Answer to Undertaking J18.7

Undertaking:

J18.7: MR. NEME TO RESPOND TO UNDERTAKINGS J11.5 AND J11.6

Response:

J11.5: Availability of Heat Pumps that Can Provide Heat at -30° C

There are numerous cold climate air source heat pumps that can produce a significant amount of heat at -30° C, at efficiency levels that are twice that of a new gas furnace even at those low temperatures. In fact, a search of the Northeast Energy Efficiency Partnerships' cold climate air source heat pump database[1] revealed the following:

- 1742 models with a "Lowest Cataloged Temperature (Outdoor Dry Bulb °F)" of -22° F or lower (-22° F is equivalent to -30° C).
- 683 of those models were centrally-ducted products that would most typically replace a gas furnace. Those 683 centrally-ducted models were produced by 13 different manufacturers (including Carrier, Lennox, GE Appliances and Trane) under 60 different brand names.
- 161 of those centrally-ducted models had maximum heating capacities of 24,000 Btu's per hour or better at -30° C. On average, those 161 models could produce 86% as much heat at -30° C as their rated capacity at -8° C.[2]
- More than half of the 161 centrally-ducted models with maximum heating capacities of at least 24,000 Btu's per hour at -30° C also had coefficients of performance (COP) at that temperature of between 1.77 and 2.33 (i.e., 177% to 233% efficiency). That is roughly twice as efficient as a new gas furnace.

These numbers likely understate the availability of cold climate heat pumps that are able perform at -30° C because they only include models for which manufacturers have documented and reported performance at that temperature. Because it is not a required field, not all manufacturers are providing a lowest operating temperature in the data that they submit to NEEP. In addition, I know of several anecdotal examples – including the Mitsubishi cold climate heat pumps that heat my office in Hinesburg, Vermont without any electric resistance or other type of back-up system[3] – of heat being produced at temperatures much lower than those advertised by manufacturers. It is also worth noting that the performance of cold climate air source heat pumps at cold temperatures has been improving over time, so the list of products that can produce significant heat at -30° C is likely to continue to grow over time.

It is difficult, without extensive research, to identify exactly which of the cold climate air source heat pump models that can function at -30° C are available for sale in Canada. However, it appears likely that most, if not all, are available in Canada. For one thing, every one of the fourteen different brands listed

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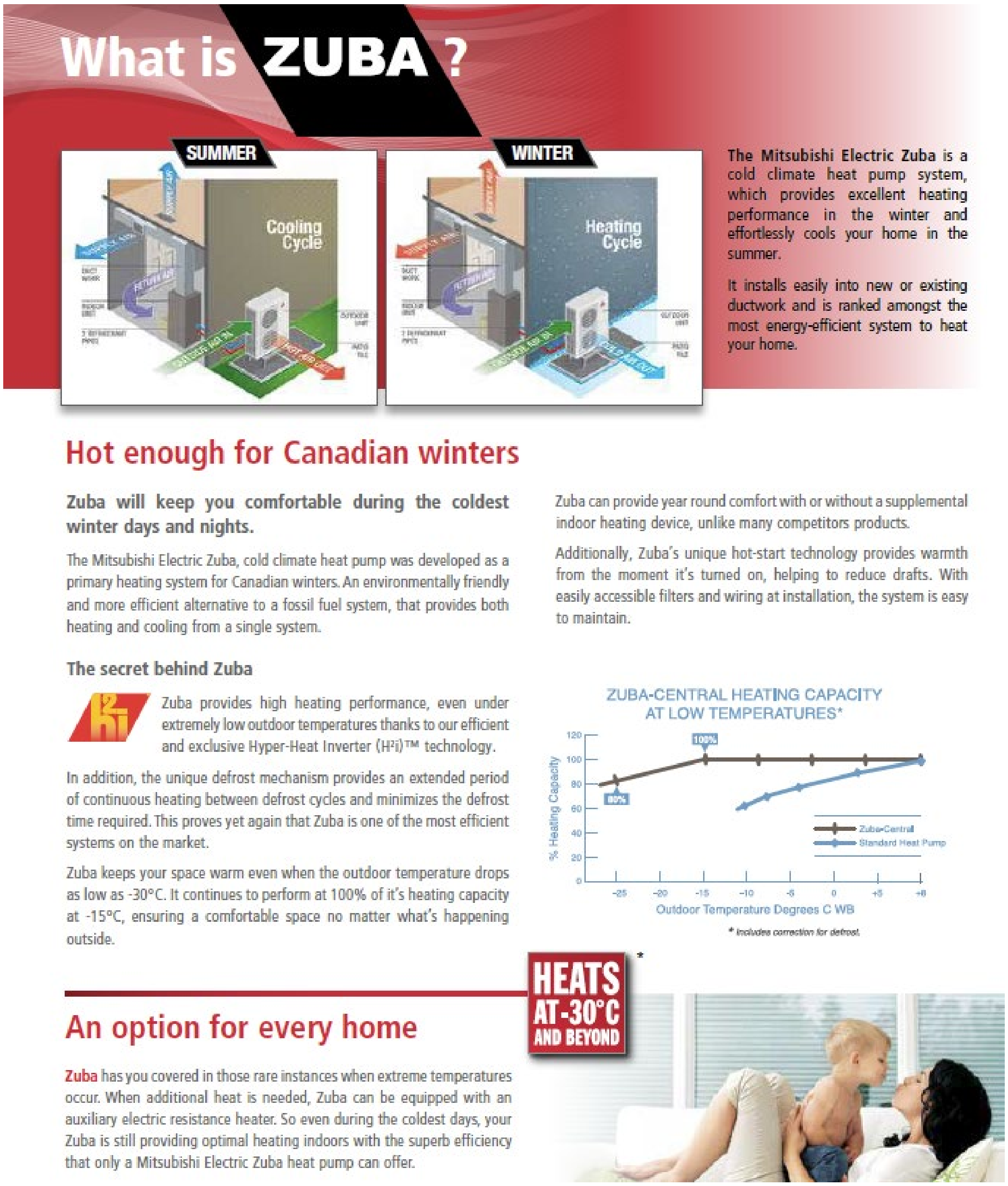
[1] Based on a review of the NEEP database downloaded on July 11, 2023.

[2] Comparison of maximum capacity at -22° F to rated capacity at 17° F.

[3] Our heating climate is comparable to Toronto's. In fact, over the past three years the number of heating degree days at the Burlington, Vermont airport was about 7% greater than at the Toronto City airport (https://www.degreedays.net/).

in the NEEP database as having centrally-ducted heat pump models with both heating capacities of at least 24,000 Btu's per hour and COPs of at least 1.77 at -30° C also has models listed by NRCAN as eligible for its Greener Homes program rebates.[4] In addition, we know that some heat pump manufacturers are actually marketing their products as viable in Canada's climate. For example, as the excerpt below shows, the Mitsubishi brochure for its Zuba heat pump models explicitly calls out its ability to provide heat to homes at -30° C "and beyond." It also explicitly states that its product is "Hot enough for Canadian winters."[5]



4 https://oee.nrcan.gc.ca/pml-lmp/index.cfm?language_langue=en&action=app.search-recherche&appliance=ASHP1_GH.

5 https://www.mitsair.com/wp-content/uploads/2020/08/MEM-202006V2-E-Zuba-Brochure_EN.pdf

Similarly, ClimateCare, which bills itself as "Ontario's largest cooperative of local, independent heating and cooling retail contractors", is advertising Moovair cold climate air source heat pumps as eligible for NRCan incentives, noting: "The Central MoovSeries units can achieve up to 100% of their rated capacity at -20° C while maintaining a high COP at temperatures as low as -30° C."[6] Moovair is a brand of The Master Group, which describes itself as "the largest independent distributor of HVAC-R products" in Canada.[7]

J11.6: Greenhouse Gas Emissions Impacts of Hybrid Heating Systems vs. Heat Pumps with Electric Resistance Back-Up.

Hybrid heat pumps (i.e., with gas furnace back-up) have higher greenhouse gas (GHG) emissions than all electric heat pumps (i.e., with electric resistance back-up). Indeed, as Table 1 below shows, an analysis by Guidehouse that was conducted for Enbridge[8] estimated the greenhouse gas emissions from all-electric systems – cold climate heat pump with electric resistance back-up – to be nearly 20% lower than a hybrid system with an existing gas furnace and on the order of 10% lower than a hybrid system with a new gas furnace. That was true across all four cities analyzed – Toronto, Ottawa, Windsor and Thunder Bay – as well as across small, medium and large residential heating loads in each city.

Table 1: Comparison of GHG Emissions from All-Electric vs. Hybrid Gas-Electric Heating in Ontario

City	Heat Load	Annual GHG Emissions (kg CO2e)			All Electric Emissions as % of Hybrid Emissions	
		Hybrid w/Existing Gas Furnace	Hybrid w/New Gas Furnace	All Electric Cold Climate Heat Pump (electric resistance back-up)	vs. Hybrid w/Existing Gas Furnace	vs. Hybrid w/New Gas Furnace
Toronto	Small	1253	1140	1018	81%	89%
	Medium	1990	1823	1630	82%	89%
	Large	2486	2279	2038	82%	89%
Ottawa	Small	1646	1519	1321	80%	87%
	Medium	2628	2429	2117	81%	87%
	Large	3284	3037	2649	81%	87%
Windsor	Small	1138	999	918	81%	92%
	Medium	1768	1591	1469	83%	92%
	Large	2197	1987	1837	84%	92%
Thunder Bay	Small	2022	1889	1652	82%	87%
	Medium	3235	3023	2649	82%	88%
	Large	4044	3779	3314	82%	88%

Furthermore, the Guidehouse figures would likely overestimate the emissions arising from widespread adoption in the future of all electric heat pumps because its analysis appears to be based on current *short-run marginal emissions rates*. However, current and future *long-run marginal emissions rates* are what really matters. The importance of focusing on long-run marginal emissions rates when considering

[6] https://www.climatecare.com/wp-content/uploads/2023/04/ClimateCare_Moovair_-Cold-Climate-Air-Source-Heat-Pump.pdf.
[7] https://moovair.ca/why-moovair/.
[8] Exhibit K2.2, p. 276 (Memorandum from Guidehouse to Enbridge on May 19, 2023).

the impacts of policies and/or programs has been very well documented by several papers published by the U.S. Department of Energy's National Renewable Energy Laboratory.

One example can be found in *Planning for the evolution of the electric grid with a long-run marginal emission rate* by Pieter Gagnon and Wesley Cole.[9] The authors describe how the short-run marginal emissions rate neglects to represent "any influence that new load could have on the structure of the grid (e.g., building or retiring of capital assets such as generators or transmission lines)." The most important structural change is that "[a]dding electrical load has the potential to induce the construction of more non-emitting generators, such as wind and solar." The authors conclude that the long-run marginal emissions rate is more accurate and generally results in significantly lower emissions estimates.

In the discussion that led to the request for Undertaking J11.6, Enbridge's witness, Ms. Giridhar, was asked by Commissioner Moran if she was suggesting that it is "better to have gas as a back up to your heat pump than using electric resistance heating as a backup to your heat pump." The question was clearly asked with respect to GHG emissions. Ms. Giridhar's response was "That is correct…to the extent that the resistance heat is provided by gas-fired generation, we would be better off having gas as a back-up in the home, coming off a 95 percent- plus efficient furnace." A little earlier in the discussion, Ms. Giridhar explained that her conclusion was based on comparing (1) electricity supplied by gas turbines that are 50-60% efficient to electric resistance heat that is 100% efficient with (2) heat supplied by a gas furnace that was 90% efficient (or perhaps slightly better than that). Ms. Giridhar's response was technically correct for the very specific underlying assumptions that she made – i.e., comparing back-up gas heat to back-up electric resistance heat supplied solely by fossil gas-fueled combustion turbines. However, those underlying assumptions are not reasonable. As a result, her conclusion is misleading.

There are several reasons for this:

- **Many cold climate heat pumps can provide a substantial amount of heat – *at efficiencies much greater than that of electric resistance heat* – at temperatures at which winter peak demands are likely to be experienced**. As discussed above, there are more than 80 models of cold climate heat pumps which manufacturers have documented as capable of supplying more than 24,000 BTUs of heat at -30° C and at efficiencies ranging between 177% and 233%. There are likely others whose performance at those temperatures is similar but which manufacturers have not documented and/or have not disclosed through the NEEP cold climate heat pump database.
- **The gas furnace component of hybrid heating systems will often operate not just during a handful of winter peak hours**. Indeed, the Guidehouse analysis referenced above assumed that the gas furnace components of hybrid systems would provide nearly 20% of the heat needed for an entire winter in Toronto and about 33% of the total winter heating load in Ottawa. This has important implications for GHG emissions for two reasons. First, gas heating would be used during a number of hours at which outdoor temperatures are warmer than the coldest winter peak hours – and at which most cold climate heat pumps can supply substantial amounts of heat (if not all the heat needed by the home) at efficiencies much greater than that of electric resistance heat. Second, while gas-fired power plants may be the marginal electric generating resource today at the winter peak heating hour, other non-GHG emitting resources may be on

[9] https://www.sciencedirect.com/science/article/pii/S2589004222001857.

the margin during some of the other hours that the gas furnace component of hybrid systems would be operating.

- **The already small emissions from fully electrified heating will become even smaller if additional generation built to serve additional winter peak load driven by widespread heat pump adoption is non-emitting over the medium and long-term:** Gas-fired generation may be on the margin during winter peak demand today (at least for some hours). And existing gas-fired generation may continue to operate in the future. However, neither of those things are relevant to the question of what new emissions might be created during winter peak hours by a wider shift to new all-electric heating systems. New generation facilities built to meet the demand for heating electrification would likely need to be non-emitting in order to meet climate targets over the medium and long term. This would result in a decline in the emissions arising from full electrification, even during winter peak hours, when measured with the long-run marginal emissions rate, which, as noted above, is more appropriate for assessing the impacts of programs and/or policies in comparison to the short-term marginal rate.