

RESIDENTIAL GRID-INTERACTIVE HEAT PUMP WATER HEATERS IN MANUFACTURED HOUSING: A KEY STRATEGY FOR BENEFICIAL ELECTRIFICATION

LA PLATA ELECTRIC ASSOCIATION PILOT PROVIDES KEY INSIGHTS



The Beneficial Electrification League (BEL) is working with utilities across the country to promote beneficial electrification, which includes installing residential heat pump water heaters (HPWHs) when they lower costs, increase comfort, benefit the environment, or assist the grid. A future where HPWHs can be controlled en masse to provide the energy storage and demand response capabilities increasingly necessary to balance variable wind and solar generation is a key application of the principles of beneficial electrification.

In many cases, low- and moderate-income Americans can save water heating costs by switching from gas or propane to ultra-efficient HPWHs, but careful evaluation, planning, and programmatic support by electric utilities and their partners are necessary to ensure such upgrades benefit the users at a reasonable cost. Managing installation of these advanced water heaters—which require more space and venting than standard units—with minimal disruptions to residents is a significant challenge in itself.

EXAMPLES TO LEARN FROM

The value of the electric thermal storage (ETS) resource in water heaters is widely known in the energy utility industry. Cooperative G&T Great River Energy in Minnesota typically stores more than 800 MWh of interruptible load in some 110,000 home water heaters. GRE and operators of similar programs use electric resistance water heaters (ERWHs) because HPWHs' more complex operating modes and settings can complicate control of the resources and lead to user complaints about lack of hot water.

Modeling by the Brattle Group (*The Hidden Battery*, January 2016) indicated that with “emerging technology,” utilities could use residential HPWHs instead of ERWHs to lower consumer energy costs, reduce greenhouse gases, and provide demand response capabilities—albeit with less load-curtailement capacity per unit than ERWHs due to the “relatively low and uniform load necessary to heat water” with heat pump technology.

It's telling that grid-interactive HPWH systems have been deployed in multi-family buildings, including the retrofit of a 100-unit Seattle apartment building profiled on the Beneficial Electrification League website.

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--The Brattle Group



Similarly, PG&E has launched a large-scale Watter Saver program with Virtual Peaker that will use existing HPWH and electric resistance water heaters (ERWH) for demand response. Though there are still many opportunities in single family homes to evaluate and deploy HPWH technology.

La Plata Electric Association (LPEA) in southwest Colorado is piloting an HPWH beneficial electrification program by installing Rheem Proterra HPWHs in the homes of about 20 low-income member-consumers. LPEA chose Rheem's hybrid HPWH model because it also has electric resistance heating coils that can enable the utility to shift load over long periods of time during critical events by heating stored water to temperatures beyond what a heat pump could achieve on its own.

Through HPWH pilots and other programs LPEA is preparing for a future in which increasing proportions of the utility's electricity will come from variable wind and solar. And because national forests surround the utility, greater transmission interconnections that could provide access to additional flexible generation will be difficult, if not impossible, to build.

"To maintain and improve reliability in the future, we are looking for ways to optimize the grid and use our energy more efficiently," said LPEA CEO Jessica Matlock. "That means partnering with our communities to find ways to manage and use their DERs to support the grid and the cooperative community."

IDENTIFY AND PLAN FOR IMPLEMENTATION CHALLENGES

The Beneficial Electrification League is working with utilities across the country to gather and share knowledge through its Weatherization-Electrification Together (W/E Together) program. A key goal is to explore how weatherization and electrification can be leveraged together to benefit low and moderate-income consumers, reduce emissions, and improve the efficiency of the grid.

For a variety of reasons, it can be challenging for utilities and their partners such as community action agencies to integrate weatherization and electrification. Yet, doing the two together provides the highest level of benefits for the lowest cost and with the least disruption to residents.

Weatherization reduces energy losses through improved insulation and air sealing, while

electrifying with high-efficiency, properly sized HVAC systems, water heaters, stoves and other appliances can reduce home energy usage, lower greenhouse gases, improve home comfort, and increase grid resiliency and flexibility. As seen below (Finesse the timing of electrification and weatherization), LPEA handled the W/E challenge with a strategy that may benefit other utilities.

Before going ahead with the project, LPEA staff assessed that Rheem's EcoNet would integrate with its distributed energy resources management system (DERMS) from Camus. And that system has functioned well since the project was completed in October, 2022; LPEA is monitoring the household financial savings as well as the value of the grid-responsive capabilities and expects to report publicly on the results in 2023.

"Many apartments and houses in disadvantaged communities require electrical upgrades and other repairs before they can be electrified. And older mobile homes—of which there are millions—are especially tough to electrify. The lessons learned from this pilot will be relevant and useful nationwide. Specifically, installing grid-interactive heat pump water heaters in manufactured homes is a task at the intersection of a whole variety of national strategic initiatives "

— Keith Dennis, CEO, Beneficial Electrification League

Another challenge faced by the LPEA staff was that the HPWHs had to be installed in manufactured homes—where tight spaces and lack of attics make venting and other requirements of HPWHs difficult to accommodate. Additionally, the mobile homes were using inexpensive natural gas, so forecasting energy cost savings was more uncertain than if the homes had been using propane. "If we were displacing propane, the financial savings from switching to a heat pump water heater would have been more straightforward," said Jon Kenney, LPEA's energy management advisor.

The challenges LPEA faced—working with mobile homes and displacing inexpensive natural gas—will be encountered by many utilities and community agencies nationwide as they seek to put the Inflation Reduction Act (IRA) electrification funding to work.

BEL is also working with Flint Energies, an electric cooperative in Georgia, and Anza Electric Cooperative in California on pilot projects that will also advance the knowledge and practice of weatherizing and electrifying low-income homes.



BEL also convenes a W/E Together Advisory board to develop resources and share the learnings from these and other utilities.

The BEL views such difficult pilot projects as essential to realizing the promise of the IRA, which makes as much as \$14,000 available in upfront rebates for low-income households to efficiently electrify water heating as well as HVAC systems, stoves, and clothes dryers. Low-income households bear energy cost burdens that are three times higher than those of the average American, according to the U.S. Department of Energy. Using the IRA funding to electrify low-income homes, especially when weatherization is performed at the same time, will provide cost savings to those who need them the most.

Find and leverage funding sources

In addition to its challenges, LPEA had some robust allies, including BEL, which facilitated a \$25,000 grant from NRECA for the \$100,000 project. Other funding came from Tri-State G&T and LPEA's own budget—an expenditure justified by the potential future wholesale power cost savings and benefits to member-consumers.

The mobile home park owners' group was strongly in favor—and in fact, one homeowner was the original advocate for the project. For implementation and coordination help, LPEA worked with its partner for weatherization and energy-efficiency upgrades, the Four Corners Office for Resource Efficiency (4CORE). 4CORE screened applicants to ensure they met LPEA's low-income criteria of 80% or less of area median income. A 4CORE energy auditor visited applicants' homes, taking measurements and photos, and completing a checklist developed by LPEA.

The auditor also specified modest weatherization and efficiency upgrades prescribed by LPEA, such as low-wattage LEDs, low-flow showerheads, and weather stripping around drafty doors. "While the core of the project was the water heater, we wanted to use the opportunity to address some modest efficiency upgrades," said Kenney. This was also a way to hedge against any potential increases in total utility costs for the residents. A specialist contractor performed the efficiency measures, using parts stocked by LPEA; and this did require a separate visit to the homes. (See "Early Lessons Learned" below for more discussion on why weatherization was limited.)

In addition to wiring water heater closets for 240-volt service and capping gas valves, the contractors—two plumbers and one electrician—had to install 8" wide vents to accommodate the HPWHs' heat exchange requirements. In two cases, installation would have been too difficult, and LPEA had to inform the homeowners that they could not participate. And in one case, sound dampening insulation and special venting had to be installed because of noise from an HPWH near a bedroom.

"The most difficult aspect of this whole project was fitting the heat pump water heaters into the tight spaces available in mobile homes," said Kenney. "We're hoping the manufacturers will recognize this and develop a 30-gallon option with a slimmer profile and additional venting options."

4CORE Executive Director Laurie Dickson reported that finding contractors with HPWH expertise was also challenging. "This is a new technology for this region. It took a lot of work to find the right contractors," she said.

For more information on projects and resources, including checklists that should help to minimize the number of times contractors are required to visit before, during, and after a project, please visit the BEL W/E Together website at: <https://be-league.org/we-together/>

Orchestrating DERs

To boost the demand-response capacity of each HPWH, the utility had contractors install mixing valves. These enable preheating the tank to 140° or 150° F while keeping water output to a safe and comfortable 120° F. “This lets us curtail these during a peak event, without depriving people of hot water,” said Kenney.

Kenney’s colleague Dominic May, energy resource program architect, reports that this feature allows the Rheem water heaters to be used for load shifting as well as load shedding. “The ability to preheat allows us to shift when energy is used by heating up water ahead of our peak, then shutting off the water ahead of our peak, then shutting off the systems for a brief period. We can similarly call on water heaters without

preheating and have them run only on their heat pump without additional [electric resistance] coils or to turn off for as long as the water temperature thresholds we have set will allow.”

As more grid-interactive water heaters are installed in the years ahead, LPEA anticipates “orchestrating” these resources with all other types of DERs. “Eventually, we’ll integrate real-time forecasting,” says May. “If the system senses a voltage drop on a circuit or if a cloud is about to pass over a big solar array, the grid will react automatically, turning off water heaters and EV chargers, dispatching Tesla Powerwalls, and electric buses. Everything will be integrated into a virtual power plant.”

Sharing early lessons learned

While LPEA will report comprehensive results of the pilot next year, some initial lessons have emerged that may be useful for other utilities:

- Depending on regional natural gas prices, fuel switching from gas water heaters to HPWHs can be hard to justify economically. If the mobile home park had been on propane, the economic benefits to the residents of installing HPWHs would have been more robust. In this case, natural gas price increases in the first half of 2022 are yielding an estimated 20-30% savings from the conversion to HPWHs and energy efficiency measures.
- Obtain a complete picture of each home’s installation challenges. “Space requirements are the easiest to capture, venting is harder,” said Kenney.
- Be prepared to finesse the timing of electrification and weatherization. “Our program was designed to move quickly, and that’s why we decided to perform our own light weatherization on our schedule,” said Kenney. “With weatherization by 4CORE, the residents would have received more significant air sealing and insulation, but we would have had to wait much longer. We would like to see better integration of weatherization and electrification through these types of programs in the future.”