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120-Volt Heat Pump Water Heaters Executive Summary

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Executive Summary

The benefits of heat pump water heaters (HPWHs) when replacing electric resistance water heaters has been established in the Midwest and nationally. However, electric resistance water heaters only account for around 8% of residential buildings in ComEd territory. The much larger natural gas- and propane-fired water heater market presents a significant opportunity for site energy and environmental benefits, but also poses additional economic challenges. One of those challenges is prohibitively expensive costs for upgrading home electric infrastructure to accommodate the new electric water heater.

To address this barrier, manufacturers have developed a 120-volt HPWH (120V HPWH) that can plug into a 15-amp shared circuit. This product functions similarly to the standard 240V HPWH, but manufacturers substantially reduced or eliminated electric resistance backup heating elements to meet the power requirements of a shared circuit. Manufacturers have recommended thermostatic mixing valves to enable higher setpoints and increased tank sizes as strategies to reduce the chances for cold water events. These methods can increase the amount of hot water in the storage tank, but come with additional costs

The research team conducted energy modeling, cost analysis, secondary data analysis, and supply chain research to determine the best technological applications for 120V HPWHs in ComEd territory. This report shares insights on the technology, its feasibility, and best use cases.

Home electric upgrade cost savings

The 120V HPWH was designed to reduce costs that customers and utilities may incur from installing a standard 240V HPWH in a fuel switching retrofit. Table 1 shows the estimated cost savings from a 120V HPWH in a fuel switching retrofit. Due to differing existing electric equipment in homes, certain buildings may be more or less likely to have electric upgrade cost savings by opting for a 120V HPWH. We estimated cost data through supply chain interviews, invoices from projects in the Midwest, and secondary literature. We have included a range and typical cost estimate for each intervention because cost estimates have significant variation. These results show that the 120V HPWH can provide significant cost savings for amp-constrained households.

Table 1. 120V HPWH's home electric upgrade cost savings

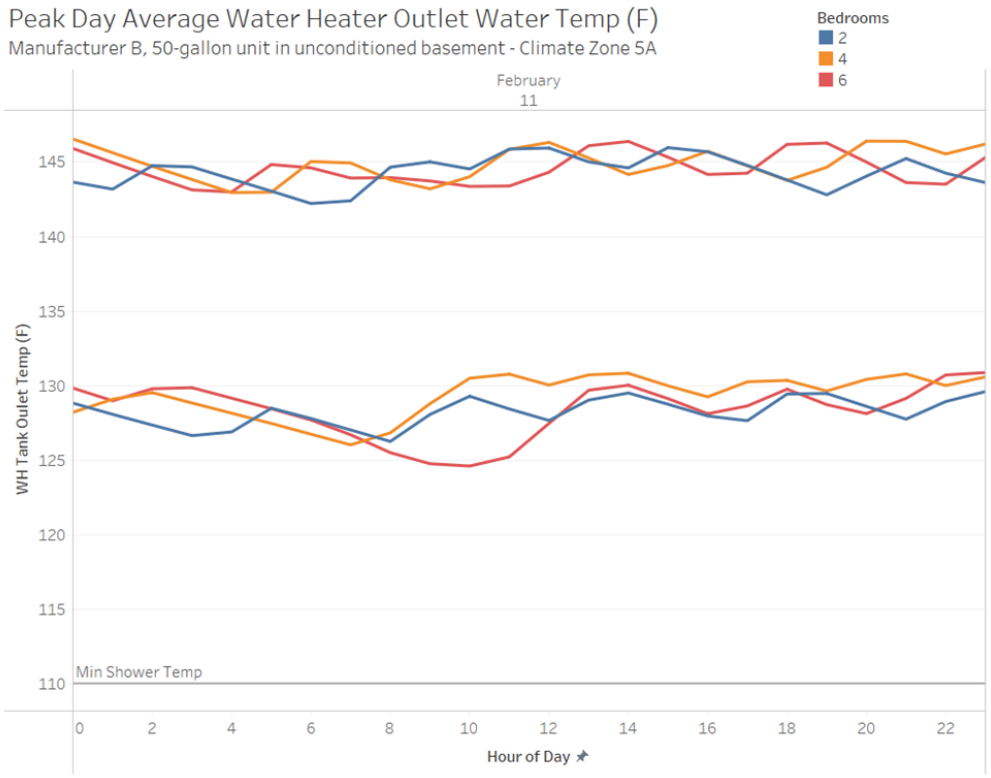
Intervention	Percent of Installations with Electric Upgrade Costs		Average cost estimate In single family home
	120V HPWH	240V HPWH	
Electric Permit	40-60%	100%	Range: $75 - $250 Typical: $150
Extension of shared circuit	40-60%	0%	Range: $150 - $400 Typical: $300
Dedicated Circuit	0%	100%	Range: $150 - $1,000 Typical: $400
Replacement panel or subpanel	0%	15-45%	Range: $500 - $2,000 Typical: $1,000
Amperage service upgrade	0%	7%	Range: $900 - $15,000 Typical: $3,000

Modeled Performance

The research team conducted performance modeling in OpenStudio to investigate three different models of 120V HPWH in ComEd's climate zone. The modeling analyzed energy consumption, operating costs, and cold-water events.

Importantly, the results show that the 120V HPWHs provided sufficient hot water throughout the year, even during peak hours of the coldest week of the year in high occupancy homes. Figure 1 shows that hot water temperatures at 125°F and 140°F setpoints do not approach the 110°F threshold for a cold-water event, even for a 6-bedroom household.

Figure 1. Average water heater outlet temperature for highest hot water use day



The 120V HPWH's energy performance was comparable across all studied models but varied based on conditions such occupancy, setpoint temperature, and ambient air conditions near the water heater installation. The average annual usage for a 50-gallon tank serving a 4-bedroom home installed in semi-conditioned space was 1,117 kWh. Increasing the temperature setpoint from 125°F to 140°F increased energy usage by around 14%.

Market Opportunity

We estimate around 66% of ComEd homes are on 100-amp service, which suggests that there may be significant opportunities for 120V HPWHs to save on electric upgrade costs, especially in small to mid-size residential homes with propane or natural gas water heaters.

However, the current economics may not convince the average household, besides climate-motivated early adopters, to electrify their gas water heaters. This could change if incentives become available for electrification or changes to fuel prices. Manufacturers expect similar equipment costs for 120V and 240V HPWHs, which will result in similar first cost barriers for customers.

Distributors and plumbers that are advocates for 240V HPWHs may be good candidates for 120V HPWH programs. All levels of the supply chain emphasized that field

validation in the Midwest would be needed before they would be comfortable selling the 120V HPWH. Permitting officials skeptically agree to installing a water heater on a shared circuit once they learned that the manufacturers recommend this. They encourage using common sense and not installing on the same circuit as other large appliances.

Key findings

We have the following key findings from our research.

The 120V HPWH can provide enough hot water under Midwest Conditions

Our modeling results suggest that the 120V HPWH can supply enough water to satisfy up to 4-6 occupant single family home in Illinois. Although the delivered hot water temperature did decrease on the highest usage days, it never dipped below a typical shower temperature of 110°F.

Manufacturers are targeting areas with fuel switching incentives

Motivating fuel switching retrofits will likely require a dual strategy of incentivizing customers to reduce the upfront equipment cost and offering competitive electric rates because natural gas prices are currently lower than electric rates. Under these conditions, the 120V HPWH could be an attractive decarbonization technology for amp-constrained homes driven by economics.

The 120V HPWH can provide significant electric upgrade savings

The 120V HPWH can provide substantial electric upgrade savings by avoiding the need for a panel or service upgrade. Targeting amp-constrained homes will provide the most compelling economic case for adoption of 120V HPWHs. Programs can target areas with older homes to maximize cost savings from 120V HPWHs.

The 120V HPWH may consume more energy than the 240V HPWH but there are 43-50% reductions in site energy compared to fossil fuel burning water heaters.

Our modeling shows that the 120V HPWH has a lower efficiency than the 240V and may use slightly more energy depending on the make and model. The lower efficiency is likely due to longer compressor runtimes. However, the real use case for this technology is fossil fuel burning water heater replacements. From a site energy reduction perspective, there will be 43-50% energy savings from switching from a fossil fuel fired water heater to a 120V HPWHs, in addition to providing load shifting capability. The energy savings are greater when replacing a propane water heater compared to a natural gas water heater.

All manufacturers plan to make 120V HPWHs compatible with demand response programs

Since all the 120V HPWHs come with the Ecoport, a load shifting compatible universal port, they have load shifting capabilities that allow homes to participate in demand response programs. This will allow utilities to build a grid resource as they electrify fossil fuel water heaters with 120V HPWHs.

Distributors and plumbers are skeptical about 120V HPWH performance

The 120V HPWH is a new technology that has not had its performance validated in the Midwest. Even distributors and plumbers who are champions for 240V HPWHs would be skeptical to invest or recommend a 120V HPWH without examples of successful installations in the Midwest.

Supply chain emphasizes consumer demand and supportive programs

The manufacturers, distributors, retailers, and plumbers we interviewed all emphasized that consumer demand drives their interest in stocking or selling a given technology. Direct marketing to consumers that sparks interest in electrifying their water heaters through energy or non-energy benefits would motivate the supply chain to support the 120V HPWH. ComEd may benefit from research on customer demographics and messaging strategies to enable an effective marketing campaign if this information is not currently available. Along with building consumer demand, they all suggested that intelligently designed incentive structures and program support will help build the market.

Performance relies on ambient conditions

With increased reliance on its compressor for heating, the 120V HPWH's performance is more dependent on its installation conditions and maintenance. The ambient air temperature, its air supply, and filter replacement all will have a big impact on equipment performance

Permitting officials reluctantly accept 120V HPWHs

Although all permitting officials agreed that 120V HPWHs would be allowed, many expressed skepticisms about installing an electric water heater on a shared circuit. Permitter education and wider adoption are likely to overcome any hesitancy from permitting officials.

Recommendations

We offer the following recommendations from our research.

Focus on the lowest hanging fruit

Approximately 8% of residential homes in ComEd territory have electric resistance water heaters. Water heating efficiency programs should prioritize replacing electric resistance water heaters with 240V HPWHs because the economic benefits have been

validated in the Midwest. Replacing the small percentage of propane water heaters is the next priority, which may be good targets for 120V HPWHs, as they have more attractive economics. Natural gas water heaters can also be addressed with 120V HPWHs, but this market may be more difficult due to lower prices of natural gas compared to propane.

Consider collecting data on homes electric service and equipment

Electric upgrade costs can be a substantial barrier in electrification retrofits. ComEd did not have data on the amperage service level and electric equipment in their customer's homes readily available. Access to this information would be useful in electrification planning and when determining the opportunity for 120V HPWHs in ComEd territory.

Field validation needed before promoting 120V HPWHs

Plumbers and distributors both emphasized the need for field validation of this product in cold climates. Potential customers can face cold water events if this technology does not perform well in the field, which has a larger impact on satisfaction than energy efficiency performance. The supply chain is unlikely to sell this product until they can validate its performance.

Adjustments to rate structure can support 120V HPWH adoption

There is uncertainty around operating cost impacts when switching from natural gas to electric fuels. Adjustments to rate structures to incentivize electrification can make water heating electrification more palatable to customers. This is especially important when promoting the technology to ComEd's income eligible populations.

Identify 240V HPWH champion plumbers for the 120V HPWH

Plumbers familiar with heat pump water heaters are ideal candidates for early program engagement. They are likely to be more comfortable with the technology and may already have experience selling this equipment. ComEd's Diverse EESP Incubator program may be a good place to find champion 240V HPWH contractors. From interviews, there is at least 1 plumber in that program that encourages HPWH replacements of electric resistance water heaters.

Ensure customers are trained on 120V HPWH maintenance

The 120V HPWH's performance is more reliant on the ambient air temperature and available air supply where it is installed than other water heaters. It will be important to ensure the supply chain, including customers, are trained on proper maintenance practices for 120V HPWHs as we see field deployments.

Coordinate program design with Inflation Reduction Act funding

The Inflation Reduction Act (IRA) can present an opportunity for state's decarbonization efforts. Although details on Illinois' implementation of IRA funding have not been disclosed at the time of this report, the federal bill has provisions for financial support on electric panel upgrades and HPWHs. If Illinois provides funding for electric panel upgrades, ComEd may want to focus on leveraging these funds to support long-term electrification planning. In this scenario, 120V HPWHs may be most useful as an emergency replacement technology because 240V HPWHs are recommended when home electric upgrade costs are not a barrier.