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Assessing heat pump performance data requirements in cold Canadian climates

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Abstract

Supporting air-source (air-air) heat pump adoption in Canada requires appropriate performance reporting approaches that highlight regional differences and identify systems that meet desired objectives. This paper uses a simulation-based approach to examine how different heat pump data reporting approaches influence estimations of heating energy use and system sizing in the cold Canadian climate. Performance curves are developed using (i) AHRI 210/240 minimum data, (ii) Canada's Amendment 17 to AHRI 210/240, and (iii) full manufacturer performance tables. Curves are simulated across four regions, five archetypes and three construction vintages to assess relevant parameters. Results highlight the strong importance of the added cold climate capacity points, provided in Amendment 17 and manufacturer data, for improving energy performance predictions and system sizing. Key recommendations include the need for (1) extending performance data reporting to temperatures below -15°C and (2) increasing COP reporting to match capacity data.

Keywords: Air-source heat pumps;cold climate; heat pump performance data; residential sector

1. Introduction and Scope

The Government of Canada is committed to achieving carbon neutrality by 2050 while providing industry and building owners with the resources needed to maintain competitiveness and improved affordability [1]. The built environment must play a key role in this transition: Canadian buildings account for 17% of national greenhouse gas (GHG) emissions, with over 60% of this total directed towards space heating [2].

Air-source (air-air) heat pumps are a popular choice of heat pump integration in Canadian homes, driven by their relative lower cost and ease of installation. However, regional context is important in supporting the adoption of these systems in Canada: Wide variations in both climates (mild maritime, to extreme cold) and utility rates and structures (vast differences in prices of natural gas vs. electricity) mean that the impact of heat pumps (e.g., on energy savings, utility costs, greenhouse gas (GHG) emissions) can differ greatly in a given city or province.

Developing evidence-based policy to support heat pump adoption requires performance metrics that reflect these regional variations. Appropriate performance data allows policy makers to better understand variations by climate and better identify systems that meet desired objectives. However, additional data reporting can also place a greater testing/reporting burden on manufacturers, increasing cost and development timelines. Understanding what heat pump performance data is (and is not) required is critical to effective market uptake.

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This paper examines how different air-air heat pump performance datasets influence performance predictions in space heating. Three sets of performance curves are generated using data reported under (I) AHRI 210/240, (II) Canada's Amendment 17 to AHRI 210/240, and (III) enhanced manufacturer capacity and efficiency data. Performance curves are then integrated into a custom data-driven heat pump model and used within a simulation-based methodology to assess system energy performance and sizing in single family homes across Canada. Results are used to identify the importance of data reporting in predicting the energy performance of heat pumps and provide guidance on performance metrics needed to support the alignment of policy development and measured impacts in Canada.

2. Definition of Base Cases for Heat Pump Integration

Climate plays an important role in determining the impact of various heat pump datasets. Four Canadian regions are selected for this analysis, each representing a different context for performance assessment. Table 1 summarizes key parameters for each region [3].

Table 1: Summary of Climate and Electricity Generation Methods for Selected Canadian Regions

Characteristic	Halifax	Toronto	Winnipeg	Vancouver
Climate Type	Cold-Humid	Cold-Humid	Very Cold	Marine
Heating Degree Days (18°C)	4000	3520	5670	2825
Cooling Degree Days (18°C)	100	280	170	40
Heating Design Temperature (°C)	-16	-18	-33	-7
Cooling Design Temperature (°C)	26	31	30	28

For each region, five building archetypes are assessed to identify the impact of building size on performance predictions. These archetypes have been developed to represent specific segments of the residential building stock, with geometry and floor area derived from available literature and databases [4,5]. Two heating systems are modelled for each archetype to represent both the forced air and baseboard systems common throughout Canada. A summary of relevant parameters for each building archetype is presented in Table 2.

Table 2: Summary of Residential Building Archetypes used in Analysis

Archetype	Floor Area (m^2)	Above-Grade Floors	Basement	Primary Heating Fuel & System
Small Bungalow (SB)	109	1	No (crawl space)	Option 1: Natural Gas Furnace (Heating Efficiency 95%) Option 2: Electric Baseboards (Heating Efficiency 100%)
Medium Bungalow (MB)	190	1	Yes	
Large Bungalow (LB)	284	1	Yes	
Medium 2-Storey House (M2S)	190	2	Yes	
Large 2-Storey House (L2S)	284	2	Yes	

For each archetype, building envelope performance is modified to represent region specific construction for the four selected cities in Table 1. Three construction periods are examined, based on the timing of major updates to national building codes: (1) Pre-1984, (2) 1984-2004, and (3) Post-2004. For the Pre-1984 and 1984-2004 periods, envelope performance was derived from the EnerGuide database [5] for the appropriate regions. Post-2004 construction was selected based on the National Building Code of Canada (NBC) minimum requirements for the selected climate zones [3].

3. Heat Pump Performance Modelling

The developed archetypes are used to examine how performance curves generated from common heat pump performance data reporting approaches influence predictions of energy use and system sizing.

Heat Pump Performance Data Reporting Approaches

Three common heat pump performance data reporting approaches are compared in this study:

AHRI 210/240 Certification Data: All heat pumps sold in North America must be tested and certified according to AHRI 210/240. Testing assesses performance at a variety of outdoor conditions and fixed compressor speeds [6]. Publicly reported minimum data from AHRI is a subset of full test data, and focuses (in heating mode) on certified data for [7]:

- Nominal heating capacity at +8.3°C (47°F),
- Full capacity at -8.3°C (17°F), and
- Seasonal heating performance factor (HSPF), based on a pre-defined climate zone.

While AHRI 210/240 provides data at mild to moderately cold conditions, minimum reported data lacks:

- *Cold climate performance below -15°C*, as commonly occurs in many Canadian regions. In these cases, cold weather performance must be extrapolated using reported data at +8.3°C and -8.3°C. This approach is used in this study for performance curves based on AHRI 210/240 reported data.
- *Efficiency at specific outdoor temperatures*, typically required for energy performance prediction. This means performance must be assumed from other sources (e.g., national minimum performance standards) should the manufacturer not provide the nominal efficiency or power draw of the unit. In this paper, a COP of 3.3 is assumed at 8.3°C based on information in national energy codes [8].

AHRI 210/240 Certification Data, with Amendment 17 Data Reporting Requirements: Canada's Regulations Amending the Energy Efficiency Regulations, 2016 (Amendment 17) adds additional required reporting from AHRI 210/240 testing for all products sold in Canada [9]. This Amendment aims to provide more detail on cold climate performance, with manufacturers required to report the following (in addition to existing 210/240 reporting outlined above):

- Maximum heating capacity at -15°C (5°F)
- Efficiency (Coefficient of performance, COP) at -15°C (5°F)

Beyond -15°C, performance must be extrapolated: In this study, capacity at temperatures below -15°C is estimated using the -8.3°C and -15°C data points.

Full Manufacturer Performance Data: While not required under regulations, some manufacturers provide heat pump performance (both capacity and COP/power) at a larger set of outdoor conditions. Unlike AHRI 210/240 reported data, these curves may represent estimations rather than actual test results. In this study, manufacturer data is used to develop baseline performance curves to compare with the other two reporting approaches.

Table 3 compares reporting approaches at common test points.

Table 3: Summary of data reporting approaches

Data Point	Metric	AHRI 210/240	Amend. 17	Full Manuf. Data
+8.3°C (47°F)	Capacity	Yes	Yes	Yes
	COP	No	No	Yes
-8.3°C (17°F)	Capacity	Yes	Yes	Yes
	COP	No	No	Yes
-15°C (5°F)	Capacity	Optional	Yes	Yes
	COP	Optional	Yes	Yes
Min Operating Temperature (e.g., -23°C (-10°F))	Capacity	No	No	Yes
	COP	No	No	Yes

Heat Pump Performance Data

Two market-available variable capacity heat pumps are selected to examine the impact of different systems:

- Heat Pump A: A conventional non-cold climate unit
- Heat Pump B: A cold climate unit that maintains >80% of rated heat capacity at -15°C(5°F)

Table 4 summarizes key reported performance data extracted for each unit from AHRI 210/240 and Amendment 17 reporting. To enable assessment of multiple system sizes during simulations, capacity data (and resulting curves) is normalized based on rated heating capacity (i.e., capacity at +8.3°C).

Table 4: Reported data for HPs in Study [7,10]

Charecteristic		HP A	HP B	Notes
Capacity (Frac. Of Rated)	at +8.3°C	1.00	1.00	Via AHRI 210/240
	at -8.3°C	0.60	0.62	Via AHRI 210/240
	at -15°C	0.57	0.94	Via Amendment 17
COP	at -15°C	2.2	1.8	Via Amendment 17

Table 5 summarizes additional data relevant to curve development extracted from manufacturer literature (i.e., data not available from AHRI 210/240 and Amendment 17). Since min/max capacity ratios and minimum operating temperatures are required for curve development but unavailable from AHRI 210/240 and Amendment 17, the values listed for these parameters are used for all curve derivations in this paper.

Table 5: Manufacturer Supplied Information for HPs in Study [11,12]

		HP A	HP B
COP	at +8.3°C	3.5	3.1
Minimum Operating Temperature		-23°C	-23°C
Average Min: Max Capacity Ratio		0.3	0.3

Note: Minimum Operating Temperature for both units set equal to minimize added cross effects when comparing results

Resulting capacity curves generated from each data reporting approach (AHRI 210/240, Amendment 17, and Full Manufacturer Data) are shown in Figure 1 for both heat pumps. It should be noted that for HP B, the AHRI reported performance at -8.3°C was lower than the reported capacities at +8.3°C and -15°C. To avoid an increase in capacity at lower temperatures (driven by the slope of the capacity line between -8.3°C and -15°C, which is used to extrapolate capacity in Amendment 17 cases), a constant capacity below -15°C was used to illustrate the impact of capacity overestimation.

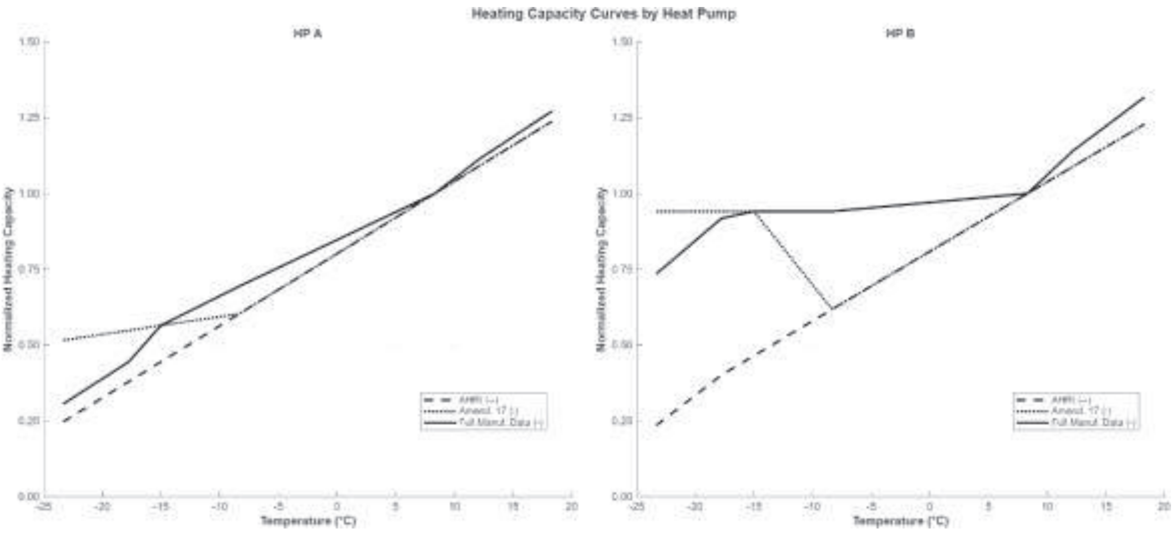

Figure 1: Normalized capacity curves for heat pumps used in analysis.

For completeness, normalized COP curves for both units and reporting approaches were also generated. Resulting normalized COP curves (normalized by COP at +8.3°C) are presented in Figure 2. Readers should note two items:

- *COP variation with outdoor temperature must be assumed for AHRI 210/240 and Amendment 17 cases*: Both these data reporting approaches do not provide sufficient data to generate COP performance curves as a function of outdoor temperature. As such, in this paper the variation of COP with outdoor temperature was instead assumed using available information for typical variable capacity air-source heat pumps in the literature [13].

- *Normalized COP curves are the same for the AHRI 210/240 and Amendment 17 cases*: Both data reporting approaches uses the same underlying curve shape to represent COP variation with outdoor temperature. The key difference is that for Amendment 17 the COP curve is shifted to ensure the heat pump has the same full load COP at -15°C as the value reported through the Amendment. For AHRI 210/240 reporting, the curve is normalized using an assumed COP of 3.3 at 8.3°C [8]
  As an example, HP A has a COP of 2.2 at -15°C according to Amendment 17 reporting. This equates to a COP at 8.3°C of 3.93 (Figure 2 shows the normalized COP is 0.559 at -15°C)

It is immediately clear that curves for both units and all data reporting approaches are similar, meaning that any variations related to power or efficiency noted in this paper are due to estimations of rated COP.

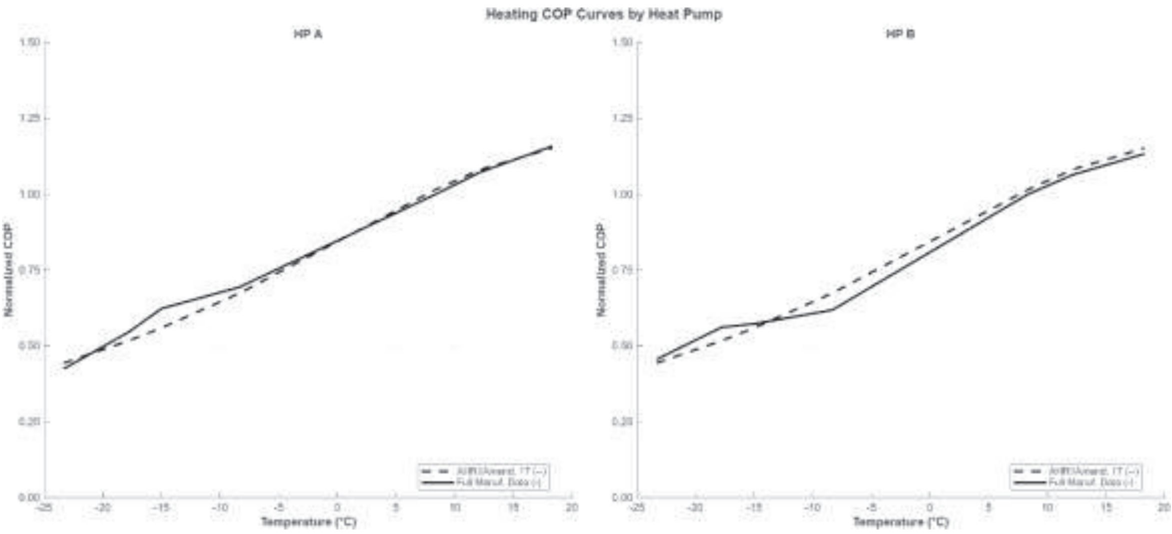

Figure 2: Comparison of normalized COP curves for each heat pump.

Representing Part Load Performance

Accurately representing part load performance is important, especially for variable capacity systems. Given the lack of information on performance at various compressor speeds under both AHRI 210/240, Amendment 17 and many manufacturer-reported data tables, part load efficiency variation is represented in this study via curves developed by Lachance *et al.* [13]. These curves are based on an analysis of a variable capacity heat pump performance database which included performance at both minimum and maximum compressor speeds.

This study also assumes that all data provided by AHRI 210/240 and Amendment 17 are at a single, consistent compressor speed. While this is necessary for curve development purposes, compressor speeds for each data point are not explicitly provided under these reporting approaches.

A Note on Heat Pump Sizing

Estimated energy performance via each heat pump reporting method is also closely tied to the relationship between heat pump capacity and building load. In this study, for each combination of archetype, construction period, location, and HVAC type, simulations were run for 10 different heat pump capacities (from 1.75 kW rated (at +8.3°C) to 17.5 kW rated, in increments of 1.75 kW) to better understand how sizing affects results.

4. Modelling Methodology

Appropriately modelling the performance of each heat pump system is critical to properly assess its potential benefits. All system models were developed in TRNSYS v.18 using the appropriate Canadian Weather for Energy Calculations (CWEC) weather file (2020 version). Simulations were run using a time step of 1 hour to properly facilitate heat pump performance while facilitating the efficient running of the over 23,000 simulations used in this study.

Heat Pump Performance Modelling

Examining the potential of variable and cold climate heat pump systems requires a simulation model capable of capturing their unique performance characteristics. In this study, all heat pump systems are simulated using a new enhanced heat pump model (TRNSYS Type 3255). This model has been developed based on extensive test experience at the CanmetENERGY in Varennes facility and integrates important new capabilities including performance variations with compressor speed. Further details on this model are provided in Breton et al. [14].

Type 3255 employs a data-driven approach, using performance maps supplied as inputs to the model to represent variations in heat pump capacity and power as a function of temperature and compressor speed. In this study, these performance maps are based on the information presented above for the respective heat pumps and data reporting approaches.

5. Results and Analysis

The developed methodology provides a basis to explore the energy and sizing of implications of different heat pump data reporting methods across Canada. Results are presented for select cities only to highlight key trends while ensuring sufficient space to discuss all relevant findings and implications.

Impact of Data Reporting Approach on Annual Heating Energy Use Predictions

Two cases are used to assess the impact of data reporting approaches for capacity and COP. Key details for each case are summarized in Table 6.

Table 6: Summary of Presented Analysis Cases

Case	Heat Pump	Capacity Curve	COP Curve	COP (at +8.3°C)
Capacity Only	HP A & HP B	AHRI 210/240	AHRI 210/240 / Amend. 17	3.3
		Amend. 17	AHRI 210/240 / Amend. 17	3.3
		Full. Manuf. Data	AHRI 210/240 / Amend. 17	3.3
Capacity and COP	HP A	AHRI 210/240	AHRI 210/240 / Amend. 17	3.3
		Amend. 17	AHRI 210/240 / Amend. 17	3.9 (COP 2.2 at -15°C)
		Full. Manuf. Data	Full Manuf. Data	3.5
	HP B	AHRI 210/240	AHRI 210/240 / Amend. 17	3.3
		Amend. 17	AHRI 210/240 / Amend. 17	3.1 (COP 1.8 at -15°C)
		Full. Manuf. Data	Full Manuf. Data	3.1

Given the heating dominated nature of the Canadian climate, results were compared based on predicted annual heating energy use (i.e., energy use for heat pump heating mode and any elec. auxiliary). To enable comparison of reporting methods, results for the AHRI 210/240 and Amendment 17 methods are normalized using the full manufacturer curves as a baseline. This means that for every simulation of an AHRI 210/240 or Amendment 17-developed curve, annual heating energy use was compared with the results of the manufacturer curve for the same location, archetype, construction period, HVAC type (ducted or ductless), HP capacity, and HP type (HP A or HP B). Positive percent differences correspond to simulations where the energy use predicted is higher than the corresponding full manufacturer data baseline.

All energy use figures are presented as violin plots. The vertical length of these plots shows the range of deviation in percent difference from the equivalent baseline simulation using performance curves generated with full manufacturer data. The width of each plot shows the relative distribution of simulations at a given percent difference: For example, greater width around a zero percent difference would indicate that a large portion of simulations run provided similar results vs. the full manufacturer curve runs.

Case 1: Capacity Only Curves: Figure 3 compares predicted heating energy use results for the capacity only case. In this case, capacity curves are varied while maintaining the same normalized COP curve and rated COP for all heat pumps. Results are shown for both AHRI 210/240 and Amendment 17 reporting methods, and HP A and HP B. In addition, results are provided for Winnipeg and Vancouver: These two cities were selected because they represent climate extremes of the four regions used during simulation: Winnipeg is a very cold climate with a design temperature of -33°C, while Vancouver is a much milder maritime climate where temperatures rarely fall below -7°C.

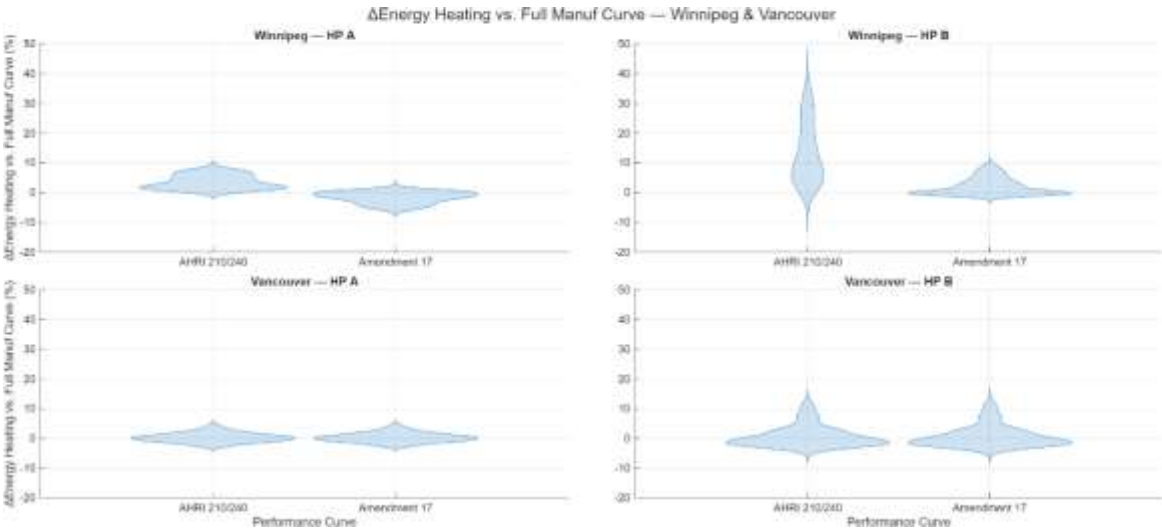

Figure 3: Comparison of heating energy use for Case 1 by HP reporting method and type for Winnipeg and Vancouver.

Given the amount of information presented, results are best explained by assessing performance at three levels:

Comparison of AHRI 210/240 vs. Amendment 17 Reporting: Differences between AHRI 210/240 and Amendment 17 reporting were found to have a strong regional dependance. Unsurprisingly, having an accurate estimation of the -15°C temperature point (as provided in Amendment 17) has an important impact on performance estimates in colder climates like Winnipeg. AHRI 210/240 curves consistently overestimate energy use, primarily because they underpredict the capacity of the heat pump at colder temperatures. Amendment 17 curves yield much lower estimates of annual heating energy use because they more accurately predict the heat pump heating capacity at colder temperatures.

This trend is not seen in Vancouver, as the milder climate mitigates the impact of the -15°C test point. Here, the key drivers of performance estimation are the capacities at +8.3°C and -8.3°C, which are the same for both the AHRI 210/240 and Amendment 17 curves.

Readers may note that in Winnipeg and HP A, the Amendment 17 curve estimates lower energy use vs. the baseline. This difference is best understood by referring to the normalized capacity curves presented earlier in this paper: For the HP A Amendment 17 curve, extrapolation beyond -15°C leads to an overestimation of capacity at very cold temperatures vs. the full manufacturer curve, resulting in lower predicted annual energy use. This type of behavior can likely be improved via additional cold temperature data below -15°C, but is an important note for policy as it could lead to missed emission reduction or cost savings objectives.

Comparison of HP A vs. HP B: Results also highlight variations for different heat pump types. A comparison of the capacity curves for HP A shows that all three approaches (AHRI 210/240, Amend. 17, full manuf.) follow a similar trend, with a greater deviation between the Amendment 17 and full manufacturer data only at colder temperatures. This results in similar performance predictions for all curves, especially in milder climates where the cold temperature capacity is not used.

In contrast, HP B shows much greater deviations in capacity for the different reporting methods vs. the full manufacturer curve. The AHRI 210/240 curve significantly underestimates cold temperature heating capacity, resulting in higher estimates of heating energy use in Winnipeg. This contrasts with the Amendment 17 curve, which underestimates heating capacity from +8.3°C to -15°C, but then overestimates heating capacity at very cold temperature (-15°C to -25°C). This trend can partially be addressed by adjusting the extrapolation method for Amendment 17 to use the +8.3°C and -8.3°C points should the current method lead to increased or constant capacity at temperatures below -15°C. In addition, the accuracy of the curves generated using reported data may be improved by ensuring all points are reported at the same compressor speed: one potential reason for the deviations seen in HP B are variations in compressor speeds used to generate the AHRI 210/240 and Amendment 17 points vs. those used to generate the full manufacturer curve.

Comparison of Climate (Winnipeg vs. Vancouver): As noted earlier, climate, especially the length of time spent below -15°C, also has a clear impact on results. Amendment 17 reporting, with added data at -15°C, has a clear benefit in Winnipeg, greatly reducing overestimations of energy use and bringing predicted annual energy use much closer to the baseline. Further capacity information below the current reported minimum temperature of -15°C in Amendment 17 can also be of value. The portion of Amendment 17 simulations that underestimate annual energy use in Winnipeg (i.e., simulations with percent difference <0%) directly relate to poor extrapolations of performance at temperatures below -15°C. Having additional capacity data down to the minimum operating temperature of the unit can mitigate these underestimations and ensure more accurate performance predictions.

Readers should note that the above observations are highly dependent on the curves used. However, they illustrate important issues that must be considered when identifying data reporting methods.

<u>Case 2: Capacity and COP Curves</u>: Figure 4 compares predicted heating energy use results for Case 2. In this case, both capacity and COP curves, along with rated COPs, are varied. Results are again shown for both AHRI 210/240 and Amendment 17 reporting methods, HP A and HP B, and both Winnipeg and Vancouver.

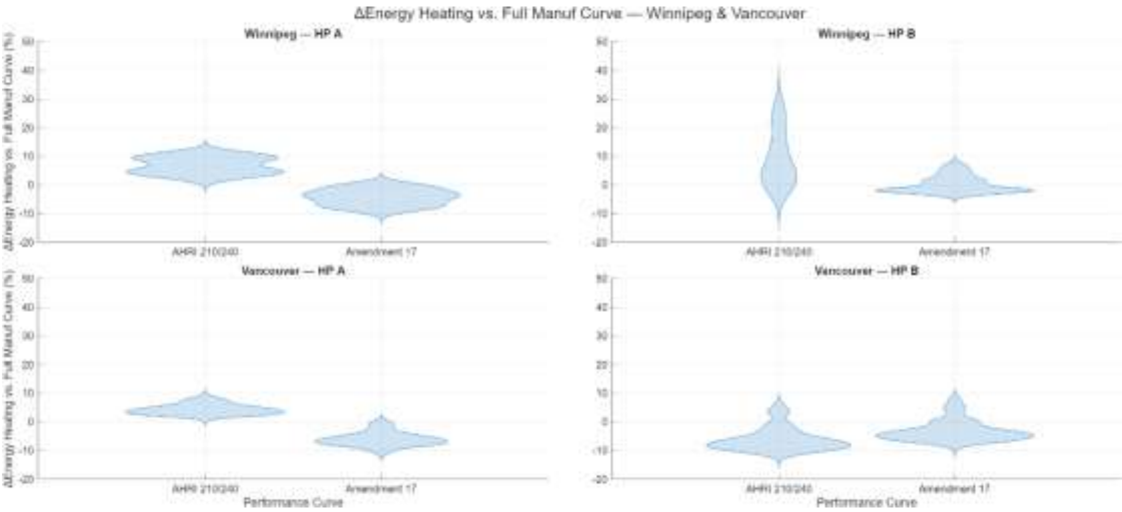

Figure 4: Comparison of heating energy use for Case 2 by HP reporting method and type for Winnipeg and Vancouver.

Impact of Heat Pump Reporting Method: For HP A, the assumed COP of 3.3 for AHRI 210/240 (selected in the absence of any COP data for this reporting method) was noticeably lower than the COP calculated using Amendment 17 or provided in the full manufacturer dataset. This led to higher estimates of energy use for AHRI 210/240 vs. those previously noted for the capacity only case.

Amendment 17 data led to an overestimation of rated COP of 8.3°C vs. the manufacturer baseline for both HPs. While this is primarily due to the curves used in this paper to predict COP at other outdoor air temperatures (vs. the sole reported value at -15°C), it underscores the need for additional COP data to limit the assumptions analysts must use during simulations or program development.

A Note on the Role of Climate: Shifts in percentage difference vs. baseline due to COP assumptions are noticeably smaller in Winnipeg vs. Vancouver. This *primarily* relates to the increased use of auxiliary energy in Winnipeg to supplement the heat pump during colder periods when the heat pump is unable to meet space temperature setpoints. In Winnipeg, heat pump operations comprise a smaller portion of the total heating energy use, minimizing the impact of COP assumptions vs. milder climates.

Impact of Data Reporting Approach on Heat Pump Sizing

Estimates of heat pump capacity can also have a significant impact on system sizing. Heat pump sizing is usually performed by targeting a desired thermal balance point temperature (BPT) [15], which is the point at which the capacity curve (at maximum speed) intersects the heating load line (defined as a straight line connecting the design heat load at the design temperature to zero heating load at 15°C). Calculation of the balance point temperature is illustrated for a sample case in Figure 5.

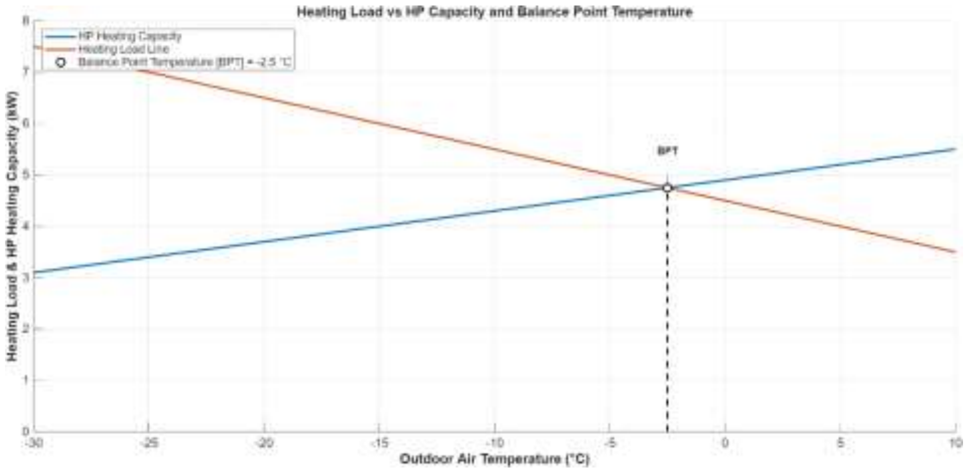

Figure 5: Illustration of Balance Point Temperature Calculation.

To assess the potential impacts of different performance reporting approaches, the thermal balance point was calculated for each simulation and compared vs. the balance point calculated using only manufacturer data. Results are shown in Figure 6 in Winnipeg for both HP A and HP B. The dashed line represents perfect agreement between the BPT calculated using full manufacturer data and the BPT determined via other HP data approaches. It is immediately evident that most points for both HP A and HP B lie above the dashed line. In these cases, the predicted balance point determined using reported data is higher than "true" balance point determined using the full manufacturer data set. This has both advantages and disadvantages: For the same size, heat pumps are likely to cover a greater portion of the load than anticipated. However, this also leads to the possibility that installers propose larger sizes than needed to achieve a certain performance objective.

Also of interest are the smaller set of points below the line for both HP systems associated with Amendment 17 reporting. In these cases, the estimated balance point is lower than the "true" value, in some cases approaching a difference of up to 5°C. From a policy perspective, these can lead to incentivizing systems whose actual performance does not meet targeted or estimated energy and GHG savings. As mentioned earlier, this situation can be mitigated with better reporting of cold temperature performance (below -15°C) for heat pump installed in colder Canadian climates.

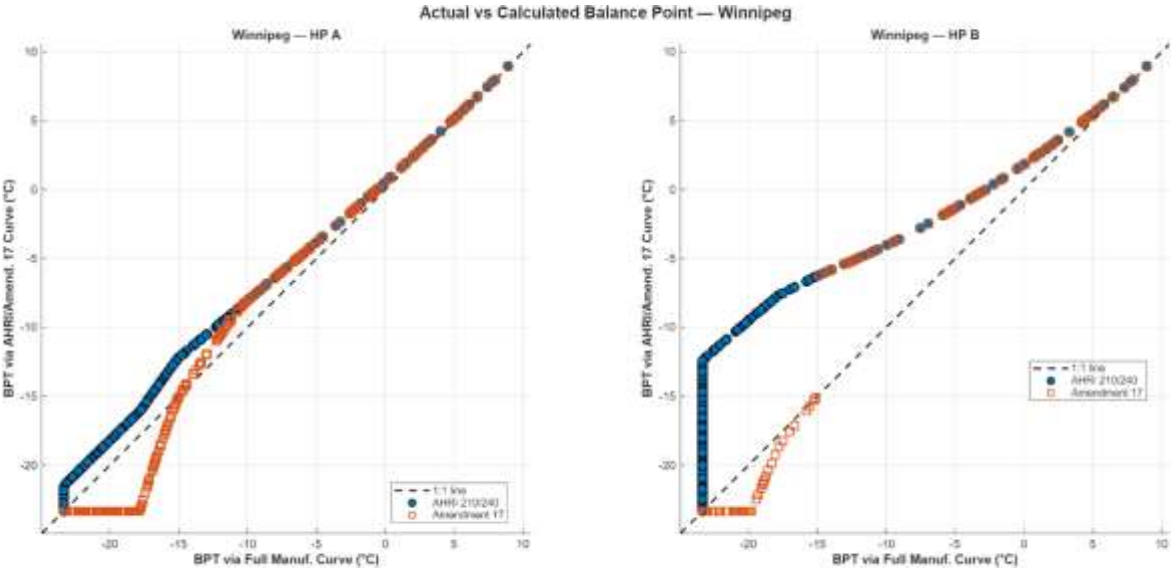

Figure 6: Comparison of thermal balance point temperatures (BPT) for HP A and HP B in Winnipeg.

Figure 7 shows a similar plot for Vancouver. Unlike Winnipeg, results are almost solely above the dotted line, meaning that heat pump sizing determined via AHRI 210/240 or Amendment 17 will cover a greater portion of heating in-situ than estimated beforehand. This is driven by the milder climate in Vancouver – overestimations of capacity via Amendment 17 no longer have an impact on sizing results, as the design temperature in Vancouver (-7°C) is well above the temperatures (<-15°C) where these overestimations occur.

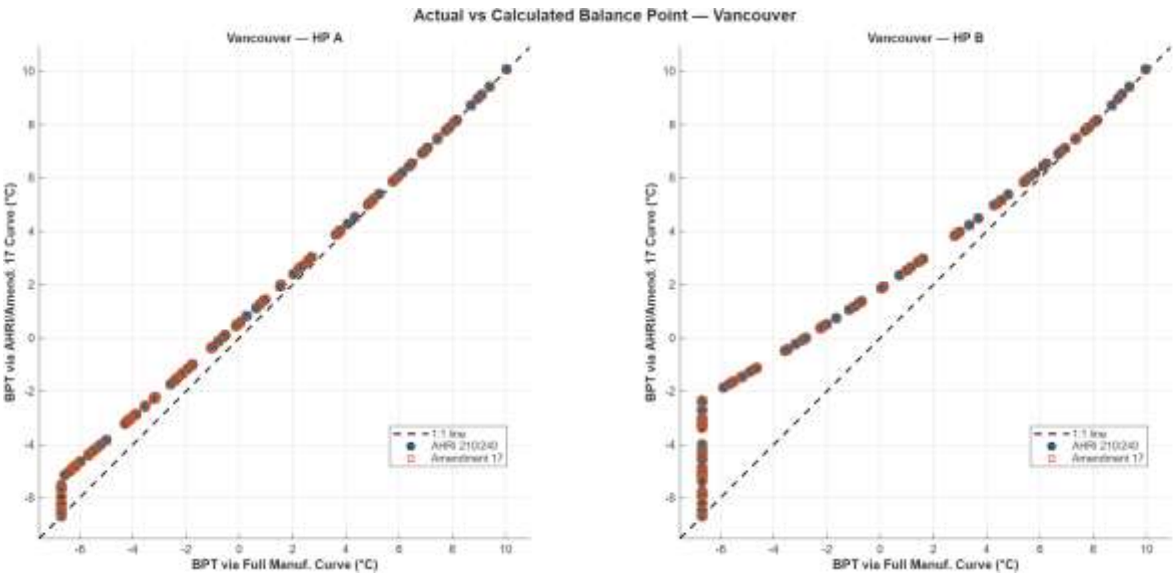

Figure 7: Comparison of thermal balance point temperatures (BPT) for HP A and HP B in Winnipeg.

6. Conclusion

This study has examined the impact of various heat pump performance reporting approaches on estimated energy use and system sizing in single family Canadian housing. A simulation-based method was used to assess performance reporting according to (i) AHRI 210/240, (ii) Canada's Amendment 17, and (iii) full manufacturer data, with simulations performed across four Canadian regions, five archetypes, and three construction periods. Results show a strong regional variation: Added lower temperature reporting is critical in colder regions such as Winnipeg, where performance extrapolation using only AHRI 210/240 required data can result in significant underestimations of capacity and energy savings potential. As would be expected, reporting cold climate performance in milder climates is much less important, highlighting regional challenges for policy makers responsible for defining performance reporting needs in Canada. Similar trends extend to sizing, where inadequate or poorly extrapolated performance near design temperatures can result in the difference between estimated and actual balance point temperatures approaching 5°C. These variations can have a significant impact on in-situ performance, and whether an incentive program reaches its targets.

Based on these results, several takeaways/recommendations can be made for policy makers and analysts:

- **Added cold climate performance data is valuable**: Although there is a strong regional dependance, cold climate data reporting provides quantitatively better performance predictions and sizing estimates in many Canadian regions. Amendment 17 represents a strong improvement over AHRI 210/240 minimum reporting in this regard, although performance data down to the heat pump minimum operating temperature should also be considered to address overpredictions of energy savings and balance point temperatures noted in certain cases using Amendment 17.

  Although not addressed in this study, poor estimates of cold temperature capacity are also likely to significantly impact auxiliary sizing. Should the auxiliary be electric, this will also strongly influence the estimated electrical demand of the home.

- **Additional COP reporting is needed**: Currently, AHRI 210/240 minimum reporting does not publicly provide heat pump COPs at +8.3°C and -8.3°C. Similarly, Amendment 17 only requires the COP at -15°C to be reported. This currently forces analysts to make assumptions about COPs and how they vary with load and temperature, introducing significant error into energy performance predictions. Additional COP reporting to match capacity reporting points would greatly improve estimates of energy savings.

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