Business & Technology Surveillance

Methods to Help Members Control Electric Resistance Heat

By Tom Tate

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NRECA
America's Electric Cooperatives

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SUBJECT MATTER EXPERT ON THIS TOPIC

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ARTICLE SNAPSHOT

WHAT HAS CHANGED IN THE INDUSTRY?

Smart thermostat programs are one of the most popular utility offerings today. However, consumers that use electric resistance baseboard heat are not able to take advantage of the controls or the ability to enroll in utility demand response programs because most of the thermostats on the market cannot work with baseboard heat. Alternatively, there is no doubt that heat pumps can provide significant cost and demand savings; however, the upfront installation cost is often a barrier for some consumers.

In aim of providing smart control for baseboard heat, a growing number of mostly Canadian companies are offering products that provide similar functionality found in a Nest or Ecobee thermostat for baseboard heaters. This report will examine those products and several pilots conducted by Canadian utilities to test these new technologies. The goal is to provide insights and recommended next steps for cooperatives who may consider offering smart control programs for consumer-members with baseboard heat.

NRECA is exploring the option of conducting a pilot of smart thermostats for efficiency and demand control in 2019. Co-ops interested in participating should contact Brian Sloboda at: brian.sloboda@nreca.coop.

WHAT IS THE IMPACT ON COOPERATIVES?

Electric resistance heat… Those words conjure up images of high bills for consumer-members in many parts of the country—and if used improperly, they can justifiably earn that reputation. However, electric resistance heat can be used in places where other heat sources cannot without substantial installation costs.

There is not much opportunity to improve upon electric resistance heat making, it a mature technology. One unit of electricity in; one unit of heat out. Nothing fancy or flashy. Companies market "advanced" electric heaters, typically as room units. These may employ oil-filled fins or "space age" quartz/infrared technologies. They still provide the one-to-one efficiency of standard electric heat units. So, when it comes to options along these lines, it is "caveat emptor."

Where electric resistance heat has fallen behind other heating sources is in the area of controls. Unlike centrally-controlled, whole-house, or commercial HVAC systems, electric resistance heating is installed and controlled room-by-room—and rather than having a central thermostat for control, each heating unit has its own. This creates challenge in the development of control technology to enable inclusion of electric resistance heat in cooperative demand response programs.

WHAT DO COOPERATIVES NEED TO KNOW OR DO ABOUT IT?

Centrally-controlled HVAC today can be controlled by an amazing array of programmable and smart thermostats. Their electric resistance counterparts have not enjoyed the same capabilities. Instead, the temperature controls for electric resistance have languished as simple rotary dials with minimal temperature markings, often just "Min" and "Max" or basic programmable models.

Two key factors are behind this technological gap:

- It has been expensive to install a digital or smart thermostat for each heater, generally one per room, especially when compared to the basic models.
- Electric heaters require line voltage (120 or 240 VAC) rather than the typical 24 VAC used to control central systems. Presence of line voltage can intimidate self-installers, meaning professional installation is required, further increasing costs.

Fortunately, with a renewed emphasis being placed on beneficial electrification as renewable energy sources increase their share of fuel mixes, companies have started to address this shortcoming and are bringing the electric resistance thermostat into the 21st century with smart thermostats to resistance electric heat (STERH).

The Market Potential for Smart Thermostats to Resistance Electric Heat

According to a **report** from U.S. Department of Energy, 34 percent of American households use electricity as their primary heating fuel, see Figure 1. Within this percentage are electric heat pumps in addition to resistance heating systems. Digging deeper, **resistance heating systems** include baseboard, wall, fan forced, electric furnaces, electric thermal storage, and other sources. Figure 2 shows the breakdown of heating sources by climate region.

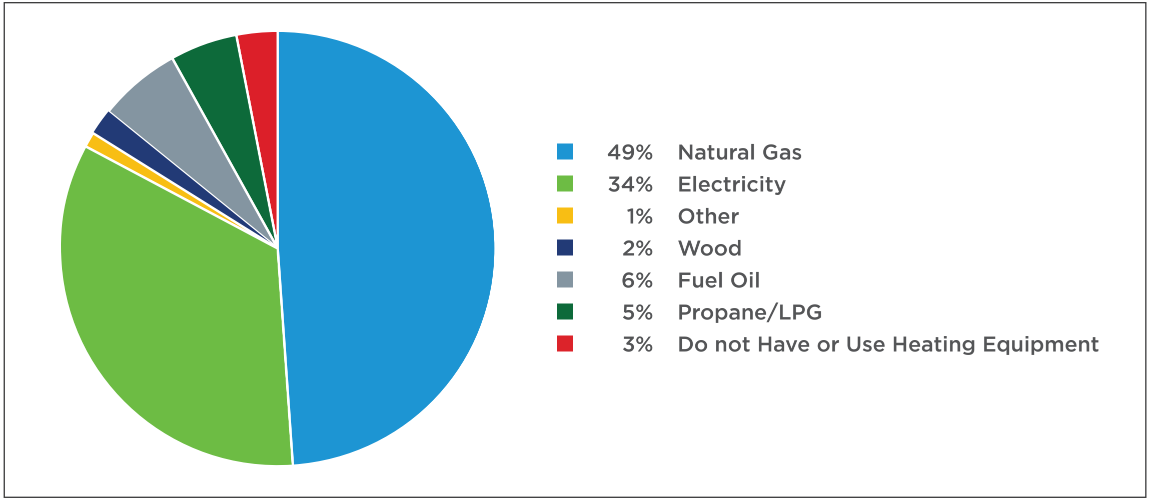

FIGURE 1: Consumers' Primary Source of Heating (https://www.energy.gov/energysaver/home-heating-systems, 2015 Data)

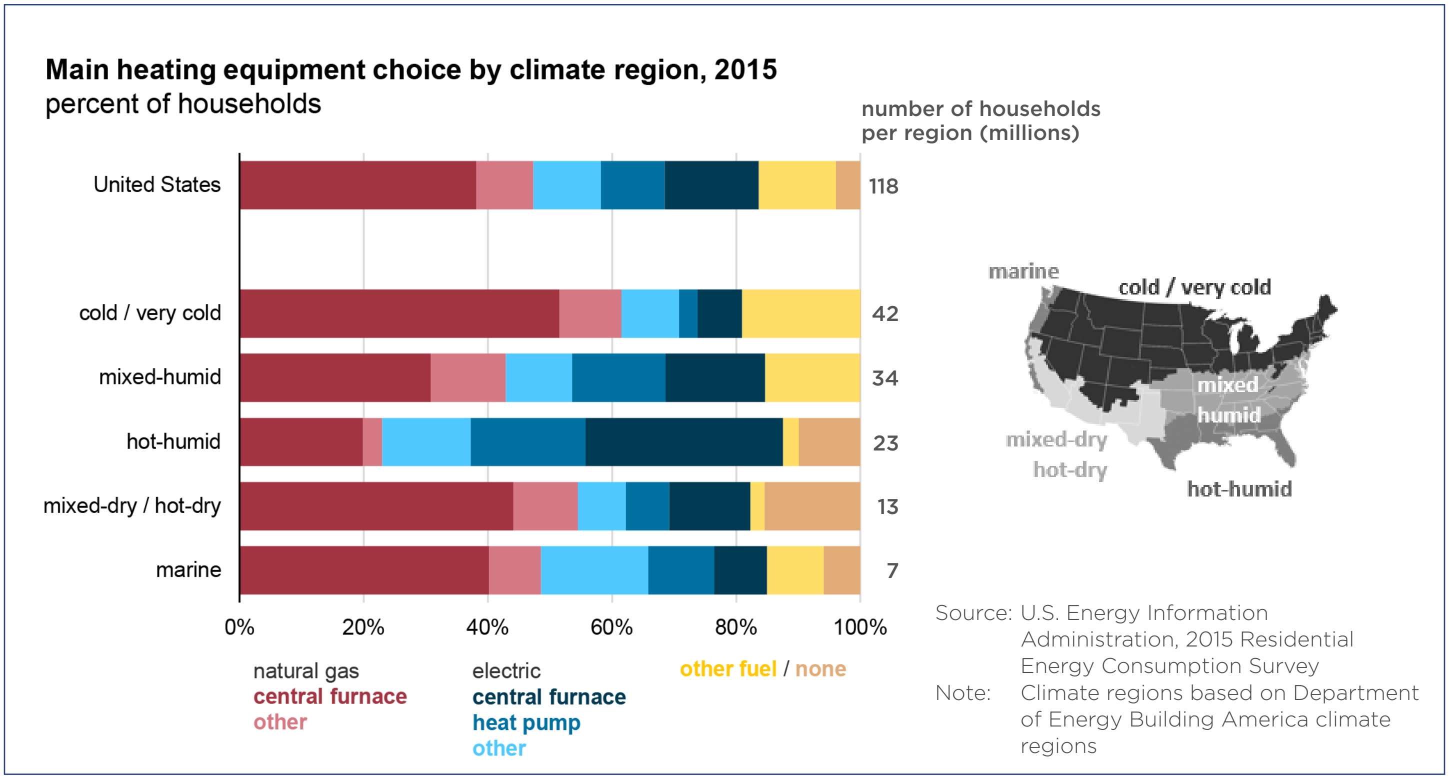

FIGURE 2: Today in Energy (https://www.eia.gov)

TABLE 1: Electricity as Residential Heating Fuel, EIA 2105 RECS Survey

	Number of housing units (million)					
		Housing unit type				
	Total U.S.	Single-family detached	Single-family attached	Apartment (2- to 4-unit building)	Apartment (5 or more unit building)	Mobile home
All homes	118.2	73.9	7.0	9.4	21.1	6.8
Electricity end uses (more than one may apply)						
Space heating	57.7	33.8	3.3	4.6	11.6	4.4
Main	40.9	20.9	2.4	3.7	10.4	3.6
Secondary	23.0	16.7	1.2	1.5	2.2	1.4
Air conditioning	102.8	65.5	6.0	7.5	17.9	5.8
Water heating	55.1	31.6	3.0	3.9	11.2	5.3
Cooking	75.0	47.1	4.0	5.6	14.2	4.0

Source: Table HC1.1 Fuels used and end uses in U.S. homes by housing unit type, 2015 (Release date: February 2017 – Revised date: May 2018)

Members will want the convenience of managing smart thermostats from the web or via a smartphone app.

Researching further, another 20 percent of American households use electricity as a secondary source of heat. Table 1 illustrates the breakdown by housing type, using 2015 data from the **U.S. Energy Information Agency Residential Energy Consumption Survey** (RECS).

Options for Electric Resistance Heat Thermostats

Mechanical options for electric resistance heat thermostats abound. You can purchase a bi-metal electro-mechanical model[1] on Amazon for around $15. Bi-metal thermostats rely on the expansion and contraction of a coil made of two different types of metal, usually steel and copper, or steel and brass. Each metal responds to temperature changes by expanding and contracting at different rates. This reaction to temperature change makes the coil get larger or smaller, and the motion makes or breaks the circuit supplying electricity to the baseboard unit.

Programmable thermostats are also available, some with digital displays. Still, each requires individual attention to program them or make changes to programs. A basic 5-2[2] programmable model[3] will set you back about $20 on Amazon.

Where true convenience and savings begin to accrue are in the smart thermostat variants that allow members to manage their thermostats from the web or via a smartphone app. There, the selection drops off rapidly, as this segment has not attracted much interest. (See the **sidebar** written by Martin Frasier, CEO of CaSA, for his take on why the market has been slow to develop.)

With price points for mechanical and programmable alternatives as low as they are, the conventional wisdom may be that consumers will not pay for more expensive, smarter thermostats. Today, pilot programs in Canada and development efforts by Canadian companies are dispelling the common belief.

Two other developments may also prove important concerning the use of smart thermostats with electric heat: the growth and acceptance of the Internet of Things (IoT) technology, and voice control through the rapidly emerging voice tools like Alexa and Google Assistant.

Application of Smart Thermostats for Control of Electric Resistance Heat

Unlike other new and emerging IoT and smart home technologies, the application of smart thermostats to resistance electric heat (STERH) appears to be simple; each heating

1 Honeywell Manual 4 Wire Premium Baseboard/Line Volt Thermostat (YCT410B1000/U)

2 5-2 programming allows two schedules, one for week days, and one for weekends.

3 Honeywell RTH2300B1012/E1 5-2 Day Programmable Thermostat

A challenge is having to control each thermostat individually for electric resistance heat.

unit requires a thermostat. Install it, program it, and walk away. End of story? Not quite.

With more members using smartphone apps every day, they will expect to have an app to control any STERH they buy. There is also the issue of having to control each thermostat individually, even if an app is available. The potential problem here is the inconvenience of addressing 5, 7, or more thermostats individually to make schedule and temperature changes.

BC Hydro, a Canadian utility in British Columbia, shared their assessment[4] of STERH options. They completed this study in 2016, and several companies covered have already advanced the state of their thermostat's "art" relative to controlling electric baseboard heat.

Their study covers two of the four companies detailed in the next section of this report, in addition to several other major thermostat players cooperatives are likely to recognize: Honeywell, Ecobee, Nest, Schneider Electric, and Emerson.

Each of these major companies offers one or more smart thermostats, but at this time, none can control line voltage electric baseboard heating units without using a relay. Because this unnecessarily complicates the installation process and adds substantially to the installation costs, none of those thermostats are covered further in this Surveillance report. However, these companies do bear watching, as they may determine this is a market they want to enter. Standard programmable line voltage thermostats are not covered either, because co-ops cannot control them as part of a demand response (DR) program.

Smart Thermostat Options

Canada is taking the lead in the development of STERH with four companies offering solutions. The four companies are:

- CaSA – **Caleo**
- Sinope – **THXXXRF series**
- StelPro – **Maestro**
- **mysa**

Of the four companies, **mysa** "appears" to be the most "modern" regarding ease of use. This observation is based upon their "Nest-like" website and marketing approach. It is also the newest of the four companies. Their website is well-done, easy to navigate, and offers a compatibility checker to let users see if their existing heaters can be controlled (Nest and Honeywell's Lyric are two smart thermostat vendors who do the same).

The company makes extensive use of an app to control its thermostats. You can group several thermostats for simultaneous control (in recognition of the potential issue of users having to program numerous thermostats individually) or control each individually. Finally, mysa offers geofencing and energy reports, all within the app. The mysa focus appears to be on smart/connected homes, and is currently untested in utility programs, as far as we call tell.

CaSA designs their products with DR in mind. As they state, "DR is not an afterthought, it is core to our business." They clearly understand the utility space and the needs faced by small distribution utilities like electric co-ops, and are taking steps to make their offering easy to apply in a DR program. They make their product easy to install and manage through their portal, which is also where owners of their products go to control their smart thermostats. While not an app in the truest sense, the portal is accessible via smartphone, tablet, or PC.

The CaSA thermostat was tested by a Canadian utility; the details of which are presented in a later section of this report.

Sinope also has experience in the DR space with two utilities in Canada testing their STERHs in DR and related programs. They offer a broader array of smart thermostats for electric resistance heat, and their products can also connect via Zigbee, in addition to using the home's Wi-Fi network. The Sinope requires a master, or *parent,* unit to which the individual room thermostats, or *child units*, connect. This implementation is similar to IoT offerings that require a hub to provide the connection to the home network. This implementation approach can present a weak point,

[4] Technical Review of Wireless Baseboard Heater Thermostats For Demand Response Pilot, Dated: April 4, 2016, Prepared by: David Rogers P.Eng. LC CEM CDSM Engineering Conservation & Energy Management BC Hydro

< PREVIOUS VIEW >

in that, should the parent unit fail, the other thermostats lose their network connection and with that, the control via the Sinope portal.

Like CaSA, Sinope requires users to access and control their thermostats via a portal—and, like CaSA, access is possible via smartphone, tablet, or PC. **StelPro** is the largest of the four companies. It manufactures a wide array of heating equipment, and their smart thermostats are one part of their total offering. Their focus appears to be on the connected house rather than utility DR, although one Canadian utility has used their product in a pilot. Their implementation is like that of Sinope, using a parent/child setup. Their devices can also control more than electric baseboard units, also similar to Sinope. This last capability may not be of much importance for an overall DR program, but it provides options for co-ops to control wall heaters and similar, less common electric resistance heat sources.

Access and control of StelPro STERHs are handled via an app. Table 2 offers a comparison of these four companies and their STERH offerings.

Portal vs. App, Which is Better?

Two of the companies in this report use an app and the other two use a portal. In the end, the results are the same, every STERH can be controlled via a smartphone, tablet or PC. However, people are accustomed to an app rather than using their browser on their smart devices. One of the two portal companies is planning to roll out an app. Time will tell on the other. In the meantime, it is more a matter of member preference.

TABLE 2: Comparison of STERH Offerings

Feature	CaSA	mysa	Sinope	StelPro
Product name/model #	Caleo	mysa	TH1500RF[i], GT125[ii], TH1129RF-3000[iii], TH1120RF-4000[iv]	Maestro/SMC402[a], SMT402[b]
Parent/child[1]	N	N	Y	Y
Communications[2]	Wi-Fi b/g/n	Wi-Fi b/g/n	Wi-Fi b/g/n, Zigbee	Wi-Fi b/g/n, Zigbee
Communications secure/encrypted	Y	Y	Y	Y
Maximum watts	3750	3800	3600, 3000, 4000[v]	4000
Compatible systems	Baseboard	Baseboard	Baseboard, fan forced, short cycle convector, radiant ceiling	Baseboard, fan forced, convection
Smartphone app	Y[A]	Y	Y[vi]	Y
Systems that the device can be integrated with	IFTTT	Amazon Alexa, Google Home, Apple HomeKit IFTTT	Samsung SmartThings	Samsung SmartThings
Use with DR/LM	Y		Y	
Self-install	Y	Y	Y	Y
Special features as per websites and literature	DR controls for water heaters	**Geofencing, grouping** thermostats, **energy** reports, **weather** integration	**Energy** reports, load **controllers** (Wi-FI & Zigbee) for other appliances, water **leak sensors**, and controls	Makes the heating systems, **grouping** thermostats, **weather** integration, **geofencing, energy** reports
Warranty	3-years	2-years	3-years	3-years
Retail Pricing	$130.00	$125.00	$110, $89, $80, $75[vii]	$200, $79[b]

Notes:
1 Requires hub/parent for thermostats to connect to the internet.
2 Internet communication method listed first followed by the child to parent communications technology, if different.
A Control through an online portal which can be accessed by smartphone, PC, tablet.
i Newest web capable thermostat
ii Central controller/hub—handles up 250 devices
iii, iv Web capable thermostats
v Respective wattages in the order listed above
vi Must access thermostats and data via a web portal—https://demo.neviweb.com
vii Pricing in order of Sinope devices listed above
a Parent - SMC402, child SMT402
b Prices for the parent, child units

What Co-ops Need to Know

Resistance electric heat remains a primary source of heating in many areas served by electric cooperatives, even as efforts are made to replace it with more efficient alternatives. Up until now, co-ops had few, if any, good options for helping members control the cost of electric heating, outside of programs aimed at weatherization, insulation, and education around energy efficiency and conservation. Weatherization and insulation efforts remain important, as they create a building shell that uses less energy by reducing leaks and retaining conditioned air. Education will remain essential in helping members understand how their homes use energy and what actions they can take to manage their total energy bill—including the use of new STERH technology.

With the advent of STERH, electric cooperatives with a significant amount of electric heat load on their system may now have a tool to help their members further control their heating costs. Also, these new thermostats provide an opportunity to include electric resistance heat in load management/demand response programs, like electric water heaters.

A pair of Canadian utilities has invested in researching smart line voltage heat thermostats. BC Hydro piloted the thermostats with customers directly, whereas the Hydro-Quebec effort was a controlled, scientific study involving a pair of identical, carefully controlled, unoccupied homes. Summary results for both follow, allowing co-ops to get a sense of the potential for programs with their members.

Thoughts from CaSA CEO, Martin Frasier

The message I'm mostly pushing forward these days is that what's now known as "advanced" demand-response requires everyone, big or small, to stop and rethink all they know about demand side management. Today's IoT technology enables solutions that were confined to science-fiction, or at best to overly optimistic tech evangelists, not so long ago. In fact, not even 10 years ago.

The traditional DR model pivots around high energy costs and low latency loads (such as A/C), but Advanced Demand Response (ADR) creates a universe of new opportunities, from standalone, spread-out assets in rural areas to highly concentrated portfolios in urban areas. CaSA's own development in electric baseboard heating and electric water heating speaks to these new opportunities. For many northern, cold-weather climates, it's not about the cost of energy and the ROI for the end user, it's about peak penalty charges and the potential savings associated with managing that peak charge for the distributor (co-op, IOU, Muni). Line voltage thermostats are the best example of this democratization of ADR for smaller operators; it's a load that's very typical of rural areas, be they hot or cold climates, and because of that, none of the large players (control manufacturers) in this space looked into solutions for it.

But for a lot of smaller, non-generating operators (distribution co-ops, Munis) in rural areas, this load is extremely significant and the lack of any solutions to organize and mitigate the impact of electric heating on the grid meant that the scope of solutions was very limited for them.

There are products available today, albeit only one or two that are truly grid-enabled and that present a satisfactory level of cybersecurity, although the same could be argued for even some of the HVAC solutions rolled-out by larger utilities. We're very much at the beginning of this new model, but because many lessons were learned in large deployment programs, from social acceptability to cybersecurity, reliability and privacy, it's now a fast-moving space, populated by companies like CaSA that are nimble and, therefore, accessible to even the smallest operator, without fear of being locked in a costly proprietary system from a major vendor.

BC HYDRO PILOT TEST RESULTS

We spoke with the program managers at BC Hydro about their pilots using smart baseboard electric thermostats, to get an understanding of the objectives of, reactions to, and the results of their pilots.

Pilot #1

One pilot used the Sinope and CaSA smart thermostats. The Sinope thermostats were deployed to focus on their effectiveness in a demand response (DR) role. The CaSA thermostats were deployed as part of a "connected home" initiative, to see if more control and awareness of energy use could change user behavior and create savings.

About 100 homes were part of the pilot. The utility pulled candidates from a pool of customers who self-reported interest in helping test new technology and savings programs. The area BC Hydro serves can be characterized by a population that is very environmentally-conscious and community-oriented. The area has a high concentration of electric baseboard heat, because natural gas service was not available until the 1990s. Also, the area is expected to have distribution constraints in the future, making load reduction efforts an important part of utility operations.

BC Hydro provided the thermostats and installation at no charge, and provided a $40.00 bill credit at the end of the heating season for customers still on the program. The program limited each home to a maximum of five (5) thermostats. The installer selected the highest use rooms, with the customer's input, to receive the thermostats. These include the usual suspects, living room, family room, and kitchen. See Figure 3.

Regarding the tests, BC Hydro dispatched approximately 36 control events each winter. Most events were called Monday through Friday, AM and PM, and ran from 1 to 4 hours each. Customers had the opportunity to override, but very few did. There were two dropouts from the program.

The events were preceded by a period of preheating followed by either a 1ºF or 3ºF temperature reduction. The utility also tested voltage reductions. The best results occurred with the 3ºF reduction and no preheating period. Customer reactions were captured following the tests and the most common reactions included, "didn't notice the event," "didn't care that control took place," "put on a sweater for the duration," and "adjusted the thermostat in one room." Additional participant responses included requests for more information on how to optimize their use of the thermostats, access to an app rather than an online portal (Sinope), and more information on demand response.

Dispatching events was easy enough for the utility. There was no integration necessary with existing utility applications. The Sinope portal served as BC Hydro's dispatch—and the CaSA thermostats were similarly dispatched. From a pilot perspective, IT impact was minimal.

BC Hydro is awaiting the official results, but preliminary data points to a reduction of .5—1.0 kW per home. Not a bad result, at least in their eyes. Should the pilot expand into a full-fledged program, BC Hydro will not give away that many thermostats and free installation. Calculating an ROI was not an integral part of the pilot. Instead, the goal was to see how effective the technology was in reducing demand and encouraging savings. However, the utility did keep track of cost data, and will use that to calculate an ROI and model future programs around this and the other results.

FIGURE 3: CaSA Caleo Smart Live Voltage Thermostat

Pilot #2

The second pilot used CaSA hardware and StelPro thermostats. The pilot will continue into the 2018-19 winter, since the thermostats were not fully deployed for the entire 2017-18 heating season. Participants were selected from the same volunteer pool and installed in the same geographic area as Pilot #1.

This pilot focused completely on DR. Each event was preceded by a 1-hour, 2º preheat, followed by the event. The CaSA portal provides more sophisticated event control options, if desired by the operating utility. The utility noted that they had issues with dispatching all the participants. Sometimes they would only see 50 percent, but they expect that rate to improve to 80 percent in the future. They feel much of the problem of the low percentage dispatch rate stems from reliance on homeowners Wi-Fi network issues.

StelPro devices were connected to a third-party portal for dispatch. The utility did not report any particular issues using this portal.

Wi-Fi Caveats

Home Wi-Fi is nearly ubiquitous today, making it is logical choice for the DR program's communication and control channel. Using existing Wi-Fi networks reduces the cost of communicating with widely distributed devices.

Two downsides are network reliability as measure by availability and range issues. Neither are major impediments and range issues can be addressed with repeaters.

Still, the reliability will impact dispatch rates and needs to be factored into the DR program's performance when committing to load reduction targets.

Other program particulars were the same as pilot #1. There was a limit of 5 thermostats per home, and a BC Hydro contractor (electrician) handled the installation. Based on initial results, the installation was the easiest part, requiring only about 5 minutes per thermostat. Because of the simplicity of installation, BC Hydro feels there is a real potential to allow do-it-yourself (DIY) as part of a full program.

The largest amount of time involved connecting to the homeowner's network and relocating thermostats that could not connect due issues including inadequate signal strength.

They also encountered issues with homeowners not having the information necessary to log into their routers. Many installations involved tying into the router provided by an internet or cable vendor, and where the homeowners were not involved in the initial configuration. To complete the setup for the pilot, homeowners needed their smartphone, the password/login information for their home network and the app for accessing the thermostat vendor's portal.

Customer reactions were also positive, with only about 10 percent saying they even noticed the events. One family dropped out because they brought a new baby home and did not want the baby exposed to the temperature reductions.

HYDRO-QUEBEC PILOT RESULTS

Hydro-Quebec conducted a study[5] in 2016 using the Sinope and StelPro thermostats. In this pilot, a pair of identical, unoccupied homes, were equipped with the thermostats and the effect of control events on temperatures within the homes was measured at various heights and locations throughout the house. The abstract of the study follows.

Hydro-Quebec Piolot Results – Abstract

While smart thermostats have been around for a few years for HVAC central systems, their equivalent for the control of electric baseboard heaters have just hit the market and have yet to demonstrate their benefit for winter demand response (DR). This paper describes the use of such thermostats in fully instrumented research houses to study DR strategies for preserving occupants' comfort while providing substantial load reduction.

The first study focusses on the advantage of preheating and setpoint ramping to create an advanced setpoint modulation strategy. This strategy is compared to a simpler step up/down strategy. The advanced setpoint modulation of ±1°C (1.8°F) resulted in significant demand reductions during the morning and afternoon events, though slightly lower than for the simpler 2°C (3.6°F) step down strategy. Based on the ASHRAE Standard 55-2013 local thermal discomfort requirements, the advanced strategy also resulted in more comfortable conditions.

The second study consists of controlling only a fraction of the installed baseboards. The load reductions achieved for several fraction levels are given, and insights on the selection of the most appropriate baseboards to control are discussed.

5 ©2016 ACEEE Summer Study on Energy Efficiency in Buildings

The first study that observed demand reductions achieved between two control strategies, Advanced and Simple, produced the results shown in Table 3:

TABLE 3: Average Load Shed, Study 1

	AM Peak Period [kW]	PM Peak Period [kW]
H1 – Advanced	2.1	2.4
H2 – Simple	2.9	3.0
Difference	0.8 (27%)	0.6 (20%)

The complete study provides detailed descriptions of the methodologies employed and the observed results. It is useful reading for any co-op considering implementing a program using smart baseboard thermostats. Rather than repeat the wealth of technical details here, it is useful to recite key outcomes observed based on the data:

The benefits of electric heat control programs to the cooperative fall into both financial and satisfaction categories.

– *Nonetheless, an advanced strategy, making use of ramps and preheating, resulted in average load shed of more than 2 kW per house using only a ±1°C (1.8°F) setpoint modulation. This was about 25 percent less than with a simple strategy (2°C (3.6°F) step down). The advanced strategy, however, resulted in increased comfort as demonstrated by the analysis of the local thermal discomfort requirements[6] of the ASHRAE Standard 55-2013.*

– *The setpoint modulation of the advanced strategy also reduces operative temperature changes (drifts and ramps) hence lowering discomfort perceived by occupants as a result of the DR strategy. It should be noted that the simple strategy often exceeded limits of the Standard for both requirements.*

Note: Echoing the caution stated the report, the data and results should be considered representative and informative rather than conclusive, given the small sample size.

How Can Your Cooperative Benefit?

The take away for co-ops is that STREHs can be used to include this heat source in DR programs, potentially good news for cooperatives looking for ways to expand their DR programs and provide additional value their members in the form of lower energy bills.

Effective DR programs are just as important as ever, if not more so. As renewable energy supplies grow as a percentage of co-op's fuel mixes, a new variability in power supply is introduced, driven by the effects of weather on the output of renewable sources. Variability is an unwelcome addition to the wholesale market/grid managers, the ISOs, and RTOs. Because this variability is extremely rapid and hard to anticipate, dispatchable resources with rapid response times are receiving renewed emphasis. DR has a role to play in fulfilling the demand for rapid response resources, making it advantageous for co-ops to grow their programs.

The benefits to the cooperative fall into both financial and satisfaction categories. The financial benefit comes from increased revenue based on the value of dispatchable DR assets in the wholesale market. The member satisfaction benefits come from the member seeing their co-op as actively involved in helping them manage their energy bill, and taking steps to support the growth of renewable energy sources in the overall fuel mix.

Direct member benefits are both tangible and intangible. Smart thermostats provide more effective and proactive control of the cost of electric baseboard heat, providing a tangible benefit, lower heating bills. Like smart thermostats for AC, there will be both an energy efficiency component and a demand reduction component. There are not enough studies available to predict the efficiency impacts to a co-op. When the member receives more information about how to use their energy more

[6] Thermal discomfort is impacted by metabolic rate, clothing insulation, air temperature, radiant temperature, air speed and humidity. This ASHRAE Standard establishes limits to minimize these impacts on people in homes and commercial spaces who are active. It does not consider impacts on individuals under covers, reclined, etc.

efficiently and receive information about their energy use in a more timely manner (via the app or portal and proactive messaging), they receive an intangible benefit, that of being in control of their energy use and the resulting bill.

What are the Challenges to Implementation?

The experience of the Canadian utilities illustrates some challenges to the implementation of a DR program using STERHs encountered in the pilots and anticipated for future expansion. Those include:

1. **Physical Installation:** Because baseboard electric heat thermostats are 240 volt, the sentiment is often that replacing them will be a lot of work. In actuality, BC Hydro found that to be the easier part of installation for their technicians. In comparison, the connection of the thermostats to the members' wi-fi networks was more challenging and required the most time, as thermostats in locations with a weak signal strength may need to be relocated. Also, if a signal repeater or amplifier[7] is required, program hardware and installation costs increase.
2. **Home Network Access:** People often do not know, or have forgotten, how to access, their home network, typically because a third party installed and configured the router/modem or the homeowner never accesses their network equipment. Not having this information readily available increases the total time to set up a member's home for participation in the program.
3. **Network Reliability:** The reliability of member Wi-Fi networks is an issue that directly impacts the number of participants dispatched in each event. Reliability challenges may be due to any of the following:
   a. Age of the router
   b. Connectivity issues throughout the home due to structure (these are likely resolved during setup unless members perform the installation)
   c. Reconnection following a power loss
   d. Members changing internet/cable providers and not properly connecting thermostats to the new network device
4. **Participant Recruitment:** BC Hydro has the benefit of an engaged, interested pool of pilot candidates. Having such a resource is an anomaly in most cases. Recruitment of participants can be much more difficult. For co-ops, the logical first step in recruitment is to approach existing DR program participants who have electric baseboard heat.
5. **Costs:** Covering the cost of equipment and installation is a hurdle. The beauty of these smart thermostats is that they also control the connected equipment, so nothing additional needs to be installed on a separate furnace or HVAC unit—nor is an additional relay required to allow low voltage thermostats to control line voltage heaters. Regardless, there needs to be a means of covering the cost of the program's physical implementation. This cost recovery may include mechanisms used for other DR programs, member participation in paying some or all of the hardware costs, allowing members to self-install, and so forth.

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7 The Canadian utilities are not considering amplifiers, this is just an observation by the author.

6. **System Integration:** Integration with existing co-op information management systems can be a challenge. For the pilots, there was no integration necessary with existing information systems. This stand-alone approach works well for dispatch and event data collection in a pilot. Still, some work is required to provide the annual bill credit. Some manual data entry and event management may not be a problem for a pilot, but is not ideal for a full program. At some point, integration with existing DR management, billing, and member information systems is inevitable.

7. **Program information and documentation:** Co-ops will need to consider processes and procedures related to a STERH program and necessary documentation, including:
   - What is covered in the member agreement, if one is required?
   - What are the provisions involving event overrides?
   - Is there a maximum number of overrides before dropping the member from the program?
   - Do members dropped from the program owe any money to the co-op for equipment?
   - What happens to equipment when a member moves out of their home?
   - How do you encourage the new homeowner to participate in the program when their house has the equipment already installed?
   - How do you communicate the program to the members?
   - How do you educate members on the use of the thermostats?
   - Who troubleshoots issues?

The list of challenges appears daunting when viewed in its entirety, but it is not much different than the challenges your cooperative faced when creating its existing DR and load management programs. It is quite possible that the existing programs can be modified to include STERHs, dramatically reducing the implementation effort.

Next Steps for Co-ops Interested in Offering an Electric Heat Program

Cooperatives interested in offering an STERH DR program need first to evaluate the potential for your members. Steps include:

1. Develop an estimate of your total opportunity. One method is to analyze what percent of your load is electric heat as measured by the number members on your electric heat rate.
2. Analyze electric heat use to develop an average of consumption per member household.
3. Develop a forecast of participation based on previous program participation.
4. Create a forecast of potential demand reduction. A starting point is to adopt the reductions experienced by the Canadian pilots and study.
5. Calculate the ROI for the program including cost of equipment, installation, employee training, system setup (no integration with existing IT and OT systems at the beginning), member communications, and on-going support. Factor in the expected financial benefits from the addition to your existing DR program.
6. Run a pilot to validate your assumptions.
7. Make your go/no-go decision.

Conclusion

The development of smart thermostats capable of controlling line voltage-powered electric heat has made it feasible to include these heat sources in new and existing DR and load management programs.

Preliminary consumer reactions to the advances in STERH technology, the expected future enhancements, and the Canadian experiences in their development efforts are very encouraging. It appears that integrating electric baseboard heat into the DR asset is within reach and is worth serious consideration. This previously inaccessible load may now become the largest contributor to the DR efforts of your cooperative.

Pilots will be key to determining if and how these devices can be used as part of a co-op's demand response or energy efficiency program. While results from the Canadian pilots are promising, more experience is needed with the thermostats to determine their energy efficiency (EE) and DR potential, and also how best to incorporate them into a DR program. Standard practices such as preheating, the usability of available utility portals, and the integration with existing DERMS platforms is not yet fully understood.

NRECA is exploring the option of conducting a pilot of smart thermostats for efficiency and demand control in 2019. Co-ops interested in participating should contact Brian Sloboda at: brian.sloboda@nreca.coop.

Co-ops who are considering offering a STERH program for DR should take the time to evaluate the potential for their membership. An effective approach to program evaluation and development is through the use of the *stage gate* development process, whereby the effort is separated into stages and each stage must be successfully completed for management approval before proceeding to the next defined stage. The **Appendix** provides an outline of one form of the approach used by the author. ■

APPENDIX

Stage Gate Development Process Outline

STAGE GATE DOCUMENT OUTLINE

- Program/Product Offering Title
- Overview
- Goals and Objectives
- Business Rationale/Strategic Fit
- Customer Profile
- Market Opportunity/Current Situation
- Business Proposition for the Member
- Marketing Strategy/Focus
- Key Benefits Member/Cooperative/Partners
- Key Implementation Issues
- Financial Analysis—Preliminary
- Recommendations
- Resource Requirements

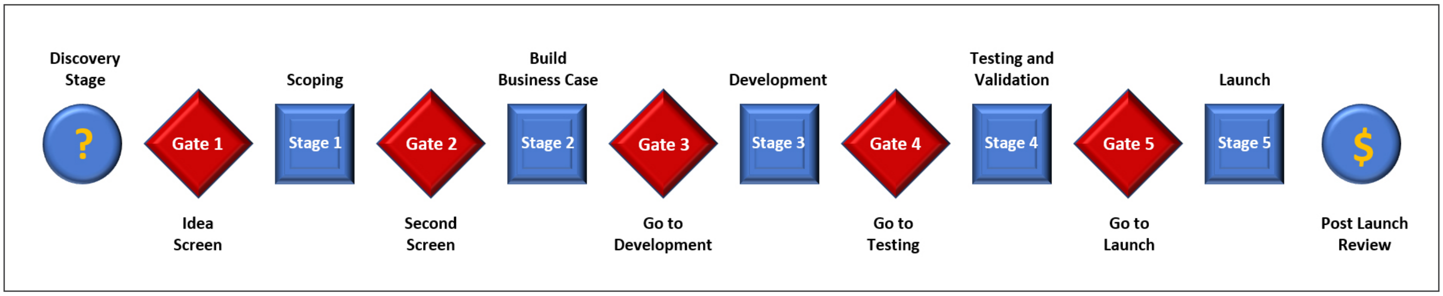
PROCESS OVERVIEW

1. Document length: 3 – 5 pages for the first stage, if at all possible.
2. Number of stages in development effort: 1 – 5. The latter for the most complicated development efforts. Two are often enough.
3. The development team should include all functional areas that will be involved in the program upon its implementation. Involvement from other functional areas can be limited in early stages. It is important to keep other departments informed, incorporating their suggestions to avoid any surprises later.
4. Benefits of the approach
   - "Back-end load" resource investment—time, people, money.
   - Build buy-in as you go.
   - A consistent format makes review easier on subsequent efforts.
   - Provides a tool to focus development efforts.
   - Very useful when dealing with the engineering/technical/financial sides of the cooperative, especially when you use the Bass Diffusion Model.
   - Doesn't require any special tools to implement.
   - Customize to your requirements but keep it consistent throughout the stages and other efforts.

Continued on next page

APPENDIX (CONT.)

Even the DOE recognized Stage Gate and published a brochure on its use in 2007 under the EERE banner. The graphic below illustrates one example of a Stage Gate process. The number of Stages and Gates is driven by the type of product or program being developed. In the example shown, the process is for a completely new product's development and introduction.



BASS DIFFUSION MODEL

The Bass Diffusion Model began life as an epidemiological model the researchers adapted for use in projecting the performance of new products or services in the marketplace. The underlying assumption is that eventually, everyone gets the "bug" whether it's the type that makes you sick or one that makes you buy.

It has been heavily researched over the past few years, and many inventions and new products have been analyzed by the model to see how accurate it would have been in predicting the rate of adoption for these innovations. One example is the first electric washing machine. The results have been amazingly close.

This model can be used to predict the penetration of a new program in your market. You can be very precise and scientific, or you can grab the parameters from similar products / services and use them as your proxy. I tend to apply the latter approach since I have typically worked in resource-constrained environments when it comes to funding primary market research and obtaining significant analytic capabilities.

Let's take a brief look at an example projecting sales of an electric water heater in my co-op's service area. We wanted to increase our penetration of the market and bundled in load management switches at the same time.

For market data, I used the last appliance penetration survey from our G&T to determine the percentage of my members with each type of fuel for water heating. Since we intended to try and woo oil and propane over or back to electric, we included those fuel's percentages to create a total market opportunity. With that number in hand, we made estimates on what kind of market share we might expect given the rate of failure for water heating sources (heaters and boiler-based) and used those data points within the Bass model.

Taking an expected share of the potential market and plugging it into to my forecasting model resulted in a sales rate over a five-year period. With that, the rest of the model can predict cash requirements and flows to determine the financial attractiveness of the program.

The Bass model takes a large amount of subjectivity out of the forecasting effort. True, estimates on market size, potential market share, and other factors have to be made. But, those can easily be tweaked to conduct "what if" analyses. Use of the Bass Diffusion Model shifts the focus to the program's potential rather than the underlying assumptions.

ABOUT THE AUTHOR

Tom Tate has been in the electric utility world for 25 years, working in various capacities for both IOU and cooperative operations and is well versed in the municipal business model. With experience in every member service, marketing, and sales management role, Tom discovered a passion and talent for writing about technology in a manner that makes complex concepts easily understandable for members and customers. Today, he runs his own freelance writing company and provides content for several cooperative and industry operations from his adopted home of Minneapolis, MN.

QUESTIONS OR COMMENTS

- Brian Sloboda, Program and Product Line Manager – Energy Utilization/Delivery/Energy Efficiency, NRECA Business and Technology Strategies: **Brian.Sloboda@nreca.coop**

- To find more resources on business and technology issues for cooperatives, visit our **website**.

DISTRIBUTED ENERGY RESOURCES WORK GROUP

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**.