Technology Innovation Project

Closing Project Brief

TIP 336: Scaled Deployment and Demonstration of Demand Response using Water Heaters with CTA 2045 Technology

Context

Water heaters are inherent energy storage devices. They can serve 3-4 hour demand response (DR) events well with full curtailment of the heating source. With more refined algorithms water heaters can serve a substantial load shifting function.

BPA & PGE have spent the last several years working with EPRI and other utilities and vendors to develop the capability to use smart water heaters for not only traditional peak load demand response, but also for everyday applications like arbitrage and renewable generation integration.

Smart water heaters have internal electronic controls that cycle the heating elements/compressor and, most importantly, a communication interface (a serial port) that lets the customer insert a communication device that can allow remote management of the water heater. This approach, while limited to new water heaters, dramatically reduces the cost of adding a water heater to a demand response program.

Description

This project deployed 100 electric resistance and 177 heat pump CTA 2045 controlled water heaters in the Pacific Northwest (PNW), and executed demand response events during Oct 2017 and Aug 2018.

The project was led by the Principal Investigators from BPA and PGE. The project plan included the following participants:

i. Eight utilities served as the host sites for approximately 277 water heaters.
ii. Two manufactures of electric water heaters provided units that conform with the ANSI/CTA-2045 modular communication interface specification
iii. A demand response service vendor provided event dispatch and bulk data recording. The same vendor also provided two-way data services between the DR dispatch server and water heaters. This provider also supplied the CTA-2045 compliant communication module that “plugs” into the water heater.
iv. Northwest Energy Efficiency Alliance (NEEA) provided final report writing services and market transformation analysis of collected data.
v. Pacific Northwest National Lab (PNNL) provided bulk data analysis, using 1 minute data, to produce average load reduction results and energy shifting results

Why It Matters

If market transformation caused every new electric water heater in the PNW (heat pump and resistance types), to be sold with CTA 2045 technology pre-installed, then advanced 24/7 demand response becomes economically attractive.

In the PNW, this represents a total potential of about 1,800 MW and 16,000 MWh of controllable power and storage over 20 years, assuming a mix of 25% heat pumps and 75% resistance tanks.

In addition, in terms of deferring the need for new peaking power plants, 24/7 operation could yield a reduction in natural gas use in power plants of more than 15 trillion Btu/year (at maximum economic potential) and a corresponding CO_2 reduction.

Goals and Objectives

Demonstrate/educate the region on the value of grid interactive "smart" water heaters;

Determine a statistically valid kW reduction (on-peak) from "smart" resistance and heat pump type water heaters;

Demonstrate a 24/7 control paradigm for arbitrage and renewables integration that includes:
- Regular shift of kWh into a shaped load at night,
- Use of water heaters to absorb (or curtail) day-ahead and hour ahead wind forecast error

Deliverables

The project report provided by NEEA includes:

1. A PNW demand response performance specification for water heater OEMs;
2. Evaluation of customer acceptance/impact of 24x7 DR operation of their water heaters.
3. A business case for market transformation (i.e., all PNW water heaters with CTA 2045);
4. A market transformation plan to inform the most cost effective way to make DR-ready water heaters the primary type installed in the PNW.

TIP 336: Scaled Deployment and Demonstration of Demand Response using Water Heaters with CTA 2045 Technology

Project Start Date: October 2015

Project End Date: September 2018

Reports, References, Links

Final Report and other materials related to this project are available on the BPA Energy Efficiency webpage at www.bpa.gov/goto/smartwaterheaterreport

Related Projects

TIP 272a: EPRI P170 Supplemental: CTA 2045 Standard Modular Communications Interface for Demand Response

Funding

Total Project Cost: $960,500

For More Information Contact:

Technology Innovation Project Management Officer:
TechnologyInnovation@bpa.gov

Technical Contact:
Tony Koch, PE, CEM , CMVP
Mechanical Engineer
Seattle, WA
jakoch@bpa.gov

PGE Principal Investigator
Conrad Eustis, Dir. Retail Technology Strategy
Portland, OR
conrad.eustis@pgn.com

Participating Organizations

Portland General Electric (PGE)
Northwest Energy Efficiency Alliance (NEEA)
Pacific Northwest National Lab (PNNL)
Clark PUD
Emerald PUD
Franklin PUD
Puget Sound Energy
Snohomish PUD
Springfield Utility Board
Tacoma Power

Conclusions and High-Level Results

After extensive study and analysis, this study shows that demand response with "smart connected" water heaters, both electric resistance and heat pump, will yield significant cost savings compared to building peaking plants. At scale, this solution could yield significant load shifting capabilities and opportunities here in the Pacific Northwest as well as in other regions across the US to enable more renewables and improve grid efficiencies.

Other findings from the report include:

- Using the base case assumption of 26.5% customer enrollment, the study shows 301 MW of demand response potential in Oregon and Washington by 2039.
- An individual utility or a single manufacturer lacks sufficient influence to cause widespread adoption of smart water heaters. It's a typical "chicken and egg" problem that requires a carefully-orchestrated market transformation intervention.
- The most cost-effective solution is to have a standardized physical communications port at the water heater with "smart" water heater logic installed at time of manufacturing. Retrofitting and aftermarket solutions push up install costs for DR of water heaters by a factor of at least 2X in the near term [1] and by 8X after 2039 [2].
- The region must have a critical mass of supportive utilities, or even better, the region should act as a bloc to implement the next phase of enabling this technology through a market transformation plan. This means working together with the major OEMs, extra-regional utilities, customers, regulators/boards, and aggregators.
- Residential customers in the study appear receptive and willing to have demand response as part of their households. However, more education and further study of customer adoption is needed to fully understand the end-state level of customer adoption.
- The nascent CTA-2045 technology works well, with negligible customer impact despite at least two control events daily; the technology has significant potential to become even better with new water heater designs in the coming years.
- NEEA's work on market transformation for (heat pump water heaters (HPWH) will likely influence the OEMs to incorporate CTA-2045 functionality into HPWHs. NEEA will have no role in implementing or operating a DR program. The current expectation is that only utilities, or their designated aggregators, will implement DR programs.

[1] The average costs for the first 510,000 enrollments through the year 2033, including all market transformation costs, is $200 each; this compares to an average cost of $400 in a single family retrofit today (consisting of $100 for the switch, $100 for marketing, and $200 for installation labor, permits, and a reserve to remove some of the units in the future).
[2] This compares to an average cost for marketing and the communication module of $51 in today's dollars for the years 2035 to 2039.

More project results, conclusions and recommendations are described in the Final Report:

CTA-2045 Water Heater Demonstration Report
Including A Business Case for CTA-2045 Market Transformation
BPA Technology Innovation Project 336

Recommendations for Next Steps

The report suggests further efforts in support of its conclusions:

- Build a coalition across a broad group of utilities, OEMs, regulators, aggregators and customer advocacy groups. (2019)
- Develop an action-oriented plan for a scaled roll-out of "smart-connected" water heaters that OEMs can support based on a revised business case specific to the stakeholder funding the rollout. (2019)

Four key pillars of work that need be implemented in parallel (2019):

- Sell the value proposition to utilities, aggregators, utility commissions and system operators.
- Engage with OEMs to identify which specific product requirements and markets to roll into first, and then second, third, etc.
- Work closely with utility commissions and public utility boards to find appropriate methods to recover the cost of the market transformation prior to the roll-out of a DR program.
- Develop a strategy and sequencing of incorporating "smart-connected" water heaters into local, state, and national codes and standards.

After a coalition is formed, undertake the following logical steps:

1. Create sufficient funding for a) the planning phase (2019) and b) the multi-year market transformation implementation starting in 2020, or later if needed.
2. As part of Step 1.a: Create agreements with OEMs to pay for non-recurring engineering (NRE) and the incremental costs for the first period (2020-2025). As part of Step 1.b: Secure long-term funding for NRE and incremental costs for the OEMs.
3. Revise the market transformation plan based on information gained in 2019 to facilitate the supply chain and minimize expense and missteps.
4. Develop white papers and case studies for utilities interested in implementing DR programs. For those with no direct interest in DR, introduce the possibility that their customers may participate in DR programs operated by others but that provide financial benefit to that utility.
5. Provide and promote needed information for Codes and Standards and help implement those inclusions as early as possible.
6. Work closely with the National Rural Electric Cooperative Association (NRECA), EPRI, the American Public Power Association (APPA), Peak Load Management Alliance, GreenTech, Smart Energy Partnership Alliance, and other influential organizations to ensure alignment. Additionally, it is crucial that the coalition work closely with the PUCs, ACEEE, USDOE, and regional organizations
7. Build training and awareness programs for all groups (utilities, aggregators, system operators, commissions and consumers).
8. Launch DR programs with the initial utility participants and water heater distributors with attention focused on appropriate training.
9. Continuously monitor and make course corrections as the plan develops and rolls out.