The Smart Home Data Stream: Opportunities and Challenges in Device-Level Energy Monitoring

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ABSTRACT

Wisconsin Power and Light is conducting an ongoing, exploratory pilot investigating the uses of a customer-facing, broadband, device-level energy monitor designed by Sense Labs. The Home Energy Monitor Pilot has three primary objectives: to identify behavioral effects produced by homeowner awareness of their energy use, derive estimates of energy savings achievable through the replacement or servicing of inefficient equipment, and assess the impact that might be achieved with demand response initiatives. The first 100 monitors were installed in rural areas in 2018; since that time 200 additional monitors have been installed. This paper describes the ongoing pilot, including recruitment, installation, evaluation methodology, and current results.

Evaluation of the pilot includes stakeholder interviews and participant surveys, analysis of appliance-level energy use data, and billing analysis. New energy-savings opportunities were sought out by nearly one-third of survey respondents, and 57% said their opinion of their utility had improved since participating in the pilot. “Always On” loads present the opportunity to reduce overall participants’ energy use by 9%. Preliminary results indicate that the participants who were most engaged with the technology reduced their electric use by 1-6% after interaction with the monitor app. After air conditioners, the identified devices that contribute the most peak coincident load are refrigerators, “Always On” devices, and dryers. Challenges to the widespread use of this technology include initial cost, installation and connection complications, and the accurate identification of all detected devices.

Background

The landscape of energy efficiency is rapidly changing. As standards continue to evolve, programs that target improving individual equipment efficiencies are becoming less cost-effective. Consequently, operational, behavioral, and market transformation efforts are gaining more traction. Program delivery and marketing have also evolved as utilities continue to place increasing importance on customer relationships and satisfaction. In addition to these programmatic changes, connected technology has continued to develop at breakneck speeds, and smart home devices are now flooding the residential market. Many of these devices purport to deliver energy savings; however, these savings are largely untested, preventing smart home devices from taking a larger role in programs and portfolios.

One technology that has seen great advancement in recent years is residential home energy monitors, which not only communicate overall energy use to customers but give them real-time feedback on the disaggregated energy use of specific devices within their homes. Early research suggests that direct, overall energy use feedback can produce whole-home energy savings of between 5% to 15% (Darby 2006). Lesic et al. (2018) found that customers tend to underestimate the electricity use of high-consumption appliances and overestimate the use of low consumption appliances, which suggests that even greater savings should be obtainable with the addition of appliance-level granularity.

Home energy monitors present a personalized and detailed behavioral opportunity compared to existing, more generic approaches and recommendations. In addition to only being generally representative of energy use (versus providing specific household consumption feedback) many existing behavioral approaches have a long feedback loop. Changes to behavior and equipment may take many billing cycles before becoming measurable, if evident at all. Home energy monitoring technology also presents an opportunity to combine behavioral approaches with sustained customer engagement that can be used to suggest specific energy-saving actions and potentially raise program awareness, satisfaction, and participation. In addition to overall energy-savings, a technology that delivers real time energy use information has the potential to deliver demand-related benefits to the grid as well.

Introduction

In its decision of December 20, 2016, the Public Service Commission of Wisconsin (PSC) stated that it was "particularly interested in examining the role broadband access could play in expanding access to energy efficiency programs and services". The PSC also directed "the development of additional Focus program offerings for rural Wisconsin that would support more equitable distribution of Focus benefits throughout all areas of the state, and also be designed to seek the additional benefits…by tying the use of the internet to increased energy efficiency measures." This decision created the opportunity and demand for new types of broadband-connected energy efficiency programs in the Wisconsin market.

Wisconsin Power and Light (WPL) and Cadmus designed the Home Energy Monitor Pilot to assess the feasibility of using energy disaggregation technology as a tool to inform and develop new energy-saving programs for Wisconsin homes. The technology utilized in this pilot is the Sense Monitor, a high-frequency whole-home energy meter that captures the shape of energy-use profiles by sampling 1,000 times per second. It is installed at the home's electric panel and uses machine-learning algorithms to disaggregate electric sub-loads throughout the home in which the device is installed. Sense Labs identifies the unique electric load signature of lights, appliances, and other end-use devices and labels them for viewing within an app that can communicate directly with the customer. This communication capability enables the technology to sidestep some of the common hurdles of residential load disaggregation. When a new device is detected, the app asks the customer to verify its identity, which increases detection reliability. The customer also receives regular reminders that have the potential to increase the persistence of associated behavioral savings.

The pilot is currently composed of four phases, each one designed to investigate a different subset of the customer population and/or application of the technology. The original phase of the pilot targeted 100 customers in rural areas to determine the feasibility of mitigating some of the inequities in access that have traditionally resulted in rural customers being underserved by energy efficiency programs. Phase II included 100 additional device installations in rural, suburban, and urban areas to more accurately represent overall customer demographics within the WPL service territory. Phase III is designed to test the ability of enhanced messaging campaigns to increase participation in Focus on Energy programs and deliver residential energy savings. Phase IV of the pilot focuses on income-qualified customers, with the objective of gaining a better understanding of the device-level energy use and appliance efficiency of this high-priority customer segment. In this paper, we will present results from the first two completed phases of the ongoing pilot.

The pilot has three primary objectives: derive estimates of the energy savings achievable through the replacement or servicing of inefficient equipment, identify behavioral effects produced by homeowner's awareness of energy use and engagement with the device app, and assess the impact that might be achieved with demand response initiatives.

Implementation Activities

Participant Selection and Recruitment Survey

Participants were recruited from rural, suburban, and urban zip codes, to represent the general population of WPL customers. All selected participants were required to live in the WPL Energy service territory and have access to a broadband internet connection. For the first two pilot phases, Cadmus selected households with slightly above average annual energy consumption as an attempt to ensure greater opportunities for implementing energy efficiency measures. Filtering potential participants based on energy consumption also removed outliers that could bias the results of the pilot. Cadmus created histograms of annual consumption and bound selection to annual household energy consumptions between 10,000 kWh and 16,000 kWh, approximately the 3rd quartile of energy use. Homeowners in WPL territory with annual energy consumption in this range were sent recruitment surveys that included questions such as the following:

- Age of home
- Square footage
- Home type (e.g., ranch)
- Number of full-time occupants
- Distance between electrical panel & Wi-Fi router
- Access to an app-compatible device (i.e., smartphone or tablet)
- Internet latency

The recruitment survey yielded a population of eligible participants. Two hundred of those customers were then contacted to schedule Sense monitor installations during the first two pilot phases.

Technology Deployment

Cadmus schedulers contacted eligible participants and coordinated installation visits with a Cadmus field technician and licensed electrician. While the electrician installed the Sense monitor in the participant's electric panel, the Cadmus technician worked with the participant to sign the customer agreement, deliver a gift card incentive, and connect the Sense monitor to the homeowner's Wi-Fi. Cadmus technicians also collected field data on the characteristics and model numbers for major appliances in the home. Additional data was collected on the square footage of the home and the percentage of light fixtures using incandescent, CFL, and/or LED bulbs.

Evaluation Methodology

Multiple evaluation activities were undertaken to assess pilot design, implementation, customer satisfaction, behavior changes, and energy-related outcomes. These activities included interviews with program actors and technicians, customer surveys, analyses of disaggregated energy use data, and billing analysis. This paper describes a selection of those activities and their results through Phase II of the pilot. Complete evaluation reports (Kramer et al., 2019, Hicks et al., 2020, and Hicks et al. 2021) can be accessed online via the PSC Electronic Records Filing system).

Customer Surveys

Cadmus contacted all Phase I and Phase II participants via email and offered them an incentive for completing an online survey. The total number of complete responses was 112, of which 63 came from Phase I participants and 49 came from Phase II participants. Surveys were designed to gather data on a variety of topics, including satisfaction with WPL, estimated monthly energy savings, and behavioral changes due to participation in the pilot.

Appliance Efficiency Analysis

Cadmus analyzed appliance energy use for 153 pilot participants. For each customer and device type, Cadmus estimated expected annual consumption using disaggregated load data. Annual consumption estimates were classified as inefficient, baseline, or efficient according to relevant definitions in the Wisconsin and Illinois Technical Reference Manuals (TRMs). In the absence of specific definitions of efficient and inefficient products, such as in the case of "Always On" loads, Cadmus defined a median wattage based on the data collected from all households participating in the Pilot and used this wattage to distinguish between efficient and inefficient usage levels. Potential savings estimates assume that all inefficient and baseline devices are upgraded to the efficient consumption level.

For refrigerators and electric water heaters, the analysis assumed low variation in daily consumption. Cadmus analyzed energy use for 153 customers who had at least two months of complete data (on average, these customers had 377.9 days of data). Expected annual device consumption was estimated using the average daily consumption over the observed days for each customer and device type. In the analysis of electric dryer and dishwasher consumption, Cadmus used a cycle-based approach to estimate annual energy use. Cadmus analyzed data for 120 participants who had at least five days of complete data (these customers had 109 days of data on average). We estimated each customer's energy consumption per dryer or dishwasher cycle by identifying the mode of daily device consumption. Cadmus then multiplied the estimated per-cycle consumption by the average annual number of dryer or dishwasher cycles (uses) per household according to either the Illinois or Wisconsin TRM, to estimate an annual consumption for each device.

For electric dryers, water heaters, and dishwashers, the analysis assumed that each home would not use more than one of each appliance type. However, the Sense disaggregation algorithm identified a greater number of these device types than one would expect (e.g., 1.4 electric dryers per home). Discussions with Sense have suggested that some appliances can have several unique duty cycle signatures (e.g., a clothes dryer may have a timed dry, air dry, or permanent-press setting). The associated unique signatures may then be classified by unique device IDs under the same device type category. Cadmus' chronological analysis of device activity generally indicated that unique device IDs of one type did not register loads at the same time. Therefore, when a customer had multiple device IDs within one of these device types, Cadmus combined their consumption to produce an estimate of the customer's total consumption for each device type.

Disaggregated refrigerator data was treated differently to account for some homes having multiple refrigerators. Each identified refrigerator was treated as a unique device. Cadmus restricted the analysis to refrigerators with non-zero consumption on at least 95% of the days in the analysis.

Behavioral Energy Savings Estimation

App access analysis. Home Energy Monitor Pilot participants can access a mobile app that provides information on real time and historical energy consumption in their homes. For participants in Phase I, access to the app was withheld for several months after the monitors were installed so Cadmus could observe participant consumption prior to any behavioral impacts related to app access.

Cadmus estimated the effect of app access on the average daily consumption of these participants using a differences-in-differences model, which allowed for variation in the date of app access. The model used customer and date fixed effects. Customer fixed effects control for variation in individual customer average consumption. Date fixed effects control for variation over time (e.g., average weather impacts). Cadmus adjusted the resulting standard errors to account for clustering at the individual participant level.

Billing Analysis. Cadmus used monthly billing data to examine changes in electricity consumption between the periods before and after participants received a Sense monitor for Phase I and Phase II participants. To conduct this evaluation Cadmus procured the following data to conduct the impact analysis:

- Monthly billing data for Phase I and Phase II participants as well as for a group of nonparticipants. Available billing data generally ranged from January 2017 to February 2020.

- Daily weather data from the National Oceanic and Atmospheric Administration (NOAA)
- Sense monitor participation/installation dates

Participants were removed if they had fewer than 300 days of pre-period billing data, or if they had no post-period billing data available. Cadmus had to remove participants from the analysis for a variety of reasons; both phases had attrition of approximately 30%. For Phase I the largest reason for dropping participants was due to the account not having a first session date. For Phase II the largest source of attrition was having insufficient pre period data.

Due to the nature of the pilot program, there is not a designated randomized control design where participant and non-participant groups are designated prior to the delivery of the treatment. Cadmus used a quasi-experimental design to attempt to control for changes in energy consumption unrelated to the installation of the Sense monitor. Cadmus selected a matched comparison group using billing data from nonparticipants using a propensity score matching approach. Customers in the participant group were matched to nonparticipants based on seasonal pre-period energy consumption and weather.

Propensity score matching produced a set of non-participants that are similar to the participants in relation to the chosen explanatory variables, in this case pre-period consumption, weather conditions, and geographic location. Cadmus confirmed that none of the differences were statistically significant using analysis of variance (ANOVA).

Cadmus evaluated savings for both phases using a difference-in-difference model specification. Difference-in-difference models estimate savings by comparing the changes in pre- to post- energy consumption between treatment and comparison groups. The difference between this difference is the estimated savings.

Peak Demand Reduction Assessment

To determine which end uses represented the largest contributions to peak system loads, Cadmus aggregated device-specific consumption across all program participants during the eight on-peak weekday hours (11 a.m. to 7 p.m.) of the 2019 Midcontinent Independent System Operator (MISO) peak day (July 19). Device-specific aggregated loads were also compared to Wisconsin Power and Light's residential service time of use rates, to assess device-level demand response (DR) potential.

Results

Participant Survey

Energy Savings Estimates. Over half of respondents (51%; *N*=112) said they saw a decrease in their monthly energy costs since accessing the Sense monitor app. Of these respondents, 57% said they noticed a decrease in monthly energy costs between $5 and $15. Eighty-four percent of respondents were satisfied with the decrease in energy costs after accessing the Sense app, with 51% *very satisfied* and 33% *somewhat satisfied* (*N*=44).

Behavioral Changes. Cadmus asked respondents about their energy-saving habits before and after participating in the pilot. Of 112 respondents, all but 5% said they used energy-saving habits to reduce their energy consumption before participating. After participating, 60% of respondents said they had made additional changes to their daily behavior to reduce energy use. Approximately 30% of respondents said they had sought out additional energy-saving opportunities as well. Figure 1 presents energy-saving behaviors before and after participation in the pilot program.

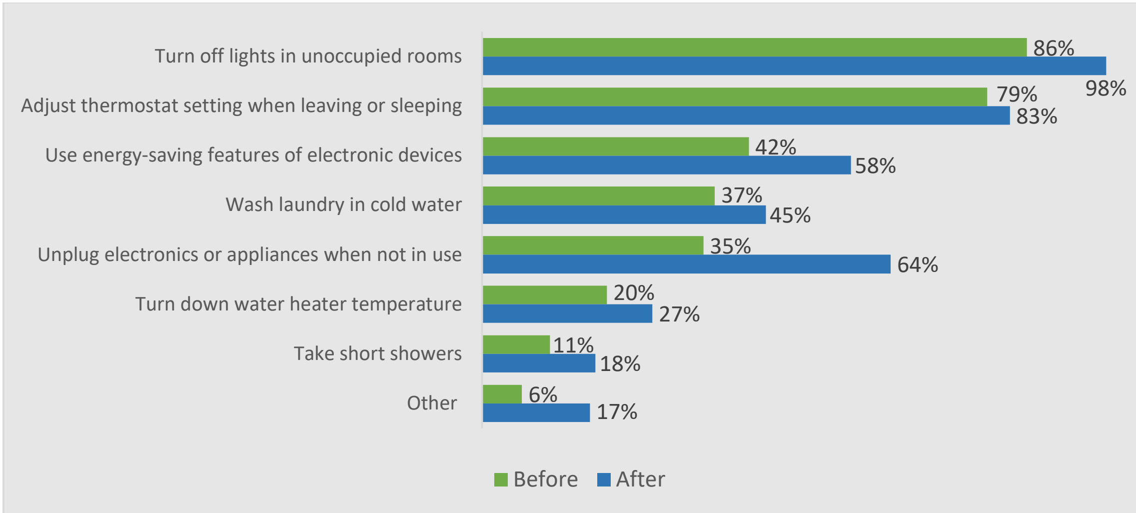

Figure 1. Energy-saving behaviors. *Source:* Cadmus.

"Always On" Savings Potential

"Always On" load reflects the baseline consumption of devices that are plugged in and draw current 24 hours a day regardless of whether they are being actively used, such as exercise equipment, laptops, and cable boxes. An analysis of the data from all pilot households reporting electric loads in February and March 2020 found a median home total wattage of 1.14 kW and a median "Always On" wattage of 0.24 kW. Overall, loads designated as "Always On" contributed 25.2% of pilot participant consumption, which is consistent with Sense Labs' reported national average (Walton 2019). Results indicate that total aggregated energy consumption among pilot participants could be reduced by approximately 8%, if half of participants reduced their consumption to the median.

Appliance Replacement Analysis

This section presents findings regarding the potential for device upgrade savings from electric dryers, refrigerators, water heaters, and dishwashers.

Electric Dryers. Energy use disaggregation identified electric dryer consumption for 120 customers. The Wisconsin TRM defines the maximum baseline and efficient annual electric dryer consumption as 768.9 kWh and 608.5 kWh, respectively (Wisconsin Focus on Energy 2019, 897). The electric dryer energy consumption of 30% of participants was above baseline levels. Another 18% of participants exceeded the efficient consumption level. For customers in the inefficient category, a dryer upgrade to the efficient level would save an average of 324 kWh per year. These savings correspond to a 2.9% average reduction relative to average participant total annual consumption.[1]

Refrigerators. Cadmus conducted savings analysis with refrigerator consumption data for 238 devices identified by disaggregation that registered non-zero consumption on at least 95% of analysis days (i.e., days for which disaggregated loads were available). The Illinois TRM indicates baseline and efficient

[1] The estimated annual average per-household consumption for Phase I and Phase II participants is 11,147 kWh.

annual refrigerator consumption of 534 kWh and 483.8 kWh, respectively (IL TRM Technical Advisory Committee, 2020).

Sixteen percent of refrigerators exceeded the baseline consumption level. Another 7% of refrigerators exceeded the efficient consumption level. Four refrigerators were identified as having unusually large energy consumption (greater than 1,000 kWh per year). In the inefficient category, a refrigerator upgraded to the efficient level would save an average of 178 kWh per year. These savings correspond to a 1.6% average reduction relative to average participant total annual consumption.

Water Heaters. Energy use disaggregation identified electric water heater consumption for 51 participants. The Wisconsin TRM indicates baseline and efficient annual heat pump water heater consumption of 3,160 kWh and 1,499 kWh, respectively (Wisconsin Focus on Energy 2019, 836)[2]. Figure 2 shows the distribution of customer electric water heater consumption relative to TRM-defined levels.

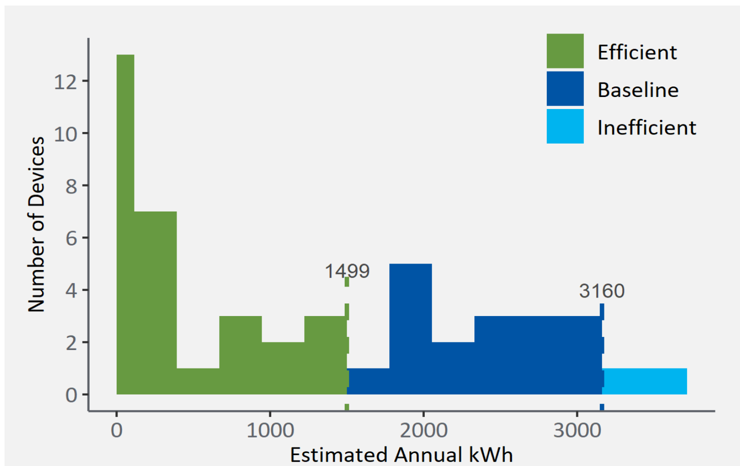

Figure 2. Water heater energy consumption. *Source:* Cadmus.

The annual projected water heater consumption for 10% of participants exceeded the baseline consumption level. Another 33% of customers had annual water heater consumption levels exceeding the efficient consumption level. For devices in the inefficient category, a water heater upgrade to the efficient consumption level would save an average of 2,489 kWh per year. These savings correspond to a 22.3% average reduction relative to average participant total annual consumption.

Dishwashers. Energy use disaggregation identified dishwasher consumption for 72 participants. The Illinois TRM indicates baseline and efficient annual dishwasher consumption levels of 307 kWh and 270 kWh, respectively (Illinois TRM Technical Advisory committee 2019, 20). Consumption for 4% of identified dishwashers exceeded the baseline consumption level. The average estimated annual consumption of the efficient devices was 151 kWh, or less than 50% of the maximum annual consumption of baseline devices. This suggests that dishwasher signatures may not be accurately identified, likely due to the wide range of device operating modes. For devices in the inefficient category, a dishwasher upgrade to the efficient

[2] The baseline heat pump water heater has an energy factor of 0.945. The efficient heat pump water heater is ENERGY STAR certified.

consumption level would save an average of 1,775 kWh per year, corresponding to a 15.9% average reduction relative to average participant total annual consumption.

Individual Appliance Replacements. Cadmus used disaggregated device data to identify appliances with high energy consumption that may need removal or replacement. Selected candidates were offered an incentive to replace qualified appliances with Energy Star models. Table 1 shows the estimated annual consumption for the original and the newly installed devices. These device replacements are expected to reduce participants' annual energy consumption by 86 kWh and 433 kWh, respectively.

Table 1. Appliance Replacement Impacts.

	Refrigerator Estimated Consumption [kWh/yr]	Freezer Estimated Consumption [kWh/yr]
Original Appliance	427	827
Replacement Appliance	341	394
Savings	**86**	**433**

Source: Cadmus.

Figure 3 depicts daily freezer consumption in June 2020 and June 2021 for the old and new devices, respectively.

Figure 3. Freezer Replacement Consumption Comparison – 2020/2021 Juxtaposition. *Source:* Cadmus.

Behavioral Savings

App Access. An analysis of consumption for Phase I participants before and after their first app access date found that an estimated savings of 1.8 kWh, or 6% of average daily consumption, could be attributed to app use, however, this result is not statistically significant ($p = 0.30$). Figure 4 compares hourly consumption for app and non-app users during the pre- and post- access periods. These groups were not randomly determined; participants self-selected into the app user group by responding to the encouragement. The analysis tested whether customers who responded to app access encouragement were representative of the whole pilot participant population. The left panel (Pre) shows alignment in hourly load shapes during the period prior to app access, indicating that those who responded to app use encouragement were representative of the whole pilot population. The right panel (Post) shows a reduction in consumption for participants with app access relative to those participants who did not access the app.

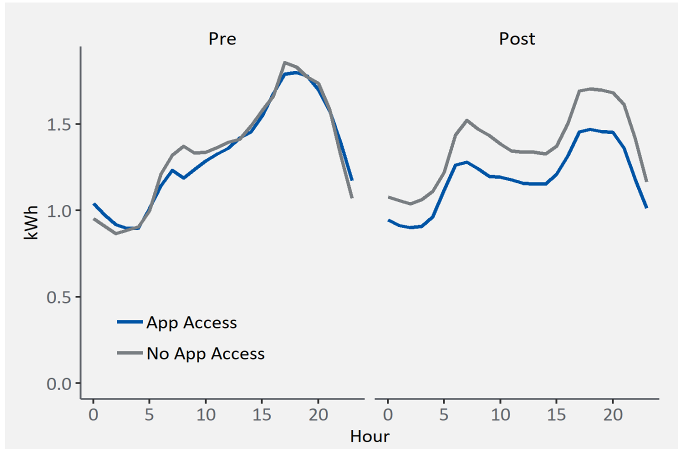

Figure 4. Average hourly consumption pre- and post-app access for Phase I participants. *Source:* Cadmus

Billing Analysis. Cadmus found savings of approximately 1.1% for Phase I and 1.6% for Phase II participants. Neither result was statistically significant at a 90% confidence level, with both savings estimates having relative precisions of over 100%. Phase II savings were estimated as slightly higher than phase I participants, however given the lack of statistical significance it is difficult to draw any conclusions about the differences in savings between groups. Additionally, Phase II monitors had an average installation date of 11/1/2019, which left a limited amount of post-period data for half of the participants (i.e., 3-4 months in some cases). Table 2 shows modeled savings estimates by phase.

Table 2. Savings estimates by phase.

Group	n	Baseline Usage [kWh]	Model Savings [kWh]	Percent Savings	Relative Precision
Phase 1	74	32.70	0.36	1.1%	±374%
Phase 2	43	30.60	0.48	1.6%	±411%

Source: Cadmus.

Load Shifting Potential

Cadmus assessed the device-specific potential for demand response savings by isolating device-level consumption during peak demand events. Figure 5 depicts the distribution of each device type as a percentage of aggregate program load during the eight on-peak weekday hours (11 a.m. to 7 p.m.) of the 2019 Midcontinent Independent System Operator (MISO) peak day (July 19). The device types that provided the greatest opportunity for demand savings were, in descending order of savings, air conditioners, dryers, water heaters, and pool pumps. This list excludes unidentified loads and devices with static loads (i.e., refrigerators and "Always On").

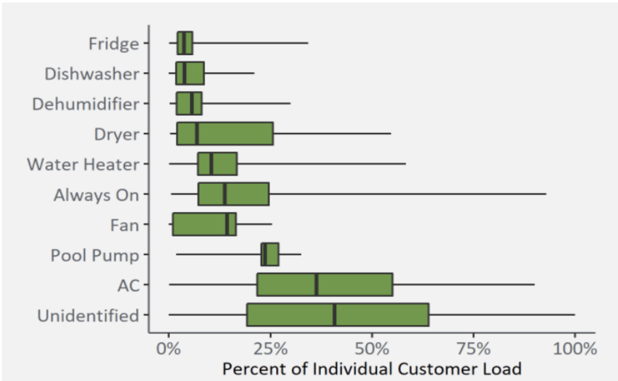

Figure 5. Percentage, by Device, of Aggregate Pilot Program Load during MISO August Peak Hours. *Source:* Cadmus

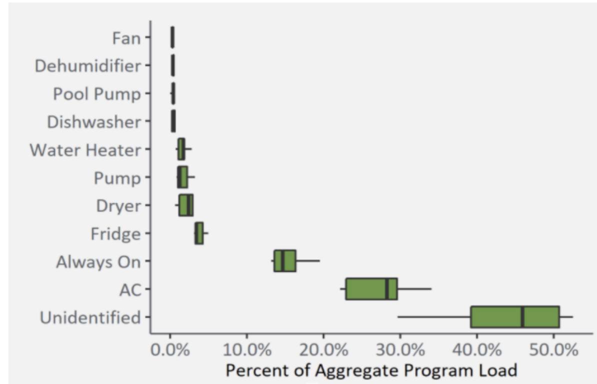

Figure 6. Device Percentage of Individual Customer Load during MISO August Peak Hours. *Source:* Cadmus

Figure 6 depicts the distribution of each device type as a percent of individual customer load during the same eight on-peak weekday hours (11 a.m. to 7 p.m.) of the 2019 MISO peak day (July 19). This figure highlights the potential for demand savings from devices that are used in a minority of homes but contribute a large percentage of customer total demand. Pool pumps contribute less than 3% of aggregate program peak load but contribute an average of 25% of individual participant load, for those that have them. Thus, pool pumps may present the second-best opportunity for per-device demand savings after air conditioners.

Device Demand Analysis

Cadmus has structured its demand reduction analysis based on the WPL time-of-use hours for residential service, summer high rate weekday times. We decomposed the summer high rate interval into high-peak (2 p.m. to 5 p.m.) and mid-peak (11 a.m. to 2 p.m. and 5 p.m. to 7 p.m.) periods. The following sections describe the analysis for each device.

Air Conditioners. Figure 7 depicts the average summer air conditioner demand profile on non-holiday weekdays. Air conditioner consumption was identified in 81 (*N*=81) unique Sense monitors during the three monthly MISO summer peak days of 2019. During high peak (2 p.m. to 5 p.m.) and mid-peak hours (11 a.m. to 2 p.m. and 5 p.m. to 7 p.m.), air conditioners present an average potential peak demand savings opportunity of 0.53 kW and 0.49 kW per device, respectively.

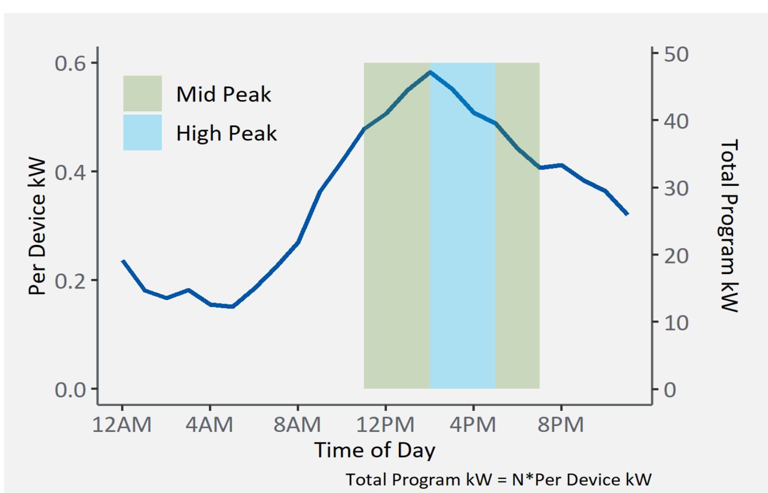

Figure 7. AC Average Summer Demand Profile. *Source:* Cadmus

Electric Dryers. Figure 8 depicts the average summer dryer demand profile on non-holiday weekdays. Electric dryer consumption was identified by 85 (*N*=85) unique Sense devices during the three monthly MISO summer peak days of 2019. During high peak (2 p.m. to 5 p.m.) and mid peak hours (11 a.m. to 2 p.m. and 5 p.m. to 7 p.m.), dryers present an average potential savings opportunity of 0.05 kW per device. Peak electric dryer demand did not typically coincide with the defined peak hours.

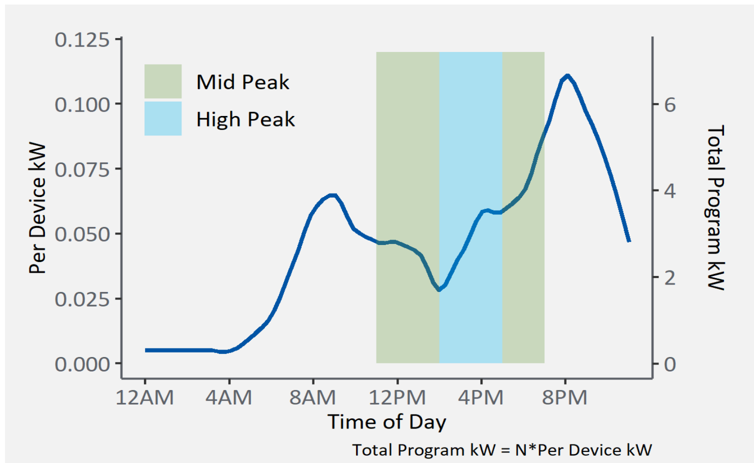

Figure 8. Dryer Average Summer Demand Profile. *Source:* Cadmus

Pool Pumps. Figure 9 depicts the average summer pool pump demand profile on non-holiday weekdays. Pool pump consumption was identified by one (*N*=1) unique Sense monitor during the three monthly MISO summer peak days of 2019. During high peak (2 p.m. to 5 p.m.) and mid peak hours (11 a.m. to 2 p.m. and 5 p.m. to 7 p.m.), pool pumps represent an average potential savings opportunity of 0.35 kW and 0.26 kW per device, respectively.

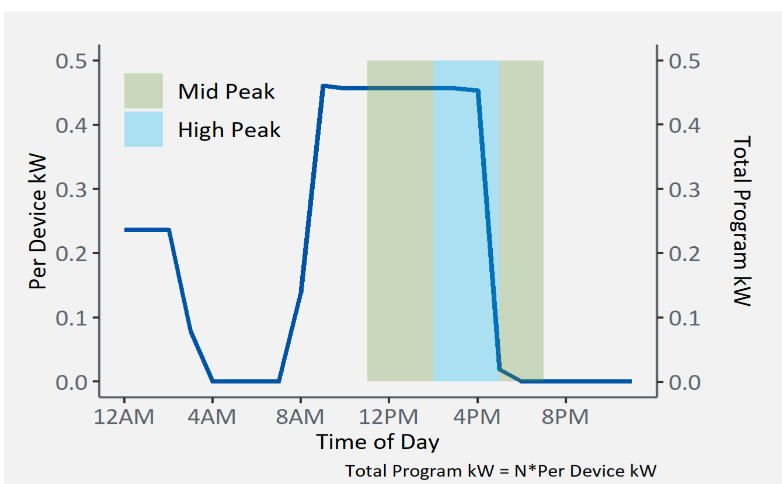

Figure 9. Pool Pump Average Summer Demand Profile. *Source:* Cadmus.

Conclusions

Device-level home energy monitoring delivers opportunities and insights in several areas of interest such as behavioral and resource acquisition energy savings, customer engagement, and demand response initiatives. The results of a subset of evaluation activities, conducted to assess pilot design, implementation, customer satisfaction, behavior changes, and energy-related outcomes are summarized below. These findings will continue to be updated as future pilot phases are executed and additional data becomes available.

Participant Survey Findings

- 57% of Phase I and Phase II pilot survey respondents said that their opinion of WPL had improved since participating in the pilot.
- Over half of participating respondents reported a decrease in their monthly energy costs since accessing the energy monitor app, which is also reflected in billing analysis results (though not robustly constrained).
- After participating, 60% of respondents said they had made additional changes to their daily behavior to reduce energy use, and approximately 30% of respondents said they had sought out additional energy-saving opportunities.

Energy Use Data Analysis Findings

- An analysis of participants' "Always On" consumption identified the potential for an 8% reduction in pilot consumption by reducing "Always On" consumption to the median level.
- Analysis of energy consumption by appliance category identified opportunities for energy savings through targeted replacements of water heaters, dryers, and refrigerators. The expected annual average kWh savings are 1,690 kWh, 725 kWh, and 412 kWh per replaced unit, respectively.
- Actual retrofits performed during the pilot show refrigerator and freezer replacement savings of 86 kWh and 433 kWh, respectively.
- A billing analysis of total household consumption before and after program participation indicated that participants in phase I and phase II saved 1.1% and 1.6% of daily consumption, respectively. These point estimates are in line with the typical savings for residential behavior programs, but the treatment population is relatively small for detecting an effect of this magnitude.
- Disaggregation analysis of device consumption during MISO peak days in summer 2019 indicated that, after air conditioners, the devices that contributed the most peak coincident load were "Always On" loads, refrigerators, and dryers.

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