Business & Technology Surveillance

Promoting Efficiency and Electrification in Home Heating and Water Heating

By Jim Hight

FEBRUARY 2020

This article was developed in partnership by:

NRECA America's Electric Cooperatives

Beneficial Electrification League ELECTRIFY!

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ARTICLE SNAPSHOT

WHAT HAS CHANGED IN THE INDUSTRY?

The efficient electric space and water heating technologies covered in this article have improved significantly in performance and pricing over the last decade, especially in the air-source heat pump (ASHP) segment. Markets are constrained in some regions due to legacy concerns about performance in cold temperatures, but cooperatives are innovating with savvy marketing and streamlined on-bill finance models. Demand response programs using grid-interactive water heater (GIWH) technology are transitioning from legacy systems with limited functions to "smart" systems that offer co-ops and members many more benefits.

WHAT IS THE IMPACT ON ELECTRIC COOPERATIVES?

When residential co-op members upgrade their heating and water heating to highly efficient heat pump systems or grid-interactive water heaters (GIWHs), they can save money and improve home comfort. At the same time, co-ops can improve their load profiles from an economic standpoint. The technology, policy and financing innovations outlined in this article represent new and emerging opportunities for co-ops to support beneficial electrification and deep energy efficiency among their residential customers.

WHAT DO COOPERATIVES NEED TO KNOW AND DO?

Every co-op has different needs, capabilities and member interests, as well as major differences in climates and regional energy markets. Yet, a common theme for co-ops is stagnant or declining load, as well as industry challenges like the rapid growth of distributed solar and the persistent low prices of natural gas. This document is intended to provide a refreshed view of the potential for deep residential energy efficiency and beneficial electrification measures which can provide residential members and co-ops with economic benefits.

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Introduction and Overview

Co-op consumer-members who upgrade from inefficient electric, gas, propane, or oil heating and water heating to heat pumps, grid-interactive water heaters, and heat pump water heaters can significantly lower their annual energy costs. Yet, to achieve these savings, customers must usually pay a higher upfront cost for equipment and installation. Reducing that upfront cost is the elusive and fundamental key to unlocking deep cost savings for customers and associated load management benefits for co-ops.

Co-ops are innovating to increase customer participation in programs for heat pumps and heat pump water heaters, while manufacturers are producing lower-priced, higher-performing equipment. "There have been some incredible advances," in the air-source heat pump (ASHP) industry, says Jake Marin, HVAC Program Manager for Efficiency Vermont. Ductless mini-split ASHPs, which cost as little as $800, are being installed to heat one floor or even entire homes. A larger capacity, multi-zone mini-split can heat "a big, two-story farmhouse that isn't ducted, providing heating and air conditioning on both levels of the home," said Jason Thorson, Energy Advisor of Iowa Lakes Electric Cooperative. (See Figure 1 for operations of a mini-split.)

The heat pump water heater (HPWH) industry has also been innovating, although pricing has been more volatile, and the market is limited in colder climates by the fact that an HPWH cools the room where it is installed. Split systems eliminate this problem with outdoor compressors, but they are significantly more expensive to purchase and install.

Grid-interactive water heater (GIWH) technology, which provides an energy storage resource that co-ops can use to reduce peak demand charges and optimize wholesale power costs, is evolving from the limited "on-off" tool that has been around since the 1980s to "smart" systems that promise more refined demand response capabilities and

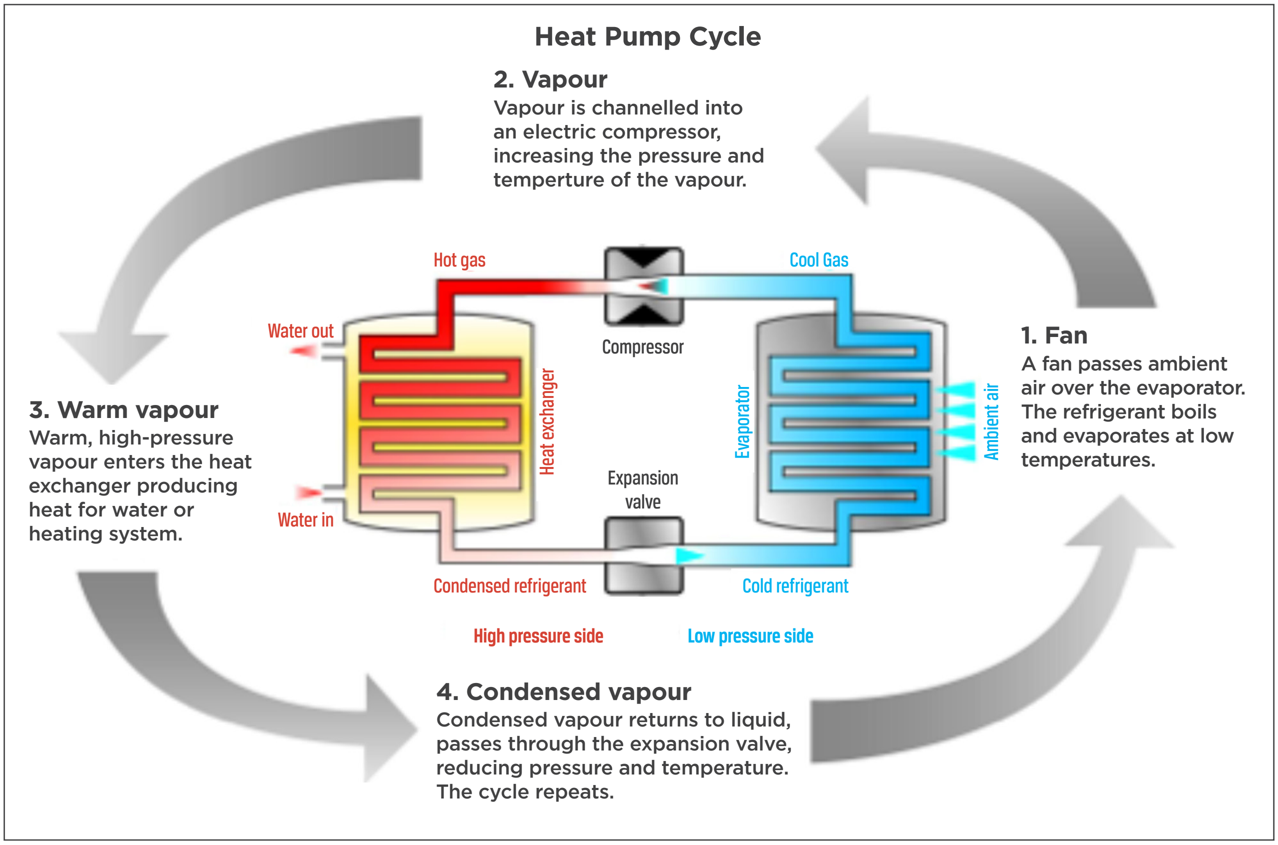

FIGURE 1: Operation of a Mini-Split Heat Pump (Source: http://www.401-e.com/air-source-heat-pumps-ductless-mini-splits)

increased responsiveness to energy market conditions. "We're foreseeing new use cases for controllable water heaters that we've never had before," said Jeff Haase, Manager of Member Services and End Use Strategy for generation and transmission (G&T) co-op Great River Energy.

Co-ops Take a Wide Range of Approaches

Co-ops are at many different levels in pursuing deep energy efficiency and beneficial electrification for residential customers' space and water heating. Some simply pass through rebates from their G&T suppliers, while others are testing the waters with pilot programs. Several co-ops are going full-throttle with ambitious and innovative financing and marketing, as described throughout this article.

Consultants and specialized vendors are supporting many of these initiatives, including the nonprofit Environmental and Energy Study Institute (EESI), the consulting firm Collaborative Efficiency, the program operator EEtility, the technology vendor Packetized Energy, and others.

Environmentally beneficial electrification is a concept that is gaining traction among a growing number of U.S. groups, including electric utilities. Beneficial electrification suggests that the use of more all-electric appliances, machinery, and equipment—like lawnmowers, water heaters, stove tops, and vehicles—provides consumers with quieter, "greener" products.

FIGURE 2: Beneficial Electrification (Source: NRECA)

State Climate Policies Support Deep Efficiency and Beneficial Electrification

In many states, leaders are embracing electrification to meet state greenhouse gas commitments. As might be expected, California has emerged as the leader in this "building decarbonization" movement, but many other states are also taking such steps.

Pre-Selling Mandatory to Forestall Default Low-Cost Choices

"Pre-selling" members on these space and water heating technologies is a pre-requisite for success. Since few homeowners upgrade such equipment until it fails, they are typically in a rush and do not investigate incentive programs or shop around for efficient units that will save money over the long run. "Unless the co-ops have done a lot of communication and education about these highly efficient options that are available, the homeowner whose heating system or water heater has just failed is going to call the plumber or HVAC company, and they typically stock standard equipment," said Keith Dennis, Senior Director, Strategic Initiatives for NRECA's Business and Technology Strategies department.

To BE or EE?

While beneficial electrification (BE; see Figure 2) has more straightforward economic benefits for co-ops, incentive programs for efficient space and water heating systems are rarely focused solely on converting members from gas/propane to electric systems. Typically, BE is integrated into a broader energy efficiency (EE) program. Some co-ops add incentives for customers switching from gas/propane to electricity, but in some states and regions, energy policies penalize or prohibit BE. In Bonneville Power Administration's vast territory, BPA's air-source heat pump (ASHP) rebates of up to $1,200 cannot be used for fuel switching. Such policies are considered by many to be due to outdated concerns over the growth of electricity consumption, as well as political support for the fossil fuel industry.

However, even when a consumer-member transitions from inefficient electric heating to heat pump technology, the switch can offer robust economic benefits to co-ops in reducing demand charges and avoiding peak energy prices.

"Incredible" Advances in Heat Pumps = New Opportunities for Co-ops

Air-source heat pumps (ASHPs) work by drawing heat from outdoor air, using refrigerants for heat exchange and a compressor to raise the temperature of the refrigerants, which then heat the air inside the building. In the summer, the cycle is reversed to expel heat, thereby cooling the incoming air like an air conditioning (AC) unit and rejecting the heat outside. See Figure 3.

While savings vary by region, in general a residential co-op member who upgrades from an electric resistance or gas/propane heating system to an ASHP can achieve significant energy savings. When more members install ASHPs, co-ops can improve their load factors to reduce demand costs and optimize wholesale energy purchases; and depending on the emissions factor of their power mix, they can also reduce greenhouse gas emissions.

Because ASHPs provide cooling as well as heating, homeowners with central AC systems "are great candidates for [ASHPs] when ACs need replacement," according to a 2017 report by Oak Ridge National Laboratory. A 2016 report by ACEEE notes that Southern states are an ideal market territory, because central AC is common and mild winter temperatures "mean that heat pump efficiency is high."

Whether due to the changing climate or changes in personal preferences, the Rocky Mountain states are seeing more demand for home cooling, which is providing a market niche for ASHPs. "We're seeing a lot of retrofits with ductless heat pumps in older homes that have baseboard heating and no HVAC ducts," said Justin Grantham, Marketing and Members Services Representative for Yellowstone Valley Electric Cooperative (Huntley, MT). Although "cooling is their number-one priority," consumer-members also see lower winter heating bills.

The performance of ASHPs in cold climates has improved dramatically in the last decade. "Not too long ago, you wouldn't consider using a heat pump in a climate like Vermont's," said Jake Marin, HVAC program manager for Efficiency Vermont. But, Efficiency Vermont's testing—and the experience of the more than 17,000 Vermonters who have installed ASHPs since 2014—show the technology can provide a great deal more winter heating than older ASHPs.

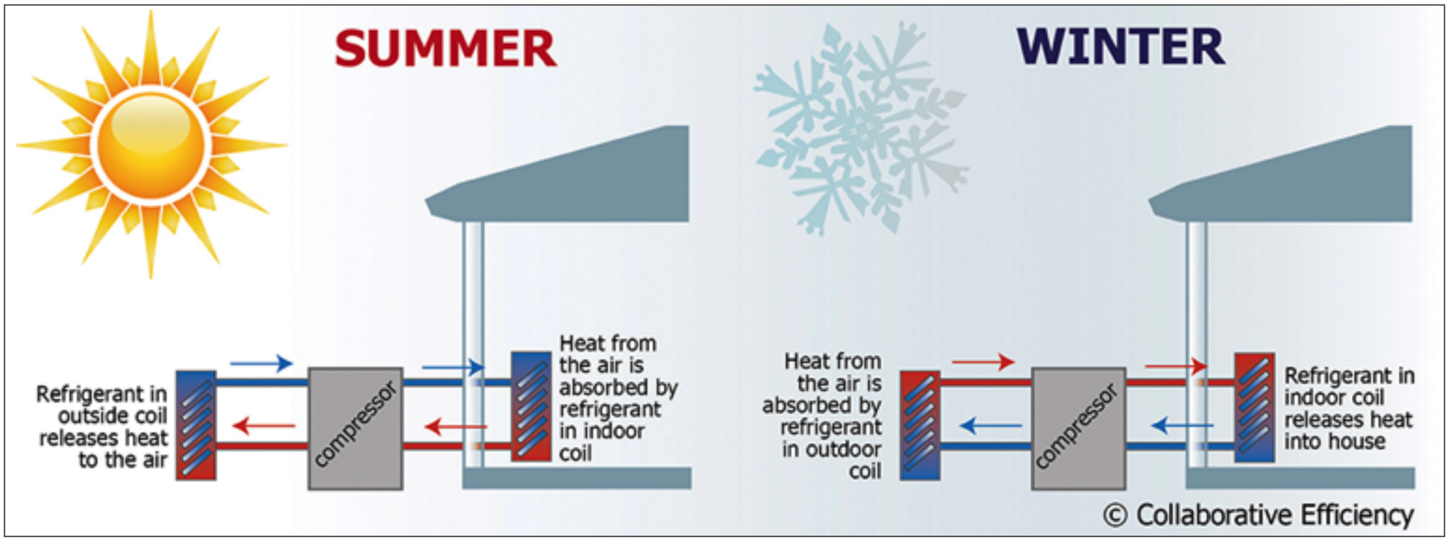

FIGURE 3: How an Air Source and Heat Pump Works (Source: http://alabamaliving.coop/wp-content/uploads/2017/08/how-a-heat-pump-works.jpg)

Backup heating systems are still required in the north. “It’s hard to get away from the need for a dual-fuel situation, because of the extremely low temperatures that do occur up here,” said Jeff Haase of Great River Energy (Maple Grove, MN). To accommodate northern heating needs, many suppliers offer dual-fuel systems that include a propane or natural gas furnace in combination with a high-efficiency ASHP.

“What an air-source heat pump can do is allow folks that heat with propane to avoid a refill during winter months,” said Haase. “And during the shoulders seasons that aren’t extremely cold, they are able to satisfy their heating needs for well over a majority of the time.”

Jason Thorson and his colleagues at Iowa Lakes Electric Cooperative have calculated that propane prices have to be under 70 cents to match the dollar-for-dollar efficiency of an ASHP with a mid-range SEER or HSPF rating. “In the summer, you can get propane for that price, but in winter you’re not going to come close,” said Thorson.

In many states with cold climates, however, HVAC contractors and homeowners still think ASHPs only work at temps above freezing. This is especially true where ASHPs are rare, such as Denver where about 1 percent of homes use heat pumps. “Heat pumps don’t work well in Denver [because] below 20° F, they lose all their benefits,” one HVAC contractor told the authors of a 2018 study by the **Southwest Energy Efficiency Project** (SWEEP).

Lack of experience can also lead to poor design and over-pricing. Joy Manning, Energy Management Advisor with High West Energy in Wyoming reports that after buying a home with electric baseboard heating—and seeing winter bills of $600/month—she sought bids for ASHPs from 12 contractors. “None of them knew how to perform a Manual J load calculation,[1]” said Manning. “All 12 of them said, ‘rule of thumb, you need a four ton.’”

Instead, she and her partner purchased a 2-ton multi-zone ASHP online. Installing the heat pump and the ducting by themselves, their upgrade cost $2,500, net of a rebate from High West’s G&T Tri-State. Manning reports being extremely pleased with the system’s heating capabilities and her monthly energy cost savings of approximately 35 percent.

Manning notes that her partner had HVAC experience, and she does not recommend do-it-yourself (DIY) installation for most homeowners. But, she is building on this experience to design an ASHP incentive program for High West. She is also anticipating the results of a pilot study being done by Mountain Parks Electric in Granby, CO (see Case Study 1 and other Case Studies starting on **page 8**).

Tri-State and the Electric Power Research Institute (EPRI) are collaborating on another pilot study using Carrier Infinity 20 ducted ASHPs in five homes spread across Nebraska, Colorado and New Mexico (see Figure 4). After one year, the study results are encouraging, according to Tri-State’s Gary Myers. The final results are expected in spring 2020.

The lack of expertise among HVAC contractors that Manning from High West encountered is also a market barrier in other states where most contractors cling to the outdated opinion that ASHPs do not perform below freezing.

Some ASHP vendors encourage homeowners to install the systems on their own, sometimes referring to YouTube how-to videos. However, even the smallest ductless mini-split

FIGURE 4: Carrier Infinity 20 Ducted ASHP
(Source: Carrier Infinity website)

1 Manual J residential load calculation is the protocol used for determining the amount of heating and cooling that a home requires to keep its occupants warm in the heating months and cool and dry in the cooling months. Source: https://www.griffithenergyservices.com/articles/manual-j-manual-d-and-manual-s-why-your-hvac-tech-must-go-by-the-book.

requires properly siting and building a level support for the exterior compressor unit, drilling 3-inch wall penetrations, charging refrigerant lines and doing electrical wiring—tasks which would be too complex for many homeowners. This is certainly the view of Efficiency Vermont, which recommends against self-installs, due to concerns for safety, performance, and compliance with EPA 608 regulations for handling refrigerants.

In states where the ASHP market has been strong for some time, HVAC contractors are not only experienced with the technology, but also eager to work with co-ops and other utilities to educate consumers about their performance and long-term cost savings. In states like Colorado and Wyoming, considerable additional outreach and training will be needed before the HVAC industry can support ambitious co-op programs to install ASHPs.

Case Study 1
Testing In The "Icebox of the Nation"

With its service territory encompassing some of the coldest communities in the United States, Mountain Parks Electric sought to test ASHP manufacturers' claims of cold-climate performance. In the fall of 2018, the co-op installed Mitsubishi Electric's Hyper-Heat ductless mini-splits (see Figure 5)—rated at 24,000 BTUs and capable of heating in temps down to –13° F, according to Mitsubishi—in three homes, which were also heated by propane furnaces. The average price including installation was $7,200, net of Tri-State's $900 rebate.

The indoor, wall-mounted air handling units—also known as cassettes—were placed in a part of the home that could be heated separately from the areas heated by the furnace. "The home was broken into two zones: a heat pump zone and an existing propane furnace zone," said Chris Michalowski, Mountain Parks' Power Use Advisor. "It took some artistry to place the indoor cassettes in a way to maximize their ability to heat as much of the home as possible."

FIGURE 5: Mitsubishi Electric's Hyper-Heat Ductless Mini-Splits (Source: Mitsubishi website)

One home was disqualified because the owner used a propane stove in the heat pump's zone; but the data from the two families who maintained the protocol allowed Mountain Parks to determine that the units did indeed function as advertised. "Even as outside temperatures approached zero, we only saw slight degradation in the temperature of the heat supply," said Michalowski.

The results of the Mountain Parks test (which are anticipated to be published in early 2020) have encouraged the co-op to consider an on-bill finance (OBF) program for ASHPs. Even with an appealing OBF and Tri-State's rebates, however, Michalowski predicts that finding contractors to install ASHPs in Mountain Parks' territory will be a major obstacle. With residential and commercial construction booming in Colorado, skilled workers in every construction trade are scarce; and as mentioned elsewhere in this article, many HVAC contractors in the state still think ASHPs do not work in low temperatures. Michalowski is hopeful that a new Mitsubishi training facility in Denver will increase the pool of qualified contractors.

Case Study 2
"Switch it Up!" Sways Consumer-Members to Upgrade with Strong Brand and Elegant Financing

Orcas Power & Light Cooperative (Eastsound, WA) is renowned among beneficial electrification supporters for its "Switch it Up!" program, which pays for air-source heat pumps (ASHPs), heat pump water heaters (HPWHs), and EV-charging systems at consumer-members' homes and businesses.

While credit for the campaign's savvy branding goes to Scarlett Coffey, the 12-year-old daughter of an employee, OPALCO's OBF mechanism—an energy conservation tariff—was developed by the co-op's head accountant Travis Neal. And, Neal credits two OBF experts for providing particularly valuable advice: John-Michael Cross, project manager for the Environmental and Energy Study Institute; and Pat Keegan, principal of Collaborative Efficiency. Another key advisor was Robert Coates, Program Manager for the USDA Rural Utility Service's Rural Energy Savings Program, which funded OPALCO's program with a $5.8 million zero-interest loan.

Located in Washington and serving 11,300 members residing on 20 islands in the Puget Sound, OPALCO benefited from a state law that allows utilities to place an energy conservation tariff on a customer's bill to finance energy-efficiency measures. This was a crucial advantage, as Neal learned from co-op managers in other states who had to seek legislation before their organizations could adopt such a tariff.

The tariff is tied to the premises and meter, and when a home is sold, the tariff obligation transfers to the buyer. OPALCO records a notice on the property, so future buyers will be alerted, although no lien is placed, as usually occurs with OBF lending programs.

After board approval, OPALCO conducted a "soft launch" in January 2019, with a small number of employees who wanted to opt in. That group included PR Administrator Suzanne Olson whose three-bedroom, 2,700-square-foot home was retrofitted with an ASHP system that cost $12,000. Olson reported that even including the $116 per

SWITCH IT UP!
This Electric Life.

month energy conservation tariff, her first monthly bill was $150 less than it had been the prior year.

In April 2019, OPALCO rolled the program out to all its consumer-members with a marketing blitz that included **a jingle**—"Saving money and energy, This electric life for me, Rebates plus efficiency, Switchin' it up to electricity,"— special events, and branded merchandise such as "Switch it Up!" LED lanterns.

Through September 2019, OPALCO financed 49 ASHP systems for a total of $527,000. After factoring in a hotel that installed ductless ASHPs in 17 units for about $100,000, the average cost for residential installs was just under $10,000. OPALCO had 35 additional ASHP projects in its pipeline at that time.

Rebates from OPALCO's power supplier PNGC Power typically cut $800 from the project cost, although OPALCO retains that money to help fund its $500 fuel-switching rebate, which it gives to members who convert from a gas or propane heating system. But, members who switch from fossil fuels to electricity do not qualify for rebates of up to $1,200 from the Bonneville Power Administration (BPA). This ban on subsidizing fuel switching—which applies in several other states—is considered by many to be a legacy of outdated concerns over the growth of electricity consumption.

In accordance with RUS rules, OPALCO charges consumer-members a 2 percent fee to cover administration and operating costs and the title filing fee. "This ensures that all costs to operate the program are borne by the participating members and not the membership, so there is no impact on our rates," said Neal.

Case Study 3
NC Co-op Upgrades to Reduce Demand Charges & Save Members' Money

Roanoke Electric Cooperative (Aulander, NC) is only a two-hour drive from the booming Raleigh-Durham metro area, known as the Research Triangle, but the economy in the co-op's territory is so stagnant that it typically loses 0.25 percent of its customers annually, according to its COO Marshall Cherry.

Roanoke Electric's response: a strategy that integrates demand response measures with an ambitious on-bill finance (OBF) program that enables members to upgrade to an air-source heat pump (ASHP; see Figure 6) and take other energy-efficiency measures. "Our strategy is centered on reducing our demand charges and enabling our members to save on energy costs, which is very important given the challenging economic conditions in the region," said Cherry.

To maximize its peak demand savings opportunity, the cooperative has deployed edge-of-grid devices to coordinate an aggressive demand response program, according to Cherry. Over eighteen months, Roanoke has equipped 990 members' water heaters with the Carina Technology water heat controller and deployed 1,250 EcoBee Smart Thermostats. Members receive the equipment at no charge and also get $4/month in credit for the thermostat, $1/month for the water heater controller. Roanoke's load drop during peak periods has been reduced on average by about 1.5 MW, which translates into about $170,000 in annual power supply cost savings, according to Cherry.

ASHPs are installed through Roanoke's *Upgrade to Save* program—an OBF program designed around the Pay As You Save (PAYS) model, which the co-op uses as part of its contract with program operator EEtility. Developed by the Energy Efficiency Institute (Colchester, VT), Roanoke's version of PAYS is based on the principle that the OBF tariff should never exceed 80 percent of verified energy savings. (PAYS is used by about 16 utilities, including Ouachita Electric Co-op and a group of Kentucky co-ops operating under the HowSmartKY brand, according to the institute.)

UPGRADE TO $AVE
Roanoke Electric Cooperative

Drawing on its $6 million low-interest credit line from USDA's Energy Efficiency and Conservation Loan Program, Roanoke has funded ASHP installations at 325 members' homes—about 100 of whom converted from gas or propane heating. This is a subset of the 740 total participants, some of whom did not meet all the criteria for an HVAC upgrade, but received less costly measures such as LED change-outs.

Cherry predicts that up to 250 additional members will upgrade to ASHPs in 2020. The co-op will also run an EV charging pilot. Like its consumer-members' grid-interactive water heaters and thermostats, the charging stations will be managed to sell energy off peak.

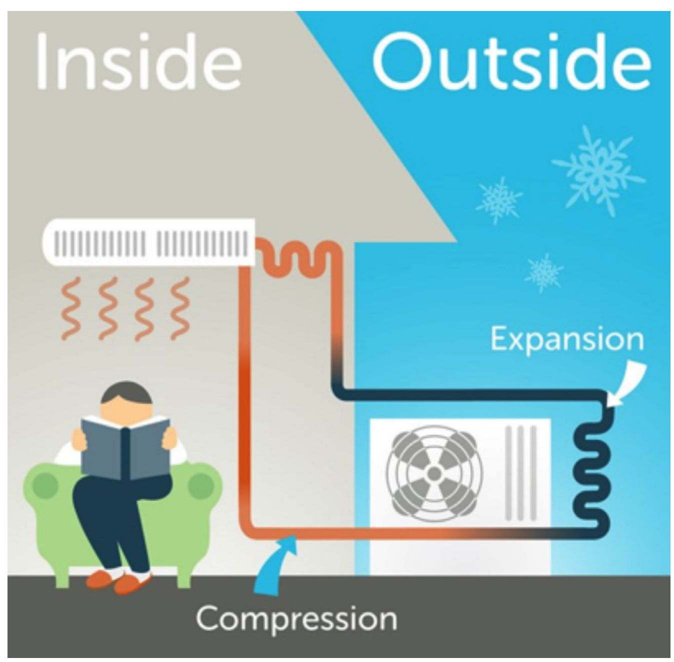

FIGURE 6: How Air-Source Heat Pumps Work
(Source: https://www.efficiencyvermont.com/products-technologies/heating-cooling-ventilation/heat-pumps)

Case Study 4
Midwestern Co-ops Invest in Geothermal Loops

Geothermal heat pumps (GHPs; see Figure 7) are the most energy efficient systems for heating and cooling buildings, enabling users to reduce energy costs by as much as 60 percent. Yet, the high costs of excavating or drilling to install underground piping loops—which enable GHPs to heat or cool a building using the relatively constant temperature of the earth—are a formidable barrier for most homeowners.

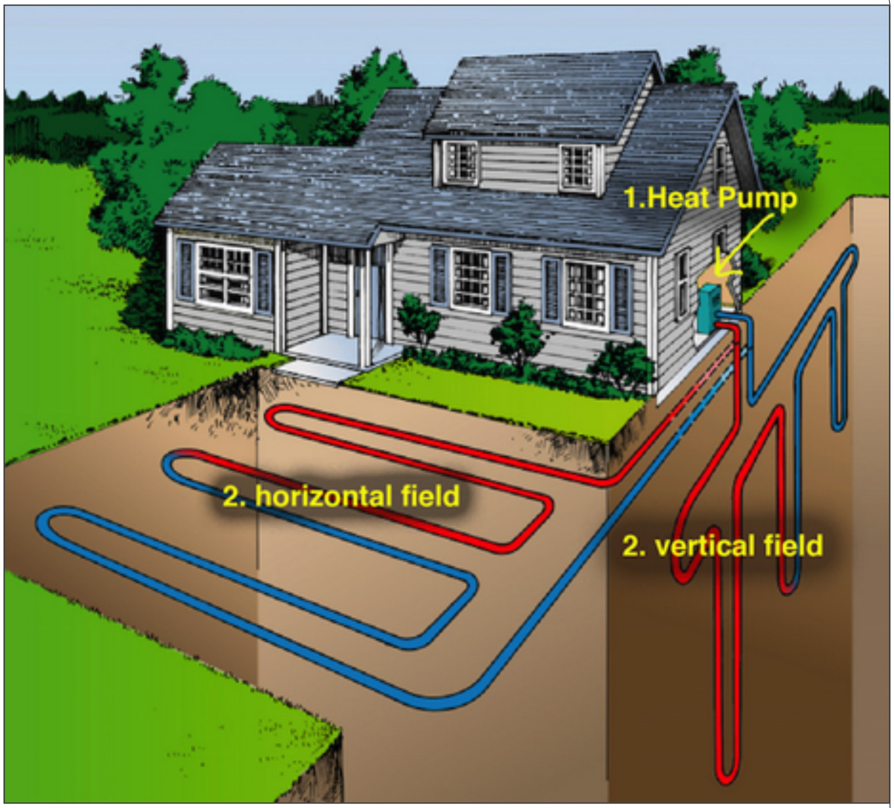

FIGURE 7: Geothermal Heat Pump Operations (Source: https://www.renewableenergyworld.com/2016/02/24/the-hidden-genius-of-geothermal-hvac-systems)

To get over this first-cost hurdle, some utilities and housing developers have used leasing models, in which third parties install the loops and property owners pay a monthly lease fee. Two Midwestern electric co-operatives have gone even further: owning and managing their own geothermal loops on customers' premises. CK Energy (Binger, OK) has installed more than 1,000 GHP loops since 2011. Corn Belt Energy (Bloomington, IL) has a four-year-old program that has invested in geothermal loops for 65 members' homes.

According to Boyd Lee, CK Energy's VP of Strategic Planning and the original champion of the geothermal program, it was conceived as a way to reduce the co-op's demand charges. Because so many members relied on air conditioning to keep cool in Oklahoma's hot summers, yet used gas or propane for space and water heating, the co-op was hit with high demand charges—based on its summer peaks—but was receiving little revenue from heating or water heating.

"We came to realize that a home that was not all-electric just didn't return the cost of service to the co-op," said Lee. But, it took another insight for Lee to convince his colleagues and board members that CK Energy should get into the geothermal loop business: they could make money with it.

Due to the vast improvement in cooling efficiency over conventional air conditioners, the 1,000 geothermal systems have resulted in a 3.5 MW reduction in summer peaks and a consequent drop in demand charges of about $300,000 annually, according to Boyd.

Member-consumers buy their GHP units and pay for installation, a cost that averages about $8,000 per home after federal tax credits (which declined from 30 percent to 26 percent January 1, 2020). The property owners grant CK Energy an easement to access its loop and are moved to a geothermal rate with a customer charge $15/month higher than the standard residential

Continued on next page

Case Study 4 (cont.)
Midwestern Co-ops Invest in Geothermal Loops

rate. Those obligations are passed on to future owners of the home. CK Energy remains responsible for any repairs to the loop—which have only been required twice, both times due to damage from excavation.

Sweetening the deal for the GHP users is a lower kWh charge than CK's standard residential kWh charge—a discount that reflects the fact that "the wholesale demand cost of the geo users is so much lower than the wholesale demand cost of the non-geo user," said Lee.

The co-op's investment in geothermal loops to date has been about $7.5 million, or approximately $7,500 per loop, with the funding coming from a small surcharge on members' bills. Lee predicts the co-op will invest an additional $15 million in 2,000 more loops by 2027.

Because heating systems are typically replaced on an emergency basis, CK Energy occasionally loses the opportunity to sway a homeowner toward a GHP system. "But, we keep enough contractors and drillers in the game that they usually can get started on an emergency basis within a day or two," said Lee.

About 700 miles to the northeast in Illinois, Corn Belt Energy was inspired by CK Energy's example to develop its own GHP loop program. "Our motivation is the same: to reduce demand changes and increase electric heating and cooling," said Justin Stuva, Director of Member Services. "We'd like to see 90 percent or more of our members' heating and cooling needs met by geothermal."

Under Corn Belt's business model, however, homeowners pay a $7 per ton monthly fee for their loops instead of a special customer charge. Corn Belt also benefits from lower drilling and excavation costs, typically paying $1,100 per ton of loop capacity, while in CK Energy's territory, costs are typically $2,000 per ton.

Loop installation costs are significantly higher in many regions of the United States, due to geology and other factors. In Colorado, for example, loop installations typically cost twice as much as in the Plains or Midwest, according to co-op leaders and geothermal industry experts speaking at the Beneficial Electrification League's **June 2019 'Electrify Colorado!' workshop** in Denver.

In northeast California and northwest Nevada, Plumas-Sierra Electric Coop (Portola, CA) has had success with a conventional geothermal lending program. According to Corby Erwin, Member Services Manager, nearly 400 geothermal loops have been installed over 25 years. Members borrow up to $15,000 and repay the loan over 15 years. As with many other on-bill finance (OBF) programs, the lending program requires placing a lien on the property. In Plumas-Sierra's program, the lien is non-transferable, so it must be paid off prior to closing.

Heat Pump Water Heaters: Robust Incentives Needed to Overcome Cost Barrier

The heat pump water heater (HPWH) industry has been innovating rapidly, and some co-ops are achieving success with HPWH programs. Consumers Power in Philomath, Oregon has installed about 500 HPWHs since 2013—including more than 175 in 2019.

However, the HPWH market is constrained in colder climates by the fact that a HPWH cools the room where it is installed (see **Figure 8**). For some homeowners with unconditioned basements though, the dehumidifying effect of a HPWH outweighs concerns about cooling. "In our territory in Illinois, we generally fall prey to musty basements, and these heat pump water heaters do an excellent job of resolving that," said Jeremy

Myers, Energy Adviser for Corn Belt Energy (Bloomington, IL).

Split HPWH systems eliminate the indoor cooling problem with outdoor compressors, but they come with a significant price premium and are much more complex to install.

While many homeowners can DIY a HPWH, most will require a plumber's help, and depending on the region, lack of experience with the technology among plumbers is a market barrier, especially when replacement choices are made on an emergency basis after an existing water heater has failed. "Most plumbers only have generic electric resistance or gas water heaters in stock," said Thomas Elzinga, Energy Services Manager for Consumers Power (Philomath, OR).

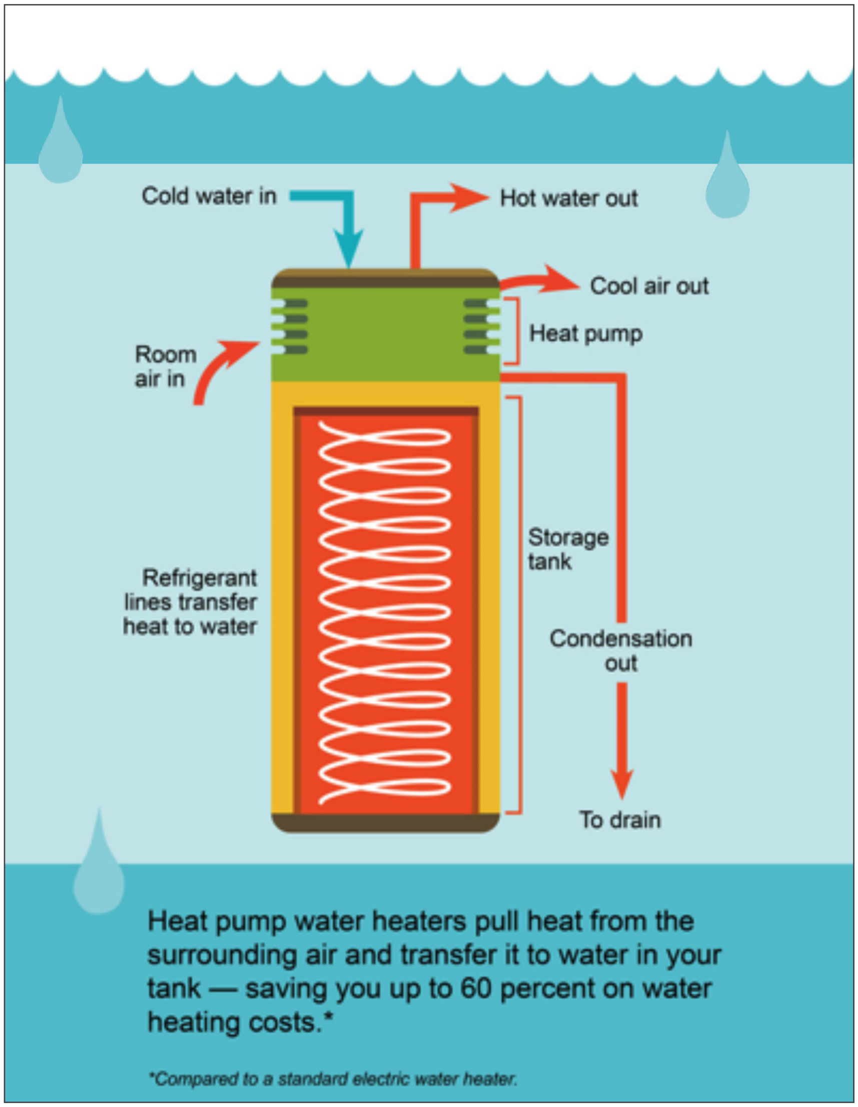

FIGURE 8: How A Heat Pump Water Heater Works (Source: https://www.portlandgeneral.com/residential/energy-savings/water-heaters)

The Northwest Energy Efficiency Alliance and other advocates of HPWH technology are reaching out to plumbing companies to provide training and support, but Elzinga says plumbers have some legitimate concerns about HPWHs. "The margin on an HPWH for a plumber is a little higher, but there's a consumer education piece for the end users that isn't required with standard gas or electric water heating technology," he said. "If a plumber's sales rep doesn't do a good job in helping the homeowner understand the settings and nuances [of] an HPWH, the homeowner may call the company back and it will have to make another call, which eats into the company's margins," he said.

Advocates of beneficial electrification are urging HPWH manufacturers to develop more 110 v models. This would "enable retrofits to happen without requiring a new electrical panel in many cases [and] reducing retrofit costs significantly," wrote Greg Hewitt in a September 2019 article for the Northeast Energy Efficiency Partnerships. As of this writing, only Rheem had a 110 v HPWH, according to industry observers.

A major question weighing in the future of HPWH deployment is whether the technology can be integrated into thermal storage demand response programs that currently use electric resistance water heaters. For more on this topic, see the section on grid-interactive water heaters, **"Hidden Battery" in Water Heaters: Poised for Transformation** (page 15).

Case Study 5
Consumers Power: Lessons from 10-Year History with Heat Pump Water Heaters

When the staff at Consumers Power (Philomath, OR) began investigating heat pump water heaters in 2010 and 2011, they were disappointed. "They didn't do what manufacturers promised, and we had test results to prove it," said Thomas Elzinga, Energy Services Manager.

Thanks in part to input from the Northwest Energy Efficiency Alliance (NEEA), HPWH manufacturers upped their game, and by 2013, Consumers Power was ready to start selling the ultra-efficient water heaters to their members. They used a direct sales approach, as they had been doing with Marathon electric resistance water heaters.

At first, the net pricing on HPWHs—incorporating Consumers Powers' $300 rebate and a state tax credit—was so attractive that members received them almost free. Within a few years, however, unit pricing in Oregon went up from $500 for a basic model to $1,200. Elzinga chalks this up to GE exiting the market, other manufacturers entering with higher-priced models, NEEA pulling back its HPWH manufacturer rebates, and tariff increases. Oregon's tax credit also expired.

Consumers Power increased its rebate to $600, and co-op staff tried to explain to members how an HPWH's superior efficiency would still pay back the cost premium over a standard water heater in two years. But few bought into that logic, and the co-op saw its sales and rebate uptake decline. "Huge electric bill savings don't seem to be that much of an incentive. It's how much the tank costs," said Elzinga.

Then in 2018, the Energy Trust of Oregon began offering through big-box retailers a $500 "instant discount" on HPWHs. Formed in 2002, the trust is funded by the state's investor-owned utilities as part of their required contribution to improving energy efficiency.

On top of the co-op's $600 rebate, the instant discount brings the net cost for a smaller HPWH to as little as $100. Furthermore, those members who do not want to be out $600 while they wait for the rebate can receive a short-term loan, so they can take an HPWH home for nothing down.

While Consumers Power has seen its direct sales decline, overall deployment of HWPHs has gone way up. In the first 10 months of 2019, the co-op gave members more than 170 HPWH rebates—more than twice the annual total in any prior year.

Most members avoid contractor costs by installing their own HPWHs—something the co-op promotes as an added benefit, and an additional reason for member-consumers to be proactive and not wait for their water heater to die. "Through our marketing, we make them aware of the advantages of shopping around and switching over [before] it's an emergency," said Elzinga. Split HPWHs are not promoted as DIY because, like an ASHP, they have outdoor compressors with refrigerant lines that must be brought through the wall.

Also, motivating many co-op member-consumers to upgrade to HPWHs is the opportunity to reduce their greenhouse gas emissions. "They want to get away from natural gas or propane," said Elzinga. "Our power mix is 98 percent emission-free, mostly hydro, but also nuclear and wind."

"Hidden Battery" in Water Heaters: Poised for Transformation

While investor-owned utilities and independent power producers win headlines for battery storage projects in the hundreds of megawatts, a more prosaic energy storage resource is already providing storage capacity at that level and is also poised for growth. This resource is the "**hidden battery**," as The Brattle Groups calls it, in tens of millions of electric water heaters in American homes.

Co-ops have been using the hidden battery of grid-interactive water heaters (GIWHs) since the 1980s. By controlling the water heaters of willing members, they shift electricity consumption from peak to off-peak times, reducing demand charges and optimizing wholesale power costs. In 2016, NRECA estimated that more than 250 co-ops in 35 states were using GIWH to reduce demand costs.

Managing these costs is still the major driver for co-ops to implement GIWH programs. But, as G&Ts install or purchase more wind and solar energy, and distribution co-ops manage more net-metered solar on their circuits, co-ops are increasingly looking at the use case that is driving private electricity providers to invest in battery storage capacity. "We see [grid-interactive water heaters] being a critical part of a future with increasing amounts of renewable energy on the system," said Jeff Haase, Manager of Member Services and End-Use Strategy for Great River Energy (GRE), which maintains an a nightly average of more than 845 MWH of stored electricity in about 110,000 of its consumer-members' water heaters. "It gives us the ability to control load when there's a large amount of variable generation resources on the system, as well as helping us avoid very expensive price spikes."

Communications and control technologies have evolved to allow more refined demand response capabilities and provide new value to occupants, such as smartphone alerts about a leaking water heater. GRE and its member co-ops are in the midst of a years-long project to transition from legacy technology—"on-off" GIWH switches that are controlled by 69 radio towers—to new technology by January 1, 2026. While hardware and software choices are pending, it is clear to Haase that the next generation of GIWH technology will provide "much more localized and focused abilities to dispatch load management, including for potential reliability events."

Kate Desrochers of **Packetized Energy**, a vendor to several co-ops using GIWHs, agrees with Haase, saying her firm's software and hardware can respond to local grid conditions in real time. "If you have an outage and need to quickly drop load to rebalance the grid, or a distribution circuit with over-voltage problems due to a large amount of distributed solar, the technology can respond locally to those signals," she said.

Another favorable development: a water heater no longer must be specially equipped by the manufacturer for grid interactivity; third-party vendors now sell smart thermostats that can easily be installed on most electric water heaters.

Packetized sells its UL-listed Mello smart water heater thermostat to utilities for between $125 and $150. Several co-ops are running pilot programs using Packetized equipment or the **Aquanta** water heater controller, which retails for $149 (see **Figure 9** for examples of technology). "It's similar to a NEST thermostat in the concept and features," said Chris Michalowski, Power Use Advisor for Mountain Parks Electric, which is testing the Aquanta thermostat on dozens of members' homes.

South Carolina G&T Central Electric is working with Packetized and **Armada power** on a pilot test of smart GIWH controls on 50 households. According to Scott Hammond, Programs Manager, the new devices provide benefits that legacy technology does not. "The ability to pre-heat and measure the individual and aggregate load of the devices are two of the main new features that we like."

However, the new devices use WiFi to communicate, "which is less reliable than the AMI system we currently use to communicate," said Hammond. "Over the first half of 2020, our co-ops will evaluate the new devices and determine if the new features of these devices are valuable and worth adding to their load management programs."

FIGURE 9: Examples of Packetized and Aquanta Technology.

Virtually all existing water heater demand response programs in the United States utilize electric resistance water heaters, and industry experts have varying opinions about how effectively heat pump water heaters (HPWHs) can be incorporated in these programs. Some worry that a HPWH's more complex operating modes and settings would complicate a utility's ability to control the resources and lead to member complaints about lack of hot water. Others—including the authors of a **2019 report for Regulatory Assistance Project (RAP)**—look more favorably on using HPWHs in demand response programs.

The RAP report also estimated that only 2 percent of electric water heaters were participating in demand response programs at the end of 2018. Therefore, there may be plenty of scope for including both electric resistance and heat pump water heaters in these programs going forward.

Conclusions

The opportunities for co-ops to improve load profiles, save member-consumers' money and build load through electrification of heating and water heating—the two largest sources of household energy demand—have improved significantly over the last decade.

The air-source heat pump (ASHP) segment has achieved the most dramatic gains in efficiency, pricing and performance. Yet, formidable obstacles remain in regions where HVAC contractors lack experience with ASHPs or still hold the outdated opinion that ASHPs do not perform below freezing. The testimony of satisfied ASHP users in Vermont, Michigan, and other northern states—as well as pilot studies by co-ops in the high Rockies—can be used to sway skeptical HVAC contractors. But, focused outreach and education for contractors will likely be needed to grow ASHP adoption in co-op territories where the market is still immature.

Similarly, consumer-member adoption of heat pump water heaters (HPWHs) will likely remain slow in colder states due to their ambient cooling effects. But, in states with mild climates and supportive state policies, adoption is growing.

The grid-interactive water heater (GIWH) industry is entering a period of rapid transformation, with AMI- and WiFi-enabled systems promising greater demand response capabilities and more benefits—like leak detection—for member-consumers, and vendors offering smart thermostats that can be installed on existing electric water heaters. These changes make GIWH more accessible to a wide range of co-ops.

Busy co-op managers who have heretofore regarded such opportunities as too complex or costly for their organization should revisit their assumptions and consider doing some initial feasibility research and analysis. Attending a **regional workshop** or reaching out to some of the managers quoted herein would likely provide valuable insights. ■

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The Distributed Energy Resources (DER) Work Group, part of NRECA's Business and Technology Strategies department, is focused on identifying the opportunities and challenges presented by the continued evolution of distributed generation, energy storage, energy efficiency and demand response resources. For more information, please visit **www.cooperative.com**, and for the current work by the Business and Technology Strategies department of NRECA, please see our **Portfolio**.