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Advancing Beneficial Electrification: The Role of Dual Fuel Home Heating Systems in Cold Climates

By Justin Margolies, Slipstream, and Art Thayer, Michigan Electric Cooperative Association

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ARTICLE SNAPSHOT

WHAT HAS CHANGED IN THE INDUSTRY?

For those living in colder climates of the U.S., dual fuel air-source heat pumps can provide a reliable and cost-effective way to stay warm in the coldest months of the year. There are several benefits of dual fuel space heating instead of all-electric space heating, which include resiliency, allowing member-consumers to adapt to changing temperatures, and improving comfort while still providing an opportunity for beneficial electrification.

WHAT IS THE IMPACT ON COOPERATIVES?

Dual fuel heat pumps provide a significant opportunity for the electric cooperative to receive additional electricity demand, while also improving the lives of their member-consumers. Integrating the dual fuel perspective into existing heat pump education and outreach can bolster your co-op's reputation as a trusted advisor to your member-consumers.

WHAT DO COOPERATIVES NEED TO KNOW AND DO?

Considering the potential benefits of incorporating more dual fuel heat pumps into the electrical grid, electric cooperatives can establish programs to incentivize their member-consumers to switch to dual fuel heat pumps. Different financing options can be explored through member-consumer engagement and pilot projects. As technology continues to improve, and as the grid becomes cleaner, dual fuel heat pumps will continue to provide additional benefits.

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Dual fuel heat pumps present a resilient resource to co-ops in cold climates and a compelling value proposition to member-consumers.

The new generation of air-source heat pumps are less vulnerable to cold weather.

The Risk of All-Electric Space Heating

High penetration of all-electric space heating is an exciting prospect for electric co-op top-line growth, but presents a potential challenge in cold climates. Severe winter weather events, such as the polar vortex that impacted the Midwest and Northeast in January 2019, result in spikes in demand for heating. Without careful co-op planning, growth in the number of electrically heated homes could contribute to the emergence of more frequent winter system peak events, expose constraints in the distribution network, and increase electricity's cost and emissions. Extremely high winter member-consumer electric bills due to electric resistance supplemental heat in an air-source heat pump (ASHP) is also a risk. In a worst-case scenario, cold snaps could result in power outages and member-consumers could lose heat when they need it most. This would not be beneficial electrification.

Fortunately, there are solutions to manage the risk of all-electric space heating. Efforts to lower the heating load of homes will help mitigate peak winter demand (see Figure 1). Some member-consumers may be willing to sacrifice a few degrees from their preferred thermostat setpoint and load management can help shed space heating load. With proper price signals, other member-consumers may be compelled to rely on thermal storage solutions or even the battery in their future electric car. While a suite of all-electric solutions will only become more cost-effective over time, dual fuel heat pumps can avoid electric heating demand during winter peaks altogether and add low-cost electric load for co-ops to serve today.

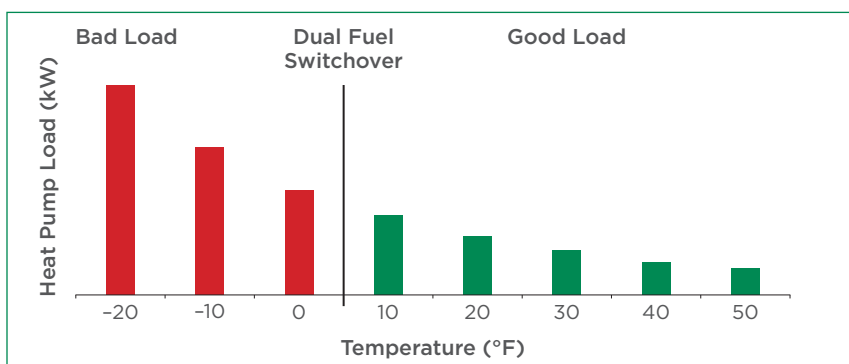


FIGURE 1: Dual Fuel Heat Pumps Generally Add Good Load in Future State of High Penetration of Electric Space Heating

In the face of an energy transition that promises uncertainty, dual fuel heat pumps present a resilient resource to co-ops in cold climates and a compelling value proposition to member-consumers. Dual fuel heat pumps increase energy security, improve comfort, and empower member-consumers with the ability to instantaneously adapt to changing fuel prices and outdoor temperatures. And, just because dual fuel heat pumps do not fully electrify space heating does not mean the opportunity for dual fuel heat pumps is small. For many homes, the added electric consumption from a dual fuel heat pump could surpass the added load from an electric vehicle.

Why Do Heat Pumps Need Supplemental Heat?

By moving energy rather than converting energy, heat pumps can be 2 to 5 times more efficient than fuel-fired alternatives. However, when it is cold outside, air-source heat pumps¹ must work harder to absorb heat and both their rate and efficiency of heat transfer decrease. Variable-speed compressors and variable refrigerant flow have ushered in a new generation of ASHPs with performance that is less vulnerable to cold weather, but most homes in cold climates will still need backup at the most extreme cold temperatures.

Figure 2 illustrates how a single-stage heat pump and a variable-speed heat pump with the same rated capacity at 47°F perform differently as temperature decreases. While it is possible in principle to oversize a heat pump to meet demand at lower temperatures, this would lead to excessive compressor cycling during the more frequent moderate temperatures and consequently less efficient performance. Overcycling would be less dramatic for variable-speed heat pumps with a wide range of output capacity and would be more dramatic for single-stage heat pumps during periods of low-demand cooling and dehumidification. To avoid this problem altogether, the heat pump can be sized to deliver a portion of the home's heating load at design temperatures and the home can rely on supplemental heat at the lowest temperatures.

¹ For more information on air-source heat pumps, see related article: [Promoting Efficiency and Electrification with Space Heating and Water Heating](#) (NRECA Surveillance, February 2020)

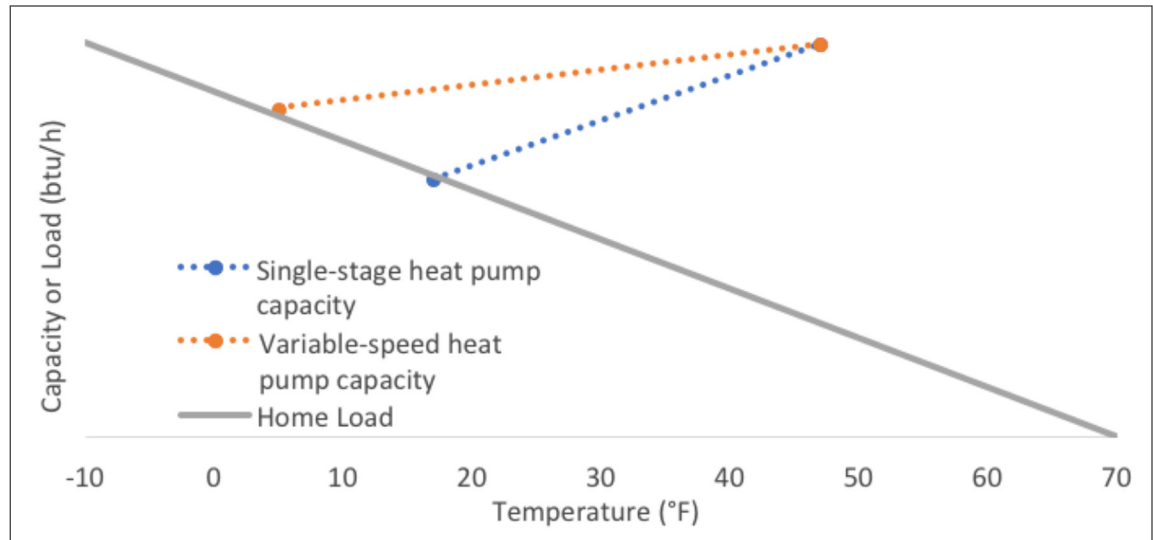


FIGURE 2: Home Heating Load Increases as Heat Pump Capacity Decreases²

The ideal source of supplemental heat for an ASHP depends on many factors...

Supplemental heat can be distributed in a variety of ways including hydronic or resistance baseboard, radiant floor, forced air, wall heaters, wood stoves, fireplaces, or even portable space heaters. The ideal source of supplemental heat for an ASHP depends on many factors, such as the incumbent heating system, the type of heat pump being installed, the design and thermal efficiency of the home, and the cost and convenience of integrating the supplemental source.

While ground-source heat pumps³ (GSHPs) are better shielded from fluctuations in outdoor air temperature, there are diminishing returns to over-sizing the ground loop to provide the home's full heating load at extremely cold temperatures. Designing GSHPs to meet partial load can lower upfront costs and a homeowner may find it more cost-effective to meet the remainder of their heating needs with an alternative fuel rather than rely on electric resistance heaters.

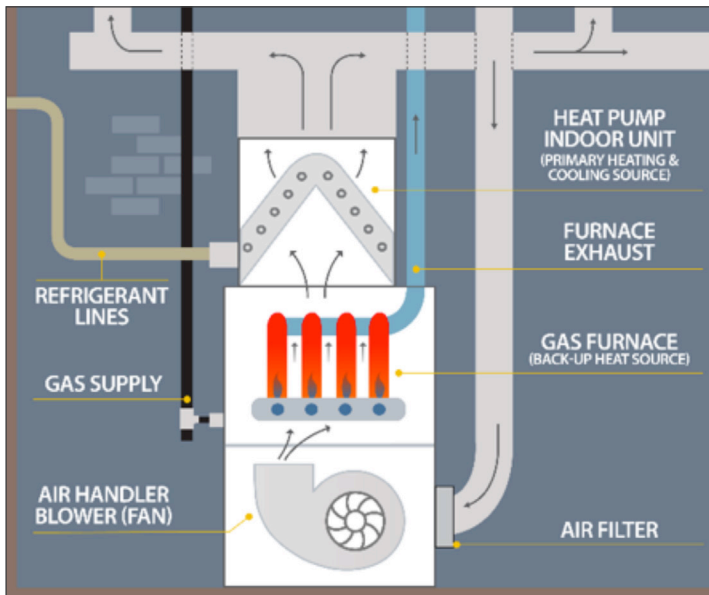


FIGURE 3: Centrally Ducted Dual Fuel Heat Pump Air Handler. (Source: <https://www.michigan-energy.org/heatpumps>)

The Centrally Ducted Dual Fuel Air-Source Heat Pump

A centrally ducted ASHP will be well-suited for the 65 percent of homes in the Northeast and Midwest that have an existing forced air system (RECS, 2018). Supplemental heat for centrally ducted systems can be provided by electric resistance coils or a gas-fired furnace adjacent to the indoor coil (see Figure 3). All-electric ducted heat pumps operate simultaneously with the electric resistance backup functioning as a “booster,” whereas dual fuel heat pumps alternate between heat pump and furnace mode.

A dual fuel heat pump's switchover most often depends on a predetermined temperature, but controls may also be configured to switch to furnace mode when the heat pump

² Note, while this graph is based on real data from two real units, it is for illustrative purposes. There are units that advertise high capacity at very low temperatures.

³ For more information on ground-source heat pumps, see related article: *Promoting Efficiency and Electrification with Space Heating and Water Heating* (NRECA Surveillance, February 2020)

TABLE 1: Fraction of TMY Hours Above the Switchover Temperatures (NSRDS, 2005)

Switchover Temperature	Pittsburgh, PA	Grand Rapids, MI	Grand Forks, ND
10°F	98%	97%	83%
20°F	94%	90%	75%
30°F	87%	79%	66%
40°F	68%	61%	53%

Even with higher switchover temperatures, dual fuel heat pumps can still meet space conditioning needs and present a significant electrification opportunity.

Dual fuel heat pumps can communicate and be programmed to optimize economic or environmental impacts.

can no longer maintain the indoor setpoint. Integrated controls driven by the thermostat make it possible to automatically switch back and forth between the heat pump and furnace throughout the heating season. The heat pump may be paired with a new furnace or may be added on to an existing furnace.

The Dual Fuel Beneficial Electrification Opportunity

Space heating makes up over half of the energy consumption in homes in the Midwest and Northeast, but only 17 percent of homes’ main heating equipment uses electricity as the primary fuel and 3.4 percent of homes use heat pumps as their primary space heating equipment (RECS, 2018).

Even with higher switchover temperatures, dual fuel heat pumps can still meet the space conditioning needs of a home for most hours each year and represent a significant electrification opportunity. Grand Forks, North Dakota is the coldest city in the lower 48 states, but a heat pump can still meet 83 percent of the hours in a typical meteorological year (TMY) when the switchover temperature is 10°F (NSRDS, 2005). Given that the 2010s were the warmest decade, and every decade since 1960 has been warmer than the last one, the proportion of hours above the switchover

temperature setpoint in the 2020s may only be higher than reported in Table 1 (NASA, 2020).

HEAT PUMPS INCREASE MEMBER-CONSUMER QUALITY OF LIFE

Some of the most cited benefits of adopting a residential ASHP include improved comfort and addition of air-conditioning and dehumidification. About half of member-consumers surveyed by a collaborative of co-ops in Michigan indicated that the convenience of electric heating motivated them to purchase a heat pump. Fluctuations of propane prices that can spike during winter fill-ups, and the labor involved with wood collection, impose burdens on the daily lives of member-consumers that can be avoided.

FLEXIBILITY STRENGTHENS RESILIENCY

Dual fuel heat pumps can easily alternate heating sources. This flexibility empowers member-consumers with choice, provides energy security, and unlocks a resource that co-ops can leverage for the good of the grid. Like other advanced electric technologies, dual fuel heat pumps can communicate and be programmed to optimize economic or environmental impacts according to co-op and member-consumer goals.

COST-EFFECTIVENESS

Table 2 reports a set of cost-equivalent efficiencies for different propane and electricity prices. According to the Northeast Energy Efficiency Partnership’s (NEEP) cold climate ASHP specification, manufacturer-reported coefficient of performance (COP) must at least be 1.75 at 5°F.⁴ Even if a heat pump can achieve this efficiency in the field, only for about half the fuel price scenarios shown below (in green) would it make economic sense to operate the heat pump as low as 5°F.

TABLE 2: Cost-Equivalent Coefficient of Performance (COP) Depends on Fuel Prices

		Electricity Price (\$/kWh)			
		\$0.08	\$0.12	\$0.16	\$0.20
Propane Price (\$/gallon)	\$1.00	2.1	3.1	4.1	5.0
	\$1.50	1.4	2.1	2.7	3.4
	\$2.00	1.0	1.5	2.1	2.6
	\$2.50	0.8	1.2	1.6	2.1
	\$3.00	0.7	1.0	1.4	1.7

⁴ <https://neep-ashp-prod.herokuapp.com/#!>

TABLE 3: Six Dual Fuel Heat Pumps in Greater Grand Rapids with \$2/gallon propane and \$.12/kWh prices and average switchover temperature of 25°F

Baseline System Modeled	Estimated Average Incremental Cost	Estimated Average Annual Savings	Estimated Average Simple Payback
96% efficient furnace and no cooling	\$5,100	\$480	13 years
96% efficient furnace and SEER 14 Air Conditioner	\$1,100*	\$500	3 years

* Based on interviews with contractors in Michigan, this value may be low for variable-speed heat pumps and could be as high as \$4,000. If this is the case, systems in the Michigan field study would still pay back in about 8 years.

Estimates indicated all systems reduced carbon emissions immediately during the monitoring period, when compared to a propane furnace and central air-conditioner.

Data in Table 3 is based on a field study of energy-efficient dual fuel ASHPs monitored between February-September 2019 in central Michigan in Climate Zones 5 and 6.⁵ The monitored systems were market-installed and the models, sizing, compressor type, and switchover temperature varied. These factors both impacted incremental costs and system performance. Additional modeling was conducted to estimate what the payback would be in a scenario where the dual fuel heat pump replaces a propane furnace.

For all systems studied, the dual fuel heat pump is cost-effective when including the cost of a cooling system in the baseline. Given an estimated equipment life of 15 years, payback is possible, but less clear if a member-consumer adopts the heat pump only for heating.

Modeling the Benefits of Dual Fuel Heat Pumps for Yourself

If you would like to model for yourself how economically or environmentally beneficial dual fuel heat pumps may be in your local service territory, the dual fuel heat pump calculator created by the NRECA-supported [Beneficial Electrification League](https://www.beneficialelectrification.com/dualfuel) is a helpful resource. The calculator is a spreadsheet tool to estimate cost and emissions savings for different installation scenarios. You can find the latest version of the calculator, which will continue to be honed and updated with additional scenarios and default assumptions and features, at www.beneficialelectrification.com/dualfuel.

SOME ENVIRONMENTAL BENEFITS TODAY, MORE ENVIRONMENTAL BENEFITS TOMORROW

Emissions impacts were also modeled using energy consumption data from the Michigan field study referenced above and applying hourly marginal emissions factors. Estimates indicated all systems reduced carbon emissions immediately during the monitoring period, when compared to a propane furnace and central air-conditioner. The most environmentally beneficial heat pump was estimated to reduce emissions by 16 percent. The variability in emissions impacts was heavily dependent on load shape. None of the systems were utility controlled, and further emissions savings could be realized if load was managed. As the grid continues to become cleaner, the emissions impacts of dual fuel systems will only decrease.

Integrating Dual Fuel Heating into Beneficial Electrification Initiatives

Before considering the design of new beneficial electrification programs, co-ops will find it valuable to take stock of existing programs that may incentivize heat pumps as an energy efficient or load building technology. Rebates, financing, or special rates already available for heat pumps may only need minor adjustments to better account for the dual fuel opportunity. Integrating the dual fuel perspective into existing heat pump education and outreach can bolster your co-op's reputation as a trusted advisor to your member-consumers.

Drawing from lessons from co-op activity in Michigan to accelerate heat pump adoption as an energy efficient technology, the following are some considerations for how to integrate dual fuel heating into beneficial electrification initiatives.

CHARACTERIZE YOUR MARKET

To understand the best points of market intervention and the right market intervention strategies, identification of barriers in your local heat pump market is an important first step. Member-consumer characterization

⁵ The field monitoring study was completed for the Energy Optimization Collaborative overseen by the Michigan Electric Cooperative Association (MECA).



FIGURE 4: Heat Pump Market Actors

Focusing education and outreach on both member-consumers and HVAC contractors can generate a “push and pull” effect toward more installed heat pumps.

efforts should account for the housing stock, fuel mix, and attitudes and preferences. Directing efforts towards actors involved in the production, distribution, sale, and installation of residential HVAC equipment can reveal key local market dynamics at play (see Figure 4). Designing surveys or simple interviews of key market actors can help co-ops gain intuition on the current state of the market.

For example, upon interviewing HVAC contractors that served a few co-op service territories in Michigan, it was discovered that all of them had installed single ductless mini-split ASHPs, but that the majority were not selling or installing centrally ducted ASHPs or whole-home ductless systems quite as readily. This finding drove the focus of subsequent contractor training, education and outreach.

ENCOURAGE ADOPTION WITH INCENTIVES, EDUCATION, AND OUTREACH

Member-consumers and HVAC contractors represent the two key actors when it comes to what type of heating equipment is ultimately selected. Focusing dual fuel heat pump education and outreach to both groups can generate a “push and pull” effect towards more installed heat pumps. System descriptions, frequently asked questions, case studies, and data on estimated system paybacks are a good start and can be incorporated into existing marketing channels. Co-ops may be well served by considering how they can partner with manufacturers and distributors to offer education and training to HVAC installers to show how heat pumps can benefit their customers and their bottom line.

While equipment rebates are most often provided directly to the member-consumer,

multi-channel incentives can be an effective strategy to accelerate adoption of heat pump technology. For example, as part of their collective efficiency program, five co-ops in Michigan began offering distributor-based midstream incentives.⁶ The incentive is provided as an instant discount applied when a contractor purchases eligible equipment from a distributor. The full equipment discount is passed through to the member-consumer, and small administrative fees and heat pump contractor bonuses were added to the program to motivate participation and installation of heat pump products.

Financing can also effectively address the cost premium for heat pump products. The Rural Energy Savings Program (RESP) offers zero-interest loans to electric co-ops that can, in turn, be lent to member-consumers on-bill, or off-bill, for technologies in energy efficiency, renewable energy, or beneficial electrification.⁷ Another option to address high upfront costs is for a co-op to pay for heat pump equipment upfront and lease it to a member-consumer. The *GeoCents* program offered by Corn Belt Energy in Illinois leases GSHP loops to members for \$7 per ton per month.⁸ Member-consumers avoid the initial out-of-pocket cost for the loop and can realize the energy savings benefits of a GSHP system.

One example of a co-op that lowers heat pump operational costs is Great Lakes Energy, the largest distribution electric co-op in the state of Michigan. Great Lakes Energy offers a special heat pump rate that applies a \$.03/kWh discount on electricity consumed by the heat pump. Member-consumers need to pay for installation of a subtractive meter to enroll.⁹

MANAGE WHAT YOU HAVE

Co-ops have offered dual fuel interruptible service rates for many years. With higher penetration of electrically-powered space heating, there is greater value to controlling the load. Incorporating electrification scenarios into load forecasts will be important to understand where and when constraints in distribution

⁶ <https://www.michigan-energy.org/midstreamhvac>

⁷ <https://www.rd.usda.gov/programs-services/rural-energy-savings-program>

⁸ <https://www.cornbeltenergy.com/geocents.html>

⁹ <https://www.gtlakes.com/2018/07/13/heat-pumps-heat-cool-for-less>

Co-ops may find it valuable to conduct pilot programs and member outreach to explore the effectiveness of communications, rates, and load management strategies.

Product development of variable-speed, add-on heat pump products could unlock a new and large market for retrofit opportunities.

capacity may arise. Co-ops may find it valuable to conduct pilots and member outreach to explore communication strategies and determine whether time-of-use rates with critical-peak pricing or other load management strategies would be most effective. Co-ops that already offer delivered fuel services may find it valuable to explore opportunities to leverage that side of their business to support dual fuel heating and beneficial electrification.

Advancing Dual Fuel Heating to Advance Beneficial Electrification

The market for dual fuel heating solutions is rapidly evolving, and co-ops should be mindful of the following trends when considering the incorporation of dual fuel heating into a beneficial electrification program.

A SIMPLE HEAT PUMP IS BETTER THAN NO HEAT PUMP

While top-of-the-line, cold-climate, variable-speed heat pumps can operate most efficiently and operate at the coldest temperatures, single-stage and two-stage heat pumps can still beneficially electrify a significant portion of space heating. These base models should not be discounted for their role as a more affordable heating solution that may be preferable to some member-consumers today.

HEAT PUMP EFFICIENCY METRICS ARE IMPROVING

Heat pump heating efficiency is typically measured with a metric publicly available from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) called the *heating seasonal performance factor* (HSPF). HSPF signals the ratio of heating output to power input based on an expected season of heating hours. The problem for co-ops in cold climates is that this metric is based on Climate Zone 4 which exhibits a more moderate temperature profile than the service territory of many co-ops in cold climates.

Heat pump manufacturers will often self-report temperature-specific COPs below 47°F and there are ongoing efforts to improve heat

pump efficiency metrics. In addition to the NEEP cold climate ASHP specification, the Canadian Standards Association (CSA) has developed a dynamic, load-based testing procedure that is more appropriately designed to test inverter-driven compressors, since it accounts for reduced cycling.¹⁰ The CSA procedure also provides ratings across all climate zones. Finally, ENERGY STAR has published a draft set of criteria for cold climate ASHPs based on the NEEP cold climate specification that indicate the COP must be 1.75, capacity must be 80 percent at 5°F, and that the system must have at least two stages to be recognized as ENERGY STAR.¹¹

NEW CONTROLS AND NEW CONFIGURATIONS WILL ADVANCE DUAL FUEL HEATING SOLUTIONS

Dual fuel centrally ducted heat pumps on the market today typically require that all components be produced by the same manufacturer as part of a matched system. However, product development of variable-speed, add-on heat pump products could unlock a new and large market for retrofit opportunities. This configuration would best serve a homeowner who is looking to add or replace a central air-conditioner with the most energy efficient, highest performing cold weather heat pump and keep their existing furnace as backup. New innovations are also expected to raise the performance and lower the costs of integrated controls between ductless ASHPs and supplemental heating sources.

Conclusion

Electrification of space heating does not need to be an “all-or-nothing” approach. Dual fuel heat pumps are a practical heating solution that can immediately advance co-op sponsored beneficial electrification initiatives in cold climates. Dual fuel heat pumps make it possible for member-consumers to minimize their heating costs and environmental impact, while increasing co-op electricity revenue during the most beneficial times. Like other co-op initiatives, careful planning, program design, and market engagement will be key to making the promise of this technology a reality. ■

¹⁰ CSA EXP07:19 Load-based and climate-specific testing and rating procedures for heat pumps and air conditioners

¹¹ ENERGY STAR Program Requirements Product Specification for Air Source Heat Pump and Central Air Conditioner Equipment. Eligibility Criteria, Draft 1, Version 6.0

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Art has worked in the energy industry for over 40 years. Prior to working with MECA, he was responsible for all sales, marketing and technical support in Michigan for WaterFurnace Int., Inc., a leading manufacturer of geothermal heating & cooling equipment. He held that position for over 10 years.

Continued on next page

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Art is the past President of the Michigan Geothermal Energy Association, a member of the Michigan Association of Home Builders, the Tri-County Economics Club, the Home Builders Association of Saginaw, and was the Chairman of the Parma LDFA, responsible for bringing a major automotive manufacturer to Jackson County Michigan. He was also the Chairman of the Zoning Board of Appeals and a councilman for the Village of Parma.

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