# CARD Webinar Audience Questions & Answers

## It's the End of Traditional AC as We Know It – and I Feel Fine

*Webinar Date: August 4, 2022*

***Why are Mini Splits excluded as the impact would be great as retro fits and new construction?***

*Mini-split technology is a fantastic technology for retrofits in homes without ductwork and in new construction. This market is rapidly growing and comprises most heat pump products sold in Minnesota today. The purpose of this study was to look closely at the largest heat pump opportunity, which is in the largely untapped 1.2 million homes in the state that have central air conditioners (CACs) and natural gas furnaces.*

***The Air Conditioning, Heating and Refrigeration Institute's (AHRI's) Heating Seasonal Performance Factor (HSPF) ratings usually are for region 4. How can we translate that to an HSPF for a Minnesota (MN) climate?***

*There is ongoing work that attempts to do this. AHRI is revisiting HSPF/SEER (Seasonal Energy Efficiency Ratio) and the CSA (Canadian Standards Association) is developing a standard called EXP07; both should provide more climate-specific ratings. However, these are still ratings, which we anticipate will vary from installed performance.*

***Did you do any analysis of the cooling efficiency of air-source heat pumps (ASHPs) across high outdoor temperatures?***

*Yes, this model does include the effects of outdoor temperature on cooling efficiency. Adjustments are made based on the SEER rating of each ASHP and capture the expected decrease in cooling efficiency with warmer temperatures.*

***So, the Minnesota Power (MP) and Otter Tail Power (OTP) rebates must be for electric-to-electric changes, correct?***

*For more details about utility rebate requirements, please contact each utility directly: Minnesota Power heat pump rebates, Otter Tail Power heat pump rebates.*

***Slides 33-35 are very interesting given cost fluctuations. with a hybrid system, seems that there could be operating characteristics that would be dictated by gas prices (because they will fluctuate more than electric rates). This is a new concept to me. Is this a "thing"? somehow automatically operating hybrid system in winter based on month-to-month changes in gas costs?***

*While possible theoretically, this is difficult in practice. There is a disconnect between real-time natural gas pricing and what consumers pay on their bill at the end of the month. Simple optimizations that bias ASHP operations toward carbon emissions or cost savings should be sufficiently robust to capture the most opportunity. I suspect that even with perfect information, dynamically operating equipment according to outside air temperature, actual equipment efficiency, and real-time prices would have a very small benefit compared to a simple strategy, at least in the current rate environment. However, I'd have to model it to better analyze the potential.*

### *What Coefficient of Performance (COP) @ what temps are you using for your modeling of ASHP and cold-climate air-source heat pumps (CCASHP's)?*

*The COP vs. outdoor air temperature (OAT) profiles for each ASHP are based on manufacturer reported data, plus adjustments for fan energy, cycling, defrost, and standby power based on data we have seen from field installations of similar equipment. These are discussed further in our report, but the COP vs. outdoor air temperature profiles are in our webinar on slide 24 (titled "Methodology – ASHP Archetypes"). Note that the profiles pictured here are for the ASHP alone, whereas system COP will depend on the baseline furnace/fan as this will affect system runtime and overall energy consumption. Each ASHP archetype also has a different minimum operating temperature reported by the manufacturer.*

### *At one point you said the unit performance didn't correlate to the cost well, because of other variables in installation costs. Can you talk about that?*

*We had mentioned in our presentation that there isn't a clear relationship between system capacity (in tons or British thermal units [BTUs] per hour) and installed cost due to the significant variation we see in recent bids for identical equipment. While we would generally expect higher capacity equipment to come at a higher cost, any capacity-based effects are eclipsed by other influences on current (2022) quoted costs.*

*We did not mention this in the presentation, but it is true that unit performance also does not tend to correlate with cost. In addition to the variation we have seen in contractor bids, comfort, availability, support, control, brand reputation, etc. can all contribute to unit prices without necessarily translating to customer energy/cost savings. There is also sometimes an additional cost for unit performance at very low temperatures, which we did not study either because 1) they were below capacity switchover for CAC-sized equipment or 2) the economics dictated higher switchover temperatures.*

### *Wondering if there is a metric that captures the environmental cost/benefit of these changeovers in addition to the financial cost/benefit?*

*We have some metrics such as source energy factor and emissions intensity. The ratios between these parameters for the ASHP/furnace are analogous to the utility rate ratio we use for costs, but they are subject to more variation than cost and would be harder to integrate into operating decisions. There is also a significant amount of ambiguity about the appropriate scale or timeframe to evaluate these parameters, and the methodological differences do impact outcomes.*

### *With such strong sensitivity to utility rates, do you see potential benefits in MN of time-of-use rates, real-time rates or otherwise grid-responsive rates (e.g., if renewable electricity supply is high)?*

*We would have to specifically study these scenarios to know, I suspect the answer is complicated and will vary substantially over time.*

### *"Right Size" was used several times. Also reference of covering cooling load sizing. Did you look at oversizing the cooling on a VS or modulating and how does that improve savings?*

*We assumed the baseline CAC system would be oversized, consistent with the existing oversized CAC system. Two of our variable speed air-source heat pump (vsASHP) systems were oversized (2.5 and 3 ton) because the real equipment upon which those models were built were not available in the optimal two-ton size. At least in this study, there were no consequences to oversizing. The minimum capacity of both systems was significantly less than both oversized and correctly sized single speed machines. In both cases, we essentially got extra heating capacity; however, the economics of most current rate scenarios prevented us from using that capacity in practice. Nonetheless, having that capacity available adds an extra dimension of flexibility over what I'm sure will be many changes in utility costs and grid requirements over the equipment's lifetime.*

### *Have you done the analysis with a new 97% with an electronically commutated motor (ECM) vs a ASHP since most customers are replacing the entire system.*

*Our highest efficiency baseline in this study is a 95% furnace with an ECM motor and two-stage heating and cooling. This is also the replacement furnace used in our full replacement scenarios. Assuming the same fan type, operating behavior, and furnace features, we do not expect a practical difference between furnace efficiencies above 94%. A 2% increase in efficiency could theoretically raise the economic switchover temperature in cases that are more sensitive to gas rates, but we lack the precision to demonstrate it here. Cooling results will be identical to the existing 95% scenarios as this only depends on the fan type and operating behavior.*

### *My personal experience (for my home) in the past (4-8 years ago) was that implementation contractors were not comfortable installing ASHPs. In your interviews, do you think that attitude is changing?*

*The pool of 30 contractors interviewed did not indicate a lack of familiarity or comfort with installing heat pump technology. The centrally ducted ASHPs are largely consistent with an air conditioner (AC) installation with a few additional design considerations, which should ease contractor adoption. The main barrier we uncovered from the contractors was the lack of customer demand. However, even though the survey didn't highlight barriers related to contractor comfort with the technology, we are aware through other program work and research that, in practice, there is hesitation in the contractor trades.*

### *Was there a reason to not examine high velocity systems? Generally, would these same findings apply? Are there additional technical barriers?*

*Our scope was limited to heat pumps (HPs) as AC replacements; we did not consider major duct system retrofits. There are additional barriers posed by adding work scope to these projects.*

### *How applicable are market research findings for residential customers to the needs/aims of multi-family building owners (i.e., upfront costs, payback periods)?*

*Multi-family building owners were not included as an audience in the market research surveys.*

### *Also wondering about backup power options being considered for AHSP (aside from natural gas).*

*We looked exclusively at the dominant market in MN: HP as AC replacements for houses heated by natural gas. In other contexts, propane and electric resistance systems can serve as backups. The economics of these alternative systems are much more compelling and urge us to consider different equipment (larger ASHP systems that serve a greater fraction of heating load).*

### *A bit of a personal question, but I am a solar generator so my electric rate is very low or no cost out of pocket, can I use a heat pump as a supplemental heat source as well as cooling source. The impact on overall monthly cost. I currently have an LP (liquefied petroleum) furnace and an older CAC.*

*Residential solar installs vary, but usually the amortized cost of electricity from rooftop solar is less than the 0.09 $/kWh minimum we considered here, which would be favorable to the heat pump costs. However, your residential solar system was likely not sized for the additional load of an ASHP, which means you will probably be consuming more grid electricity to power it and the utility rate is what you should compare against. That said, propane is significantly more expensive than natural gas, which opens the door for ASHPs to be installed at larger capacity (than an AC) to displace additional propane use at a lower cost. Propane still makes for a good backup.*

### *You mention the comfort advantages. Is that only due to variable fans, or what are other factors related to comfort?*

*The primary contributor to comfort that we are considering is extended system runtime. This could be a result of lower cooling capacity (in tons or BTU per hour), variable capacity, or a combination of the two. A system that runs at a lower capacity will run for longer to deliver the same cooling load, allowing for improved dehumidification. This is true for all fan types, but long runtimes with less efficient fans will result in high fan energy consumption. We also explored the advantage of potentially having two cooling flow rates for variable speed systems, but this wasn't addressed in the presentation (and from what we can tell, most current vsASHP products do not leverage this).*

### *How does the reliability and expected life of heat pumps compare with traditional ACs?*

*The lifespan for ASHPs is expected to be similar to air conditioners, about 18 years. Stakeholder responses from our market research have noted that ASHPs may have shorter and more error-prone lifespans, though this may be for reasons outside the product's quality, e.g., unfamiliarity, installation difficulty, complex controls, etc. Survey responses from distributors mentioned that ASHPs are perceived to be higher tier products with long lifespans and better warranties. We should also recognize the impact of ASHPs' much higher runtime compared to CACs used in MN climates. This may impact lifetime, but we do not have data yet to evaluate.*

### *Is there any expectation that gas and electric prices will decouple in the future? Is there a trend, or is that uncharted territory?*

*Uncharted territory. They will always remain coupled in some sense as long as we generate electricity from natural gas. But that will certainly be complicated by how and when that electricity is generated, as well as other factors in the natural gas market (e.g., international exports).*

***Also, seems like a BIG impediment will be getting the trade fully on board in terms of advocating for heat pump systems. With heat pumps, we're talking about added complexity (panel upgrades, removing gas equipment, etc.) and overcoming institutional momentum (trade knows A/C and gas furnaces and not heat pumps so much). How can we surmount these barriers?***

*We only investigated heat pumps for AC replacements with natural gas backup. Our application avoids these barriers, which is why we picked it. In most cases, these systems are sized like the AC. There are no panel upgrades required. The gas furnace remains in place. In fact, many of these installs should be the exact same for the contractor, save more low voltage control wires (which they already do for advanced CAC systems) and an additional switchover setting on the thermostat.*

***In the long-term if we shift to a future where a lot of customers have installed ASHPs and the gas system is serving a backup role for the coldest weeks, and therefore overall gas throughput is lower and the volumetric portion of gas rates is higher (higher $/dekatherm), how do you see this changing the economics of your 3 scenarios?***

*This is a great question and requires a very different rate analysis than we performed in this study. I suspect there is a tremendous uncertainty to this work that we must respect, given the high volatility of gas pricing. It may be hard to conclude much or distinguish between the likelihood of multiple scenarios with diametrically opposed outcomes*

***So, you include cold climate heat pumps but assume that these won't, in and of themselves, provide sufficient heating capacity (and must be supplemented by gas heating). Will cold-climate heat pumps (ccHPs) soon (due to technology advancements) be able to meet 100% of heating requirements?***

*This study only looked at one ccASHP and it was not sized to meet the heating load; a larger sized unit could come very close, however. ccASHPs can meet heating requirements in about a quarter of all MN homes and electric resistance backup is a relatively cheap option to extend security against prolonged periods of extreme weather. Another possibility is to add substantial auxiliary capacity. Typically, the economics will dictate that we should meet about 90% or 95% of the load with the heat pump and supplement with electric resistance on the coldest days (<200 hr/yr). The answer to meeting heating load with ccASHPs in more buildings is not the heat pump technology, but a better building that is well insulated and air sealed against extraneous heat loss.*

***Do you have any data you might consider evaluating for the impact of variable speed system to reduce kilowatts (kW) during peak to benefit the grid?***

*This is outside the scope of our study, but vsASHPs offer cooling peak load reductions approximately proportional to their SEER improvement over baseline CAC equipment. In other words, our SEER 14 ASHP provides minimal benefit, but the higher end vsASHP systems should offer peak reductions on the order of ~30% or more.*

***A number of research papers were discussed at the beginning of the presentation espousing the efficacy of ASHP in decarbonization efforts. Could these please be shared?***

- *Combating High Fuel Prices with Hybrid Heating: The Case for Swapping Air Conditioners for Heat Pumps (https://www.clasp.ngo/research/all/ac-to-heat-pumps/)*

- *US. Building Stock Characterization Study (https://www.nrel.gov/docs/fy22osti/83063.pdf)*

- *Electric and Gas Decarbonization Options for Homes and Apartments. (https://www.aceee.org/webinar/electric-and-gas-decarbonization-options-homes-and-apartments)*

- *Carbon and Energy Cost Impacts of Electrification of Space Heating with Heat Pumps in the US (https://eta.lbl.gov/publications/carbon-and-energy-cost-impacts)*