by Comms)

Figure 1 - Heat pump outdoor unit. This unit has been mounted well off the ground leaving room for ice buildup underneath. It is situated away from walkways, so ice removal is not needed. Outdoor units for ductless or central ducted systems are similar.

Results

Heat pumps demonstrated high operating efficiencies throughout a majority of cold temperatures experienced in a typical Yukon winter.

On average, the correctly commissioned ductless ccASHPs (i.e. mini-splits and multi-splits) that were monitored were able to achieve very good COPs across the full operating temperature range, right down to approximately 2.3 at an outdoor ambient temperature of -25ºC. These systems also tended to have SCOPs close to the range of the manufacturer-rated SCOPs; an average measured SCOP of 3.05 for ductless systems was observed.

On average, the correctly commissioned central ducted ccASHPs that were monitored were able to achieve COP of approximately 1.15 at -25ºC, 1.6 at -15ºC, and 2.55 at 0ºC. An average measured SCOP of 1.85 was observed.

Table 1 SCOP average as measured for Ductless and Central Ducted ccASHPs.

	SCOP
Ductless	3.05
Central Ducted	1.85

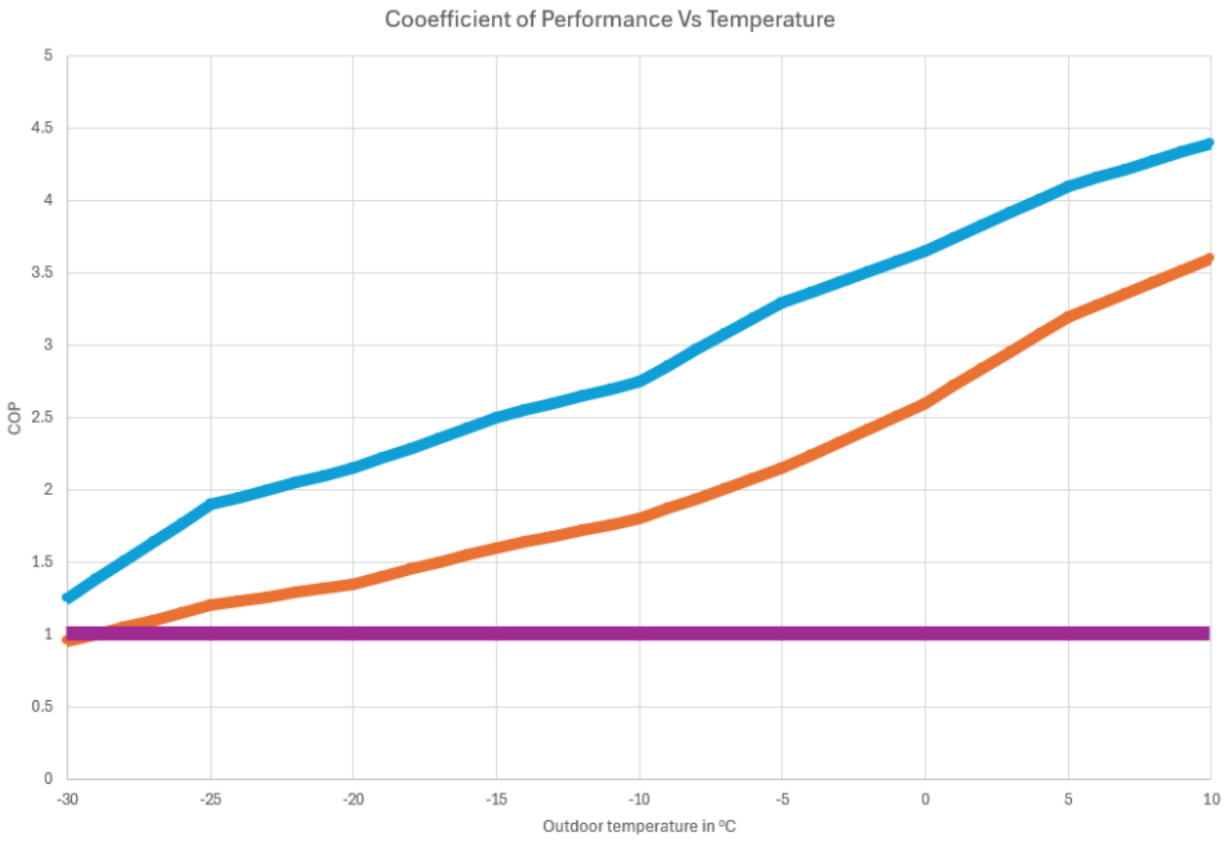

Figure 4 This graph shows the average Co-efficient of Performance achieved by heat pumps in the study at each temperature from 10°C down to -30°C. Centrally ducted heat pumps are shown in orange, ductless heat pumps are shown in blue. The Purple line at 1 shows the COP of traditional resistive electric heat.

Cost Savings

Heat pumps in the study generally achieved substantial operating cost savings when compared to the baseline heating systems being displaced. The amount of savings a homeowner can expect will be affected by many factors, including;

- sizing of the heat pump capacity in relation to the homes design heating load;
- type of heating system being displaced;
- type of backup heating system used and control settings for when and how the backup takes over;
- heat pump model and performance characteristics; and,
- quality of installation.

Figure 2 - Central Ducted ccASHPs appear similar to an oil furnace and use similar ducting to circulate hot air around the home.

Sizing Commentary

Properly sizing heat pumps for their intended operating range is critical for ensuring optimal performance. If a heat pump's capacity is too low, the system will likely be forced to rely excessively on supplementary heating systems during milder weather, instead of just during colder weather, increasing overall operating costs (where supplementary heating is electric, propane or oil based).
The additional running costs associated with an undersized air-source heat pump (ASHP) typically outweigh the higher upfront cost of installing a larger unit. Conversely, oversized systems can also present issues, such as excessive low-load cycling and reduced performance (i.e. lower COPs) at milder temperatures.

Conducting an energy assessment to determine the design heating load for the home and then sizing the heat pump accordingly is the preferred approach. Sizing a ccASHP based on square footage of the home is not an accurate method and can lead to reduced performance and higher running costs.

Figure 2 - A ductless ccASHP indoor unit mounted close to the ceiling. This unit heats and circulates air within the space. Ductless heat pumps can be mini-splits which have a single indoor head, or multi-splits which have multiple indoor heads heating multiple zones.

Interpretation

A simple interpretation of the results is that central ducted and ductless ccASHPs are well suited to serve the majority of Yukoners' residential heating needs, assuming a backup heating system is in place for temperatures below the operating range of the specific ccASHP (-20 to -30 ^{0}C in most cases). Cold Climate Air Source Heat Pumps meet the majority of the heating needs very efficiently and thus save significantly on home heat energy costs as compared to conventional oil, propane or resistive electric heating systems, and do this while also reducing GHG emissions associated with heating. The highest efficiencies, best cost and emissions results and greatest homeowner satisfaction come when ccASHPs are sized properly and designed, installed and commissioned with care and attention to detail.

For further information please access the full reports here LINK, or contact the Energy Branch at electrify@yukon.ca