# Whole-Home Demand Flexibility using Load Balancing Technologies

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## ABSTRACT

Utilities need better ways to manage home electricity use as customers add electric vehicles, heat pumps, batteries, and cooling loads (Martini and Schwartz 2023; Murphy et al. 2024). This paper shares early results from Puget Sound Energy's field study of whole-home automated demand response on Bainbridge Island. The study tests whether load-balancing technologies (LBT), including smart panels, add-on panels, panel upgrades, and circuit controllers, can help utilities control multiple home loads and demand response (DR) devices with a single system. We screened 18 homes and selected 13 with a variety of existing panel layouts, service sizes, existing controllable loads, and battery systems. For each LBT we installed, we surveyed and interviewed customers and contractors, tested the circuit-load-monitoring and control features, and assessed utility access via APIs and fleet tools. Early results show that contractors generally completed installations well, and most customers had a positive installation experience. However, contractor quality and comprehensiveness of LBT configuration, especially as it relates to circuit prioritization and control, varied. Contractors often didn't clearly explain circuit priorities, how the LBTs would handle DR events, or smartphone app settings. Initial customer survey results show that customers used the apps only occasionally and often weren't sure what the systems would do during an event. SPAN and ABB offer the strongest utility-facing tools today, while other products still rely on limited APIs or per-home access. Whole-home load control shows promise, but utilities will need better integration, stronger contractor training, and clearer customer value to scale these tools.

## Introduction

### Why Study Emerging Load-Balancing Technology?

Puget Sound Energy (PSE) is turning to automated DR pilots and programs to ease grid congestion and enhance resilience amid building and transportation electrification, increased cooling loads, and accommodate load growth on the distribution system. Like PSE, other utilities, including (Green Mountain Power 2023), (PG&E 2026), and (Nicor Gas 2025) are studying emerging load-balancing technologies (LBTs) that may improve the performance of existing ADR programs and measures at the distribution system level, where traditional system-wide solutions are often less effective (Kevala 2025; Martini and Schwartz 2023). LBTs also offer the unique benefit of controlling multiple loads or circuits through a single system, unlike commonly used device-level DR technologies and programs that control single loads, e.g., smart thermostats, EV chargers, and water heaters.

While utilities are interested in using LBTs to improve grid resiliency and manage load growth cost-effectively, customers are looking for ways to reduce their utility bills and participate in electrification without triggering costly service upgrades.

This Field Study ("study") evaluates emerging LBT technologies as part of a whole-home DR solution. The study aims to understand (1) whether these technologies are market-ready, and

(2) the customer and contractor experience installing and using them, including whether they can deliver more targeted and flexible demand response than traditional device-by-device enrollment (e.g., batteries, thermostats, EV chargers, and water heaters).
Through customer and contractor surveys and interviews conducted at installation, after three and six months of operation, the study informs utility strategies for integrating whole-home DR into existing and future residential load-control programs—including PSE's Flex programs—while maintaining affordability and supporting continued electrification.

The study can inform how utilities can integrate whole-home DR into their existing and future residential load-control programs, including PSE's own Flex programs. PSE was also interested in understanding if it could leverage these automated panels and targeted circuit-based controls for its "Targeted DSM" programs and achieve better results than device-by-device DR enrollment (e.g., per battery, thermostat, EV, water heater).

**Limitations of traditional DR technology and how whole-home solutions might help**

Whole-home solutions are unique because they transfer control from a network of connected DR-enabled devices to a single point of control for a home. Whole-home LBTs have been tested to enable electrification (Srushti Koli et al. 2025; Kabat and Gridizen 2024; Zhou and Mai 2021), but not specifically for whole-home DR. Instead of controlling individual devices via DERMS or aggregators, the utility sends a single DR signal to the home, with localized controls managing which devices reduce load. LBTs let administrators to set dynamic service ratings (DSRs) to lower service levels, or use APIs and apps to control circuits based on customer preferences. These methods effectively establish a load ceiling for homes or parts of the grid.

Traditional DR technologies rely on a fragmented customer experience, with customers having to enroll in multiple device-based offerings. Using PSE Flex (PSE 2026) as an example, customers would enroll separately in its water heater, smart thermostat, and EV charging programs. This results in high customer-interaction burdens, potentially higher risk of overrides, and uncertain persistence of participation over time.

Whole-home solutions might allow utilities to prioritize or shut down specific electrical circuits in one or more connected homes more effectively. Whole-home ADR technologies enable coordinated, automated control at the circuit or panel level, allowing multiple end uses to be managed as a single flexible resource. These technologies can support multiple demand-flexibility services through a single enrollment, including peak reduction, load shifting, constraint-based load limiting, and resilience-oriented load prioritization.

Our study hypothesis is that a whole-home approach may offer benefits over device-level DR programs, including a more fluid customer experience, larger and more sustainable load reductions, utility insights into specific feeder load types and growth, and enable electrification.

**Overlapping value proposition for customers and utilities**

Whole-home ADR technologies must create value that overlaps for both utilities and customers. Scalable demand flexibility emerges only where customer and utility value propositions intersect (Figure 1). Whole-home LBT technologies enable this intersection by coordinating multiple residential loads with low customer burden and high operational reliability.

Utility value is primarily driven by dispatchable and predictable flexibility (especially when managing distribution-level constraints), along with better integration into planning and operations and a strong potential for cost-effectiveness. The most important factors include reliable, dispatchable flexibility at constrained locations, predictable performance that persists over time, scalable deployment with operational simplicity, and the ability to provide a cost-effective alternative to traditional infrastructure investments.

Customer value is driven by convenience through automation and “set-and-forget” operation; electrification enablement, including the potential to avoid costly service upgrades; enhanced resilience by prioritizing critical loads during outages; and opportunities to manage bills under time-varying rates or participate in multiple utility programs. More broadly, customer value also depends on trust, transparency, and strong data privacy protections, which are essential for sustained adoption and engagement.

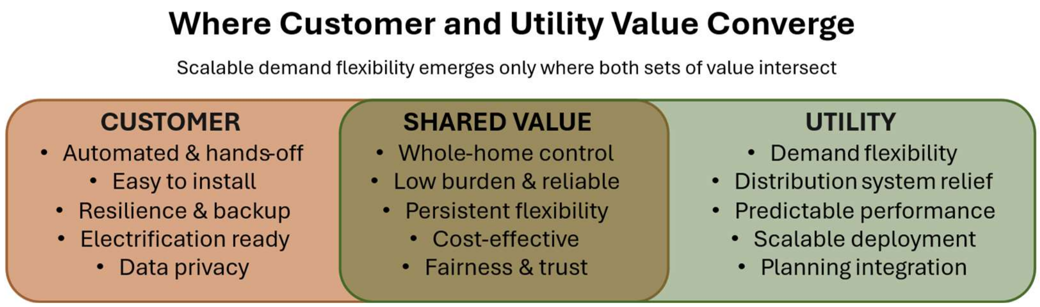



Figure 1: LBT Shared Value Proposition: Where Customer and Utility Value Converge

## Study research objective

The primary objective of this study is to assess whether emerging whole-home LBT technologies can provide user-friendly and reliable automatic control of distributed residential loads in ways that meet both customer and utility needs, with overlapping value propositions (Figure 1). Unlike recent studies (Kabat and Gridizen 2024; Srushti Koli et al. 2025) that focus on electrification and avoiding service or panel upgrade costs, this study examines the experiences of customers and contractors in installing, setting up, and using these technologies for whole-home DR purposes in targeted DSM applications.

We hypothesize that if panel and circuit load-control products and their apps are easy to install and use, they can help reduce peak loads in targeted areas. From a utility perspective, the study evaluates whether this whole-home approach can provide predictable, dispatchable flexibility to address local grid constraints, support electrification planning, and enable cost-effective program design, while contributing to system peak reduction where applicable. From a customer perspective, the study evaluates whether these technologies deliver enough value like convenience, electrification support, and cost savings. This study addresses the following topics:

- **Product installation and support.** Understand contractor LBT installation requirements and configuration complexity. Evaluate scalability by product type and manufacturer.
- **Technical implementation and integration.** Understand how data flow and communication protocols integrate with utility systems, smart home products, and load control devices; access, store, monitor, and control device data using software or APIs.
- **Customer experience and engagement.** Understand customer interest in adopting emerging LBTs, their experience using LBT products, and their support needs.
- **Overall value proposition.** Understand utility and customer costs and benefits, including aspects like overall value proposition, non-energy impacts, and cost-effectiveness.

## Study approach

### Preliminary technology scan

We conducted a preliminary, broad scan of whole-home LBT technologies available in the mass consumer market and categorized them into four technology types (see Technology scan below). From this scan, we identified two types of technology (smart panels and circuit controllers) suitable for actively constrained grid areas on Bainbridge Island. We selected these based on compatibility with existing home conditions and software compatibility.

### Customer recruitment

We worked closely with PSE's program and distribution grid planning teams to identify candidate homes on constrained feeders or in distribution-limited areas where targeted load control could provide measurable relief from constraints.

We prioritized homes with large, controllable electric loads—such as EV chargers, heat pumps, and hot tubs—and screened sites for electrification readiness and willingness to host new equipment. Initial screening confirmed electrical panel condition, wiring layout, connectivity, load inventory, and compliance with safety and code requirements. From the resulting candidate list, we issued a qualifying survey to gather additional site-specific information and narrow the pool to 18 qualifying homes. We framed the customer value proposition around automation, resilience, electrification enablement, and bill management, while emphasizing constraint mitigation and scalability learnings for utility stakeholders.

### Site Selection and Pre-Installation Assessment

From the 18 qualifying homes, we conducted follow-up phone calls and site visits to refine the final study cohort. These assessments allowed us to validate electrical infrastructure conditions and ensure sufficient diversity across sites.

Table 1 lists our final selection, including home and electrical infrastructure information we gathered to ensure our site is representative of diverse real-world conditions, including a variety of existing utility service ratings, electrical panel configurations and sizes, and battery energy storage systems.

Table 1. Final selection of participating homes

| Site | Build year | Floor area (ft$^2$) | Utility service (A) | Existing electrical panel configuration | Battery energy storage systems |
|---|---|---|---|---|---|
| 3 | 2000 | 3,200 | 200 | Main panel w/ Garage sub-panel | None |
| 4 | 1981 | 2,000 | 400 | Main indoor panel<br>+ Main outdoor panel w/ sub | None |
| 6 | 1995 | 2,200 | 200 | Main battery-protected panel<br>+ Unprotected loads panel | Tesla Powerwall 2+ |

| Site | Build year | Floor area ($ft^2$) | Utility service (A) | Existing electrical panel configuration | Battery energy storage systems |
|---|---|---|---|---|---|
| 7 | 1998 | 3,200 | 200 | Main panel w/ Garage sub-panel | None |
| 8 | 1990 | 1,800 | 200 | Main garage panel | None |
| 9 | 2012 | 3,100 | 320 | Main garage battery-protected panel w/ Generator panel<br>+ Main indoor battery-protected panel w/ Unprotected sub-panel | Tesla Powerwall 2 |
| 10 | 1980 | 2,000 | 400 | Main utility panel w/ Battery-protected sub-panel + Main indoor unprotected panel | FranklinWH aPower 2* |
| 11 | 1990 | 1,410 | 200 | Main panel w/ Battery-protected outdoor sub-panel | FranklinWH aPower 2* |
| 13 | 1999 | Unknown | 200 | Main panel w/ Battery-protected sub-panel | FranklinWH aPower 2* |
| 15 | 2016 | 2,700 | 200 | Main service panel w/ Battery-protected sub-panel + Main indoor panel | FranklinWH aPower 2* |
| 16 | 1980 | 1,700 | 320 | Main service panel w/ Guest suite sub-panel + Main indoor battery-protected panel | Tesla Powerwall 2 |
| 18 | 2000 | 2,900 | 200 | Main outdoor panel w/ sub | None |
| 19 | 2006 | 2,900 | 200 | Main panel w/ Battery-sub | FranklinWH aPower 2* |

* FranklinWH batteries replace existing Sunverge batteries installed by PSE through a previous pilot program.

### Installation and commissioning

We reached out to PSE-approved trade allies, “TAN Reps,” to participate as installation contractors for this study, focusing on contractors with qualified electricians and some experience installing smart electrical panels. From this group, we selected contractors Puget Sound Solar and Northwest Electric & Solar based on their respective availability and interest. Both contractors are pre-certified to install SPAN smart panels, but not the other brands.

Because contractor training affects installation and commissioning success, we’ll use a post-installation survey to capture feedback on training effectiveness, installation challenges, and opportunities for improvement. We’ll document site and technology factors that may affect installation time and complexity, including panel condition, breaker availability, wiring layout, and inspection requirements. The survey will also capture feedback on commissioning, including contractors confirming data connectivity and communications, completing and correcting circuit mapping, and helping set load-shedding priorities based on customer needs.

### Product functional testing

We'll configure each product's fleet management software, app or portal, or in some cases, establish a rudimentary connection to each available technology's API (if needed). This connection will allow us to test product load control features remotely.

Features we'll test include controlling individual circuits, responding within defined timeframes, and predictably restoring service after each load control event. Testing will focus on whether each technology's control logic preserves power to critical circuits while managing discretionary loads, with emphasis on how customers experience events, their level of engagement, and any noticeable impacts on home comfort and equipment availability.

### Home Use Test (HUT) for testing customer experience

With our market research project partner, C+C, we're conducting a HUT study that includes learning about customers' experiences with contractor installation and commissioning of the technology, initial impressions, and subsequent medium- and long-term customer engagement with the technology. The HUT includes online surveys, select customer interviews, and relevant data collected from the technologies themselves. The HUT assesses how customers interact with the system, including preference for automated operation, use of priority settings, and reliance on manual overrides. And, it will help us learn about customer usability, perceived value, and the conditions needed to sustain reliable demand flexibility at scale.

## Technology scan and the technologies we selected for inclusion in the study

We identified four types of market-ready LBT technologies that may be integrated into a whole-home DR solution. The following types may be used either on their own or together:

- Smart electric panels, including replacements, sub-panels, and panel add-ons
- Circuit controllers, including smart plugs and circuit splitters
- Advanced two-way communicating load control switches
- Home energy monitoring (HEM) devices with load controls

Our technology types align with CalNext's 2025 report LBT categorization (Srushti Koli et al. 2025) and the Consortium for Power Efficiency's 2024 framework (Kabat and Gridizen 2024). Though we use slightly different groupings because of our focus on grid demand flexibility instead of electrification enablement. We combine smart electrical panels and sub-panels into one category, and add 1) advanced two-way-communicating load-control switches, and 2) HEM devices.

Not all of the technologies come with utility-enabled direct load control capabilities. The majority of circuit controllers operate locally, turning off entire circuits to prioritize a specified primary circuit with loads such as an EV charger or a clothes dryer. These controllers either turn off loads to prioritize another load or ensure the whole-home electric load remains below a predetermined threshold—most commonly 80% of the rated electric panel load or the corresponding service rating, e.g., 200 Amp. We found that because LBTs are primarily designed to enable electrification, remote utility-led DR control functions were either missing altogether or in a rudimentary stage of development.

Other technologies, like HEM devices, give customers information about their energy use without giving them or a utility direct access to control loads. These types of products rely on passive behavioral techniques to encourage users to reduce loads at specific times, making it easier for customers to identify loads they can turn off when electricity prices are higher or a utility offers an incentive to reduce load (or a penalty for consuming more).

We outline all products and underlying technology in the sections below with an emphasis on products that _do_ allow customers and utilities to actively control and prioritize loads based on remotely delivered DR event calls. We denote products installed in this study with asterisks (*).

**Smart electric panels**

Smart electrical panels offer customers (and residents) the same integrity and load-center capabilities as traditional electrical panels, but with many additional smart features. The panels meet the same NEC requirements as traditional panels, plus UL standards that the NEC references. What's unique is that the panels can tie in more loads than a traditional panel would, because they can monitor the complete panel load and shed circuits to maintain a total load no greater than 80% of the panel's rated capacity.

Primarily designed for utility service upgrade avoidance and electrification enablement purposes, smart panel features continue to expand and now also include tight integration with solar and battery energy storage systems, and more recently, utility demand response. We found three types of smart panel designs, each with its own trade-offs and best use cases.

**Replacement panel (*)**. These panels replace the entire existing electrical panel with a new one. SPAN is the market leader, though other vendors include GENIUS (Koben System) and Schneider Square D. What sets SPAN apart as market leader is the number of panels already installed—"10s of thousands" according to SPAN, and the number of ongoing utility technology demonstrations, pilots, and programs involving the panel. Examples include PG&E (PanelBoost and SAVE), SMUD, and NYSERDA electrification pilots, Con Edison dynamic load control testing, Green Mountain Power and Nicor Gas resilient smart neighborhood pilots, PSEG low-income electrification deployments, and smaller research pilots (e.g., EPRI, SEPA, LBNL).

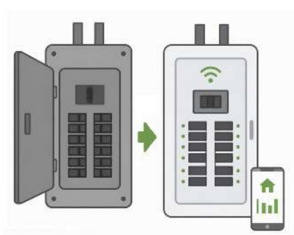
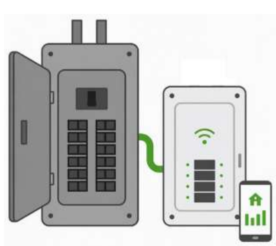
The number of SPAN product offerings increased last fiscal year, building on the success of their SPAN 32 panel with two new, smaller options and two larger ones: SPAN 40 and SPAN 48 target larger homes needing more circuits, while SPAN 16 and SPAN 24 serve the retrofit market as main or subpanels. The newest, SPAN Edge, attaches directly to the meter via a collar connector (installed by a utility meter technician), eliminating a common barrier to home electrification projects: the need for a new electrical panel or service upgrade.

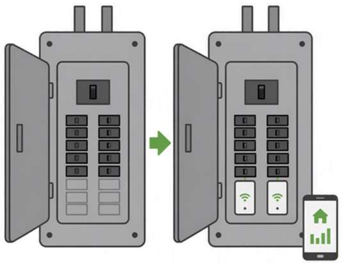
**Add-on panel (*).** Instead of replacing an existing panel, another vendor, formerly Lumin and now ABB, offers a panel that taps off existing breakers and combines monitoring and controls into a separate add-on panel. It's technically not a sub-panel because the ABB ReliaHome product doesn't replace the existing circuit breakers. Instead, it makes their loads visible and adds software-controllable relays. This also means that if the ABB panel fails (e.g., loses power or loses connectivity), the existing electrical panel continues to function normally. While the ABB ReliaHome panel doesn't have as many circuit slots, it's easier to install than

SPAN because the electrician doesn't need to disconnect the home from the grid (requiring utility disconnection/reconnection), and doesn't trigger code compliance (e.g., new bonding or new external main disconnects).

**Panel upgrade (*).** Similar to the ABB ReliaHome panel, but instead of necessarily adding a new panel, Savant's products offer additional flexibility, though with more installation complexity. Its solution involves adding individual power modules that attach to an existing panel's main bus bar and are wired in-line with existing circuit breakers. This works well for panels with remaining free breaker slots. If there are no free slots, Savant also requires an extra panel, resulting in a solution that is physically similar to ABB's. One benefit of Savant's approach is that all its circuit modules can combine into a single virtual smart electric panel. Currently, ABB's panels do not combine and appear as individual control points.

Table 2. Smart Electric Panel: Selected technologies

| **Technology** | **Features and limitations** | **Use cases** |
|---|---|---|
| **Replacement panel:** E.g., SPAN Panel | | |
|  | • Panels come in various sizes and configurations (up to 48 circuits, and with or without a main breaker).<br>• Full monitoring and control of all individual circuits.<br>• Integrations with leading battery vendors for prioritizing load shed based on the state-of-charge.<br>• EV charger throttling integrations.<br>• Customer uses App to monitor and prioritize loads. Can turn each circuit on/off. | • Existing electrical panel needs replacement (indoor or outdoor)<br>• All large or critical circuits for load control are on one panel.<br>• Other solutions, which require potentially more than one technology, are more expensive. |
| **Add-on panel:** E.g., ABB ReliaHome | | |
|  | • Control and monitor up to six 110V circuits and up to an additional six 240V circuits.<br>• Consumer uses mobile app to monitor, and prioritize loads based on battery state-of-charge. Can turn each circuit on/off. | • Single panel with up to 12 large controllable loads.<br>• Multiple panels close by (in garage or utility space) with large controllable loads on both panels |

| **Panel upgrade:** E.g., Savant Power System | | |
|---|---|---|
|  | • Control and monitor as many circuits as available, as panel (or new sub-panel) space allows.<br>• Consumer uses App to monitor, and prioritize loads based on battery state-of-charge. Can turn each circuit on/off.<br>• Integrations with existing GE lighting products, thermostats, and appliances. | • Multiple spread-out panels with diverse loads<br>• Existing panels with spare breaker space. |

**Circuit controllers**

Circuit controls include technologies that let customers turn specific circuits on or off, using a dedicated switch, a smartphone app, or automatic monitoring of existing loads. The technologies are generally designed for customers looking to electrify their homes cost-effectively. This may include helping avoid electrical panel or utility service upgrades, or adding large new loads like a new EV charger or a heat pump. Products in this category typically carry a UL certification for home energy management and, when properly installed, allow electricians to omit large new loads, such as an EV charger, from NEC load calculations (in NEC Article 750.30(C)). We found 11 circuit control technologies across three categories. Table 3 summarizes the two we selected for testing in our study.

**In-line circuit controllers (*).** An electrician hardwires a new load-control device into an existing branch circuit. This type of circuit control requires an electrician to install a new junction box in the circuit, allowing a new plug or circuit controller that feeds loads on the existing circuit branch. In-line circuit controllers can also often monitor the whole-home load and, if it exceeds 80% of the whole-home panel rating, turn off the controlled circuits. Examples include ABB's ReliaHome Flex Controller, SimpleSwitch and RVE's EV Management System. These products are designed with the main goal of limiting circuit amperage and whole-home load to within existing panel and electrical service limits.

A new sub-category of in-line load control devices also enables utility and consumer control of loads through smartphone apps and cloud-connected services. Sinope's Zigbee-connected load controller can respond to utility DR event signals, as does the Stepwise Tap product. These devices are similar in functionality to advanced direct-load-control switches but include consumer-facing smartphone apps that allow users to monitor, control, and prioritize loads.

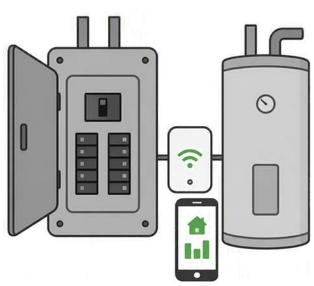
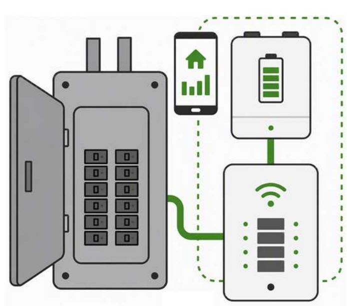
**Smart circuit hubs (*).** Like smart electric panels, but included as part of whole-home battery backup systems like Tesla Power Walls and FranklinWH power systems. We tested the FranklinWH aHub product that comes with eight smart circuits (or four 240V circuits).

**Smart plugs.** These plugs generally don't require an electrician to install, but models that also monitor whole-home loads are more complicated to install and could benefit from an electrician to ensure proper and safe installation. Examples of plug-based models include the DryerBuddy Plus AUTO, SplitterSwitch, and NeoCharge. The NeoCharge Smart Splitter is the only model in this category that comes with a wi-fi connection and smartphone app. While it doesn't give utilities DR control, the NeoCharge product uses public utility rate information to make it easier for users to schedule the use of connected appliances, typically EV charging. The product is also a market leader within the plug category.

**Smart circuit breakers.** Smart circuit breakers add circuit-level monitoring and control to compatible panels. Eaton's AbleEdge breakers work with BR-type panels, turning them into modular smart panels without a full replacement. They provide revenue-grade metering, real-time circuit status, and remote on/off control. The breakers include an open API that allows integration with other LBT systems. Other smart breaker options include the Siemens Inhab, Kanarie SmartHome, and Leviton WiFi breaker. Though the Kanarie is monitoring-only. They all use Wi-Fi, which is less secure than traditional DLC switches, but they can still support load shedding, backup prioritization, and electrification without service upgrades.

Few homes in our study area had compatible BR-type panels, so we didn't include them in this study. Because installation is simple and doesn't require new wiring, we would consider them in future phases.

Table 3. Circuit Controllers: Selected technologies

| **Technology** | **Features and limitations** | **Use cases** |
| --- | --- | --- |
| **In-line controller:** ABB ReliaHome Flex circuit controllers | | |
|  | • Control up to 5 circuits per hub (each using Wi-Fi to communicate with the main hub).<br>• Each controller is relatively easy to install upstream of each load.<br>• Customer uses App to monitor and prioritize loads, and if a battery exists, how loads are shed based on its state-of-charge. Can turn each circuit on/off. | • Need for limited circuit control (up to 60A).<br>• Tricky or limited access to the existing electrical panel.<br>• Need a flexible solution with room to add circuits later. |
| **Smart circuit hub:** FranklinWH aHub with smart circuits | | |
|  | • Control up to 8 circuits via one hub (up to 4 circuits at 240V).<br>• Consumer uses a mobile app to monitor and control loads. Can turn each circuit on/off. | • Only works with FranlinWH battery systems.<br>• Integrate with battery to shed load based on state-of-charge. |

### Advanced load control switches

As of 2019, the majority of mass market demand response capacity came from direct load control (DLC) switch programs (Smart Electric Power Alliance 2019). Switches quickly reduce peak demand by interrupting or cycling large loads like central AC units and electric water heaters. Newer switches add two-way communications, allowing utilities to confirm load shed and access telemetry such as energy use, active load, and device health, improving predictability and reducing truck rolls. Major vendors include Generac, Honeywell, Eaton, and Landis+Gyr. Landis+Gyr integrates switches into its AMI mesh network, while others rely on cellular networks. Both approaches are familiar to utilities and regulators, supporting continued use.

Another type of switch growing in popularity among water heaters is the CTA-2045 (EcoPort) module. Water heaters and other appliances like EV chargers and pool pumps use this standard to enable appliance-level load control. While the EcoPorts support a variety of appliances, water heaters are the most common utility DR program use case.

We didn't select advanced two-way switches for this study because while they show promise as part of a whole-home solution, the integrations with leading LBT technologies are not mass-market-ready.

### Home energy monitors (HEMs) with load control

Home energy monitors (HEMs) are panel-mounted devices that monitor home electricity use in near real-time with apps that help customers understand load patterns of specific circuits and appliances. The leading products are Sense and Emporia, both offering features that help customers reduce energy use over time. Sense uses machine learning to break out individual appliance and circuit energy use from the home's main signal. Emporia Vue takes a different approach by installing sensors (CT clamps) on individual circuits, providing highly accurate, real-time data on specific loads such as HVAC or EV charging without relying on machine learning. Because of limited demand response integrations beyond EV chargers and select thermostats, we didn't consider HEMs ready for whole-home ADR.

**Emporia Vue Home Energy Monitor.** Emporia currently has over 400,000 customers worldwide using roughly 500,000 of its Vue Home Energy Monitoring devices, with approximately 90% of its market based in North America. Recent partnerships with Honda and Siemens are expected to expand the brand's reach and capabilities beyond energy savings and into energy earnings for customers through bidirectional charging.

On its own, the Vue is just an energy monitor, but Emporia packages its system with smart energy plugs, an EV charger that throttles based on whole-home load, and additional integrations with smart thermostats and time-varying utility rates. But remote automated DR control doesn't yet exist, which is why we excluded Emporia from this phase of our study.

**Sense.** While Sense's use of machine learning to identify specific appliance loads is accurate for large loads like EV chargers and HVAC equipment, this approach makes it difficult to be 100% accurate all the time. The company has stopped selling its monitors directly, instead integrating its technology into products like Landys+Gyr's Revelo advanced AMI metering platform.

## Preliminary results from the HUT study and initial testing

### Product installation and commissioning

All site installations were completed as of June 15, 2026, representing a significant delay from the original project timeline (January to February completion). Issues stemmed from finding distributors with available part supplies and service in the PSE service territory. And for local installers to build a relationship with available suppliers.

Customer feedback on the installation process was mostly positive. Most customers rated the experience as good or very good (89%) and said installers led the process and answered questions as they came up. Overall customer satisfaction was positive (Figure 2).

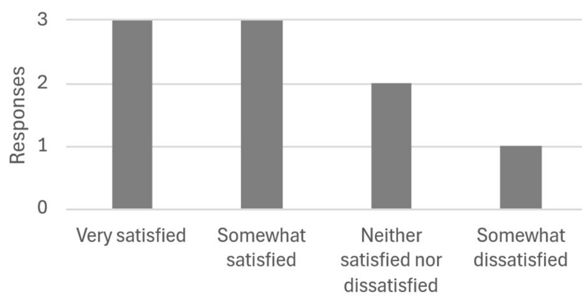



Figure 2: Overall customer satisfaction from the first customer survey

Customers stayed largely hands-off during installation and relied on installers for guidance. When questions came up, installers usually answered them on the spot. These questions focused on how the system worked, how to save energy, and what to expect during outages or demand response events. Some customers also wanted more details on battery operation and how to get the most value from the system. (Some homes already had backup batteries installed, and others received new systems.)

Despite this positive experience, commissioning and customer education were uneven. Install complexity varied, with some installations taking over three hours due to software issues or requiring panel modifications. This showed that contractors handled core installation well but struggled with setup and configuration in some cases.

The biggest gap was circuit prioritization (see Figure 3). Installers didn't mention it in 55% of cases, and only 33% properly configured and explained it. This left many customers without a clear understanding of how their systems would perform during outages or demand-response events, limiting their ability to participate effectively.

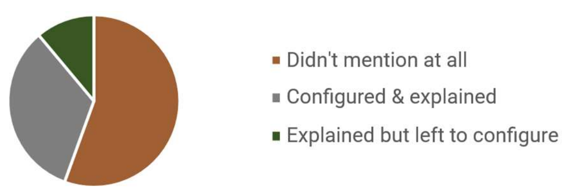



Figure 3: Customer Experience with Contractor Commissioning and Circuit Prioritization

Other contractor knowledge gaps also affected the quality of commissioning. About 22% of sites had circuit labeling errors, and some experienced software or commissioning delays. In many cases, installers didn't fully explain the system setup or operation, leaving customers wanting more guidance. At the same time, the contractors' responsibility for customer education was unclear. Many customers expected more guidance from PSE rather than from installers, which created gaps in follow-up and support.

Overall, installers delivered a smooth and well-managed installation experience, but gaps in commissioning, circuit prioritization, and customer education reduced the system's effectiveness and created risks for demand response participation.

**Technical implementation and integration**

The LBTs we selected for this study (Table 4) either use an API, fleet management software run from a web browser, or a mobile app to monitor and, in some cases, control circuits. But each LBT varies in how well utilities can connect to and control them. Most systems, including the ABB ReliaHome Flex circuit controllers and smart panel, SPAN smart panel, and FranklinWH aHub, connect to the internet and use cloud-based APIs as the main way to send and receive data. These APIs let systems send data to the cloud and receive control signals back (although in some instances, control capabilities are either in development or rudimentary). Devices can share circuit-level load data, device status, and (for some systems) battery charge levels. Utilities or DERMS providers can then use APIs to monitor and control those devices.

Most systems use Wi-Fi for communication. Some, like SPAN, also include a cellular backup to keep working if Wi-Fi fails. In contrast, the Savant Power System does not yet offer a utility-ready API. Savant currently offers a web portal that installers use to commission equipment, and a customer-facing mobile app. Lacking a web portal or API for utilities to remotely control circuits, the Savant Power System cannot currently integrate with utility DR programs or DERMS at scale.

All systems track energy use at the circuit level. This gives much better detail than whole-home energy data. Utilities and devices can see which specific loads are running and how much power they use. This supports more targeted control, such as turning off selected circuits or keeping critical loads running. Systems usually track near-real-time load, circuit on/off status, and, in some cases, battery state of charge (SOC) and power flow. For example, the systems can shed circuit loads when the battery SOC drops below a specified low level.

Both SPAN's and ABB's LBTs include features that shed specific circuits based on a customer's set priorities. ABB calls this "Panel Guard," which keeps total load below 80% of the panel's rating. This helps enable cost-effective electrification without upgrading the panel or utility service. However, ABB doesn't let utilities dynamically reduce the 80% rating using remote software or an API. SPAN offers a similar approach but extends it to utility control. It's the only manufacturer that lets utilities dynamically set panel service ratings via an API or its in-development fleet management software, which it calls "Dynamic Service Rating." Under this approach, the utility sets a total load limit for the home, and the device automatically manages circuits to stay below that limit based on the customer's priorities, reducing the need for continuous utility control.

How well these systems work with utility programs depends on the LBT APIs and fleet management tools available. ABB and SPAN offer the strongest integration today. Their APIs support integration with existing utility DERMS platforms and enable utilities to manage multiple homes simultaneously. Although ABB hasn't introduced a "Dynamic Service Ratings" feature yet, its API could be used to create custom software with similar functionality. This software can group devices by type and set clear priorities for each, so that each connected ABB system sheds lower-priority circuits first before turning off the more critical ones. While FranklinWH also offers API access, it's unclear at the time of writing whether the API supports circuit on/off control. Savant currently offers the least integration. Utilities cannot manage it through a central platform, and they must log in to each home separately (customers need to grant admin access, and utilities would need to log in to each individual customer's mobile app instance). This makes Savant's solution impractical for large-scale utility programs.

Table 4: LBT Circuit-Level Monitoring and Control Features

| Product | Platform | Circuit Monitoring | Circuit Control | Consumer Access |
|---|---|---|---|---|
| SPAN Panel | API; Fleet web portal | Yes | Yes (fleet-level control; dynamic service rating and constraint-based control) | Smartphone app; Matter |
| ABB ReliaHome Smart Panel and Flex Controllers | API; Fleet web portal | Yes | Yes (on/off control via API; advanced control in development) | Smartphone app; Web browser |
| FranklinWH aHub | API | Yes | Partial (API control capabilities not yet clearly defined) | Smartphone app |
| Savant Power System | No utility API (in development) | Yes | No (utility control not currently supported; behavioral DR possible) | Smartphone app |

Customers reported using the LBT systems alongside a variety of existing smart home technologies, including EV charger apps, smart thermostats, voice assistants, and solar or battery monitoring systems. Most who also used other smart home technologies reported no issues using multiple apps together. The couple of issues mentioned primarily relate to Wi-Fi connectivity or device restarts. Nearly half of the customers didn't report experiencing issues following installation. Among those who did report issues, comments most often related to contractors incorrectly labeling circuits or to questions about information displayed in their smartphone app.

**Customer experience and engagement**

Customers showed interest in the technology, but their engagement dropped after setup. Most respondents (67%) said they only use the app occasionally. While many gave the app fair to very good ratings, they also reported issues with slow loading and limited features. This suggests that customers do not see strong ongoing value in checking the app regularly.

Customers also struggled to understand how the system works during DR events. About one-third said the smartphone Apps Didn't clearly explain what would happen during a DR event or how to get the best results from using their LBT during such an event. Many comments raised the same concern: customers don't know how DR works or what the system does in the background. This lack of clear communication reduces customer confidence and makes it harder for them to stay engaged.

Overall satisfaction was mixed. Only one-third of respondents said they were very satisfied, while the rest reported lower levels of satisfaction or remained neutral. Most participants report setting up the app themselves or with assistance from the installer and describe using it to monitor energy use, solar production, and circuit activity. Other customers expressed interest in additional functionality or information, including historical data, expanded controls, and clearer guidance on circuit prioritization and demand response events.

Some customers questioned the value of the technology, describing it as having limited usefulness or control. Limited app functionality and unclear system behavior were the main friction points. Together, these issues suggest that customers need clearer communication, better app performance, and more visible benefits to stay engaged over time.

## Conclusion

While LBTs such as smart panels, add-ons, and upgrades show promise for whole-home DR, most of the products we tested are not yet ready for large-scale use. The exception may be the SPAN Panel. All the LBTs we tested can control load in some form, but their APIs and fleet management tools remain limited to circuit monitoring and individual circuit on/off controls. This makes it hard for utilities to scale these solutions across many homes.

Most LBTs can shed load automatically based on circuit priorities set by the customer. However, these features are usually designed for backup power or to keep the total load below a fixed limit, such as 80% of the panel rating. Utilities often cannot access or manage these features through APIs or fleet platforms. As a result, utilities have limited ability to use these systems for DR programs today.

Contractor feedback also shows gaps. Many contractors didn't receive training on how to set up these systems for DR, e.g., prioritizing circuits or helping customers set them up after commissioning. This limits their ability to configure the systems for whole-home load control and to explain the benefits to customers.

Customer feedback shows similar challenges. Overall satisfaction was mixed. Some customers saw value, but others were unsure or not convinced. Common concerns included limited control, unclear system behavior, and low usefulness after setup. These issues highlight the need for better customer education, clearer communication during DR events, and improved app performance. Customers generally liked the technology and reported decent app experiences. However, most used the app only occasionally, suggesting they didn't see strong ongoing value. Some also reported slow apps and limited features. Many customers didn't understand how demand response events work or what the system does during these events. This confusion reduced their confidence and engagement.

We'll share more details in the final project report.

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