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Energy Research and Development Division

FINAL PROJECT REPORT

Reinventing Residential Demand Response

Breaking Through Barriers with Gamification and Devices

Gavin Newsom, Governor

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PREPARED BY:

Primary Authors:
Matt Duesterberg
Lillian Mirviss

OhmConnect
350 Townsend Street, Suite 210
San Francisco, CA 94107
www.ohmconnect.com

Contract Number: EPC-15-083

PREPARED FOR:
California Energy Commission

David Hungerford
Project Manager

Virginia Lew
Office Manager
ENERGY EFFICIENCY RESEARCH OFFICE

Laurie ten Hope
Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Drew Bohan
Executive Director

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PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation and bring ideas from the lab to the marketplace. The CEC and the state's three largest investor-owned utilities — Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company — were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

Reinventing Residential Demand Response: Breaking Through the Barriers with Gamification and Devices is the final report for the Empowering Proactive Consumers to Participate in Demand Response Programs project (Contract Number: EPC-15-083) conducted by OhmConnect. The information from this project contributes to the Energy Research and Development Division's EPIC Program.

For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the CEC at ERDD@energy.ca.gov.

ABSTRACT

OhmConnect is a residential demand-response software platform that pays utility customers to reduce their energy use when the electric grid is stressed. During each #OhmHour, users respond by making behavioral changes as well as taking automated actions by connecting their smart devices to the OhmConnect platform. OhmConnect established that a market could be cultivated for residential demand-response programs and advanced energy products for the wholesale market. OhmConnect leveraged its existing platform to engage residential utility customers and encourage them to save energy during demand response events, proving that proactive customers will reduce their electric use during times of peak demand on California's electric grid.

To achieve the goals of this project, OhmConnect examined three aspects of residential demand response — users, yield, and supply — through experiments in customer acquisition, demand response participation incentives, and low-cost telemetry. OhmConnect updated its platform to better engage residential utility customers in demand response and, pairing those updates with direct marketing methods, OhmConnect acquired more than 31,000 users for this project. This project concluded that monetary incentives yielded stronger reductions during #OhmHours than environmental messaging. Lastly, OhmConnect developed a low-cost telemetry solution in user homes that utilized historical smart meter data and real-time energy consumption data from energy-efficient smart devices.

While significant progress was made in facilitating residential demand-response market opportunities over the course of this project, additional barriers remain that prevent full integration of residential demand response into the state's electric grid. This report discusses those barriers, which include market uncertainty, data inaccessibility, competitive asymmetries, and customer retail energy options, all of which impede residential demand response providers' abilities to market their demand-response reductions to the California Independent System Operator and participate in the wholesale energy market.

Keywords: OhmConnect, demand response, residential demand response, behavioral demand response, automated demand response, telemetry, #OhmHour, demand response provider, Internet-of-Things, Remote-Intelligent Gateway, smart home, smart grid, Disadvantaged Communities, Demand Response Auction Mechanism, Rule 24/32, incentives, behavior, energy engagement, energy sharing, energy broker, grid-edge

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Introduction

California is at the national forefront of clean-energy generation and delivery. With proposed legislation mandates 100 percent carbon-free electricity generation by 2050, increasing renewable resource generation is a cornerstone for meeting the state's progressive environmental goals. Large-scale solar and wind projects are scattered throughout California, and renewable energy projects represent a large portion of the state's clean-energy technologies. However, while renewable-resource energy is a vital component of reducing California's greenhouse gas emissions, it is only one element to making the state's electricity completely carbon-free. Many renewable energy technologies are intermittent rather than baseload generation sources; solar only operates when the sun shines and wind power is only generated when the wind blows.

Balancing the electric grid requires balancing electricity demand, or how much electricity Californians require at a given time, with available supply. If consumers consume more electricity than is available, the electric grid becomes stressed. In a worst-case scenario, this high demand can cause expensive blackouts for residents and businesses. The introduction of intermittent renewable energy generation like wind and solar to the electric grid can increase the risk of this imbalance, especially during summer evening hours when high air conditioning use pushes electricity demand beyond available supply just as solar photovoltaic generation drops off. Because of this dynamic, California requires more flexible energy resources that can quickly respond to fluctuating demand to prevent electricity delivery interruptions. But what does innovative demand management look like? Peak grid stress naturally parallels times of peak demand. Yet encouraging consumers to cut back on their energy use during peak-demand periods is challenging. As an example, consider California's heat waves. During times when temperatures top 100 degrees for multiple days, the last thing residents want to do is turn off their air conditioners, even for an hour, though this drop-in demand is what the electric grid requires. This scenario graphically illustrates the need to directly involve utility customers in managing electric load.

To date, residential customer engagement in the energy sector has been limited. Many residential utility programs regularly interact with customers simply due to the nature of the utility-customer relationship, but these programs provide limited exciting, interactive strategies. As the primary manager of customers' bills, residential utility programs cover the basics but lack in customer delight (the idea of pleasantly surprising a customer and exceeding his or her expectations). According to J.D. Power's 2017 study on residential utility customer satisfaction, customers are increasingly satisfied with their utility, but as Greentech Media highlights, on average these customers spend as little as eight minutes a year engaging with their utility. This further emphasizes the challenge of impactfully engaging residential utility customers in a way that empowers them to decrease demand when it most benefits the grid.

When it comes to incorporating flexible resources into California's future 100 percent clean-energy goals, customer engagement is the key in innovating demand management. Empowering residential energy customers to save energy when the grid is stressed can only occur when those customers are engaged in their energy consumption. Even more, with a delighted residential utility customer comes a proactive consumer that is excited to innovate his or her demand. Residential utility customer empowerment can thus help balance supply and demand. As more renewable resources come online, consumer-based flexible-demand resources will provide more value to California's grid, environment, and economy when utility customers are fully engaged.

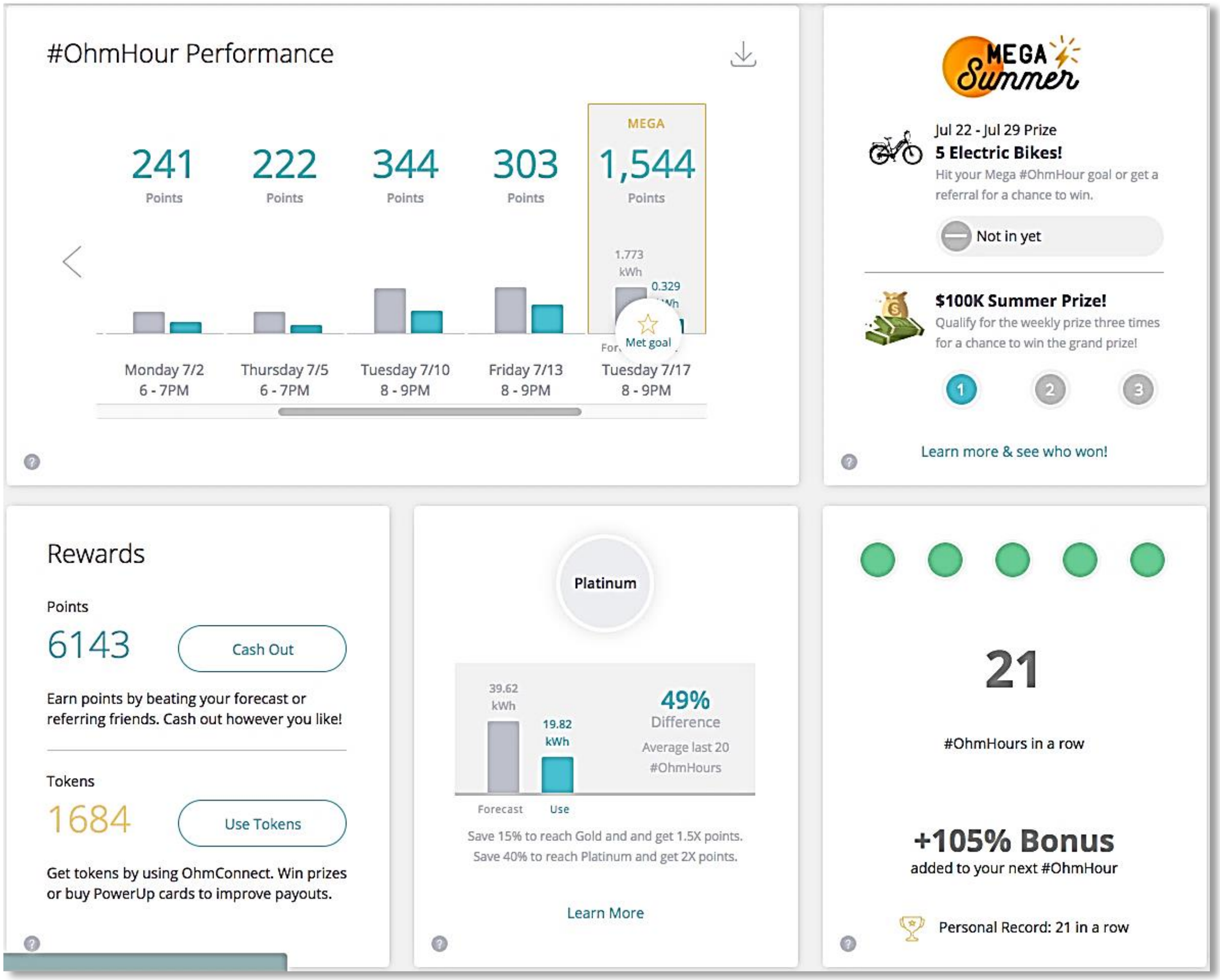
Background

Demand response (DR) is the act of reducing electricity consumption during times of high electricity demand, grid stress, and possible overload. Historically, demand response has been most crucial during summer months when air-conditioning-driven load creates high demand. More recently, DR has been retasked to contribute greater grid flexibility, to help balance the increase of variable renewable resources, an essential component of California's mandated clean-energy targets through 2050. While DR has been available in California for decades, individual residents were not able to participate in wholesale DR and the only available residential DR programs were run by electric utilities.

As the state's energy industry continues to evolve from a uniformly centralized, baseload-driven grid to a more localized, distributed one, DR in California is rapidly expanding. Recent years have seen changes in demand response provider participation as new regulations and policies have overcome traditional roadblocks to entry into electricity markets. California's dynamic electricity grid, with smart meters, high-renewable penetration, and distributed energy resources, has further pushed DR resources into California's wholesale energy markets since they are now paired with the mandated state policy objectives of affordability, decarbonization, and reliability. OhmConnect's approach to engaging customers and aggregating their load reductions as a wholesale market product stems from this grid transformation and embraces the growth of DR to directly empower residential electric customers to take advantage of a new generation of DR products.

This project maximized the benefits of residential DR to California by overcoming barriers to demand response participation in California's wholesale energy market through OhmConnect. OhmConnect is a residential DR software platform that pays households to reduce their energy use when the electric grid is stressed. The program is straightforward and fun for users, and users get paid for saving energy. At the back end, OhmConnect aggregates those users' electricity reductions and sells them as energy products to California's wholesale electricity market. OhmConnect's software product aggregates and coordinates large numbers of residential utility customers to create a market product that meets CAISO requirements for participation in supply-side markets. Customers "participate" during an event by reducing load during a specified hour; OhmConnect organizes customers into cohorts that are dispatched in consecutive hours to provide a consistent multi-hour load reduction that can reliably meet system needs. Customers respond to DR events (#OhmHours) through a combination of manual actions (turning off lights) and automatic actions (using, for example, OhmConnect-connected smart devices). Customers can track their reductions (and rewards) using the OhmConnect Dashboard (Figure ES-1).

Figure ES-1: OhmConnect Dashboard



OhmConnect's dashboard is what users see when they sign into their accounts. The #OhmHour performance widget shows how much users earn during DR events.

Source: OhmConnect

The OhmConnect platform was built on the three primary pillars of residential DR — users, yield, and supply. When working together, these three elements maximize the benefits of residential DR to California:

- Users: The number of residential utility customers participating in DR programs. By having more users participate in a third-party platform like OhmConnect, more residential customers are available to reduce electric demand simultaneously during DR events.
- Yield: How much individual residential utility customers reduce their electricity consumption during DR events, which in aggregate results in reduced demand on the electric grid.
- Supply: Wholesale market products available to pay for energy reductions from DR. These products enable third-party DR providers to pay users for their energy reductions. In the future, supply will also include flexible DR resources that ensure wholesale market products exist that promote and pay for load shifting.

Project Purpose

For this project, OhmConnect established a market for residential DR programs and advanced energy products. OhmConnect leveraged its platform to engage residential utility customers and encourage them to save energy during DR events, proving the theory that proactive customers are willing to reduce their electricity consumption during times of peak demand on California's electric grid.

The project engaged customers about energy. Participating customers could clearly understand the reasons for their electricity reductions while learning how to simultaneously save energy and earn money through California's wholesale energy market. The shared results of this project will provide future clean technology companies, regulatory agencies, and policymakers with a successful example of directly engaging residential utility customers in statewide efforts to stabilize and manage the electric grid while reducing the greenhouse gases that contribute to climate change. This research provided insight on how best to educate residential utility customers on the importance of saving energy during high-peak demand periods, ultimately changing their electricity use to the overall benefit of the state's electric grid.

Project Approach

To achieve project goals, OhmConnect researched expanding customer participation, measured aggregated load reductions, and marketed the resulting product to wholesale energy markets.

This project based its approach on the three critical elements of residential demand response: user, yield, and supply. Experiments designed to maximize each element focused on customer acquisition (users), participation incentives (yield), and low-cost telemetry for real-time market opportunities (supply). OhmConnect staff focused on user acquisition. A research team at the University of California, Berkeley, ran the data-driven analysis in participation incentives and the Electric Power Research Institute researched low-cost telemetry. OhmConnect additionally evaluated the contemporary state of the DR market and provided recommendations on overcoming existing barriers including data access, DR market uncertainty, and competitive asymmetries with utility programs.

OhmConnect focused on acquiring new users to increase residential customers' contributions to DR events and to ensure adequate data for participation incentive experiments. Based on the number and type of experiments conducted, OhmConnect determined the appropriate total sample size for all treatment and control groups to be 12,500 users. To meet this goal, OhmConnect structured user-acquisition experiments to access and enroll utility customers through direct (that is, paid user) and indirect (specifically referral) acquisition methods.

For yield, the University of California, Berkeley, and OhmConnect jointly researched how best to maximize participation and energy use reductions during #OhmHours. Researchers at the university ran three experiments across different phases. These experiments covered monetary incentives, the impacts of smart home automation for electric devices, the cost-effectiveness of user payout, and moral suasion due to environmental messaging. Phase 1 addressed two issues: how participants respond to varying monetary incentives during DR events, and how adoption of smart home automation affects those responses. Phase 2 of the experiment addressed whether incentives could be modified and targeted to improve program efficiency. For example, could OhmConnect reduce DR costs (payouts to users) by identifying the largest responders and offering them greater incentives? Lastly, Phase 3 evaluated the impact of moral suasion through environmental messaging rather than financial incentives. Phase 3 also explored how these effects varied by connected device (smart devices connected to the OhmConnect platform) status. In summary, the University of California, Berkeley, tested the impact of monetary incentives and evaluated the most cost-effective way to run a third-party DR program with residential utility customers.

For supply, OhmConnect and the Electric Power Research Institute evaluated low-cost telemetry solutions to enable residential participation in real-time market products like ancillary services. Ancillary service products currently require telemetry, which is cost-prohibitive for many residential utility customers. Overcoming the telemetry barrier would expand the suite of market products available to residential customers. This project created a remote intelligent gateway-like software solution incorporating real-time energy-consumption data from smart devices in users' homes to serve as substitutes for residential telemetry.

Project Results

User Acquisition

Recruiting new users to join OhmConnect was a key to greater energy reductions during DR events. Through direct and indirect user-acquisition methods OhmConnect acquired more than 450,000 signups and 115,000 active users, of which 31,000 were assigned to this project; this number far surpassed the initial 12,500-user goal.

The primary methods of direct acquisition included Facebook, Instagram, Search Engine Optimization, and non-profit partnerships. Based on the results of this research, OhmConnect recommends more experimentation with external marketing channels to identify the most cost-effective direct-user acquisition methods.

For indirect user acquisition, OhmConnect experimented with three referral programs — 20/20, tiered, and a $20 flat fee. For the 20/20 referral program, the referrer and referee received $20 upon referee signup. Tiered referral, on the other hand, had an overall higher incentive — users earned on average $32.77 per referral, which was based on how many referrals actually signed up — but the program was much less successful than the other programs, as revealed in the low conversion rate. This was most likely due to user confusion, where users were unclear on how much they were supposed to receive from referral payments. Lastly, the $20 flat referral method paid users $20 for every user they referred that signed up, and it proved to encourage the largest number of signups, which user comments suggest that success was likely because of its simplicity and payment.

Participation Incentives

In the University of California, Berkeley, yield experiments, OhmConnect users reduced their energy use by an average of 12 to 14 percent when compared with their baseline use during DR events. This amount was largely independent of the actual incentive level, suggesting that users were either insensitive to prices or that electricity consumption followed a binary decision model (that is, either turn the lights off or leave them on). Typically, load reductions (in kilowatt-hours [kWh]) resulted from changes in air temperature and connection status. OhmConnect users in the yield experiments reduced less than others during #OhmHours because of an ineffective product and customer engagement experience.

Rebates for smart Wi-Fi devices sharply increased device adoption (that is, increased the number of thermostats and plugs connected to the OhmConnect platform). Interestingly, the rebate was disproportionately taken up by users with low average #OhmHour reductions. This could be because these users understood and wanted to benefit from the value of a connected device in increasing their average #OhmHour reductions. The significant increase in connected devices by the bottom quartile was driven by adoption of Wi-Fi-connected plugs, whereas the increase in the top quartile was driven by connected thermostats. These differences were likely because connected thermostats were typically used in larger households while connected plugs were more appropriate for households without central heating or cooling (such as, apartments). On average, connected users, or users with a connected device, reduced their electricity consumption 16 percent more than non-connected users.

In all the University of California, Berkeley experiments, results on residential DR cost-efficiency suggested that payout costs could be dramatically reduced by sending lower incentives to customers designated as most responsive, and, furthermore, that the reduced payouts would have had little effect on energy reductions during #OhmHours. DR payouts to the most responsive customers could have been reduced to 26 points (26 cents) per kWh. The least responsive customers also actually cost OhmConnect 107 points per kWh because they responded less to #OhmHours, making them less cost-effective to both the energy markets and to third-party DRPs like OhmConnect.

In summary, OhmConnect users on average earned $2.66 to $6.13 for the first 90 days of a hypothetical OhmConnect program in the university experiments. According to the study, if a longer-term DR program called 100 events per year and set incentives consistent with the wholesale price, average user earnings could range from $1.82 to $4.80 annually. Earnings would be larger for connected users, ranging from $3.95 to $10.40 more than 100 #OhmHours, and adopting connected devices would increase earnings by $9.68 to $25.48 annually in the hypothetical programs considered.

Low-Cost Telemetry

OhmConnect designed and implemented a low-cost telemetry solution to overcome the barrier of providing real-time data to the California Independent System Operator (California ISO). Telemetry (automated energy consumption data transfer between remote equipment and the California ISO) can quantify flexible resources in the wholesale energy market and provide real-time energy products. Due to the automated nature of #OhmHours, many OhmConnect users already have smart devices that are connected to the electric grid. These devices not only respond immediately to DR events, but smart plugs, in particular, directly track real-time device electricity consumption. Leveraging these smart plugs was therefore key in designing a low-cost telemetry solution that meets requirements for supply-side services.

OhmConnect collaborated with the Electric Power Research Institute to create a viable telemetry solution that could provide enough information to meet participation requirements for wholesale energy products and aggregate small-customer ancillary services. This work could increase participation by residential DR resources in the California ISO's real-time and ancillary-services markets. The solution, a remote intelligent gateway device, connected OhmConnect's data aggregation server with the California ISO.

OhmConnect collected data from the remote intelligent gateway and analyzed how its real-time energy consumption estimates compared with smart-meter consumption data. Based on data collected across 725 users on January 4, 2019, the remote intelligent gateway data followed a similar pattern to the actual consumption data. While the actual consumption value was slightly higher than in the remote intelligent gateway data, a linear model shows that the remote intelligent gateway-predicted energy consumption data (in megawatts [MW]) closely aligned with actual consumption. Overall, available data points showed a high degree of accuracy between the estimated remote intelligent gateway data and the actual consumption, though more data is needed before determining whether this low-cost telemetry solution is effective in reliably passing real-time energy consumption data to the California ISO.

Knowledge, Technology Transfer, and the Demand Response Market

In addition to experiments performed under the EPIC grant, OhmConnect identified barriers and proposed solutions that enabled third-party residential DR participation in California's energy markets. Third-party demand response providers are relatively new in California's energy market landscape, and throughout this project OhmConnect participated in regulatory activities that advocated third-party DR market adoption. The policy and market engagement OhmConnect pursued while the project was underway helped third-party DRPs grow throughout California.

OhmConnect participated in regulatory proceedings and met with relevant policymakers, including key stakeholders at the California Public Utilities Commission (CPUC), the California Legislature, the California Energy Commission, the Load Shift Working Group, and the California ISO. From regulatory proceedings to CPUC meetings, this project helped ensure that third-party DRPs have viable market-based solutions to reduce electric loads on California's grid.

Some of the barriers OhmConnect encountered were overcome during this project, creating a larger opportunity than initially expected in the project's application. However, many of these barriers remain, including market uncertainty, data inaccessibility, competitive asymmetries, and a lack of customer retail energy options. For example, the Demand Response Auction Mechanism pilot is still being evaluated and is not yet a permanent program. While the CPUC was persuaded by California ISO comments that "providing continuous annual funding for utility programs with no solicitation for competitively procured demand response in 2018 may harm third parties' ability to compete on a level playing field and cause the nascent competitive market to wither," the absence of a permanent Demand Response Auction Mechanism could freeze many DR providers out of California. This project therefore recommends regulatory approaches that continue to improve the ability of DRPs to acquire and enroll customers in programs that reduce electricity usage.

Benefits to California

The ratepayer benefits of this project spanned financial, environmental, grid, and community arenas across California. Reducing over 27.8 megawatt hours during this project, OhmConnect project users earned $668,000 from California’s investor-owned utilities and donated an estimated $65,000 to non-profit organizations and local institutions. The project avoided 9 metric tons of carbon emissions in California, lowered ratepayer costs, and increased grid reliability. These reductions were achieved in part by the 13,000 energy-efficient connected devices on the OhmConnect platform, with as many as 6,000 connected devices deployed during a single #OhmHour.

These project benefits are just a microcosm of the full spectrum of impacts OhmConnect makes across California. The technology implemented in this project has been adopted by residential customers in the service territories of all three investor-owned utilities in California: Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas & Electric. With more than 115,000 active California users participating in and getting paid for reducing their electricity use during #OhmHours, every month ratepayers save energy and make money through the wholesale energy market by participating in OhmConnect’s residential DR model.

This project creates a precedent for third-party DR providers and highlights the promising potential impact of residential DR in reducing peak electricity demand. Greater customer engagement could significantly shift behavioral responses to grid events and inspire other third-party demand response providers to use proven engagement mechanics from gaming, affinity groups, and social networks, along with innovative financial approaches that encourage customers to reduce energy consumption. Moreover, the results serve as an example of how more third-party demand response providers will benefit ratepayers as clean technology companies take advantage of the evolving grid, which must increasingly accommodate renewable-resource generation as California meets its clean-air targets, especially as barriers to residential DR are addressed and DRPs successfully participate in California ISO’s wholesale energy market.

CHAPTER 1: Introduction

OhmConnect is a residential demand response (DR) software platform that pays residential utility customers to reduce their electricity use when the grid becomes stressed. The program is straightforward for participants; get paid for saving electricity and, on the backend, sell those savings on California's energy market. OhmConnect's software product coordinates grid-based demand response events, #OhmHours, with residential utility customers who directly connect their homes to the electric grid. Each #OhmHour, those customers make behavioral changes, like turning off lights, as well as taking automated actions by connecting their smart devices, including Wi-Fi thermostats and smart plugs (connected devices), to the OhmConnect platform.

While DR has been available in California's energy markets for decades, individuals have been unable to participate in wholesale DR programs and traditional commercial and industrial DR programs only dispatch their customers a few times a year. Before this project, the only available residential DR programs were utility-run, and California's energy markets did not accommodate third-party residential DR providers. This project dramatically increased the number of utility customers enrolled in third-party residential DR programs and expanded the number of market products available to those customers.

For this project, OhmConnect established that a user base could be cultivated for residential DR programs and advanced energy products for the wholesale market. OhmConnect leveraged its existing platform to engage residential utility customers and encourage them to save energy during DR events, demonstrating that proactive utility customers can reduce their electricity usage to ease stress on the electric grid during high-demand periods.

To achieve the goals of this project, OhmConnect researched customer participation, measured aggregated load reductions, and marketed those reductions in California's wholesale energy market.

This project based its approach on three critical elements of residential demand response: users, yield, and supply. Experiments designed to maximize these DR "pillars" focused on customer acquisition (users), participation incentives (yield), and low-cost telemetry for real-time markets (supply). When implemented together, these three elements maximize the benefits of residential DR to California. The number of residential utility customers on OhmConnect's platform (the "Users), determine how many are available to reduce their electricity use during #OhmHours. "Yield" refers to how much each of these individual users can reduce electricity use during DR events. And supply ensures that there is a means to pay these users for their reductions. This project researched these three pillars through experiments in customer acquisition (users), participation incentives (yield), and low-cost telemetry (supply).

Background

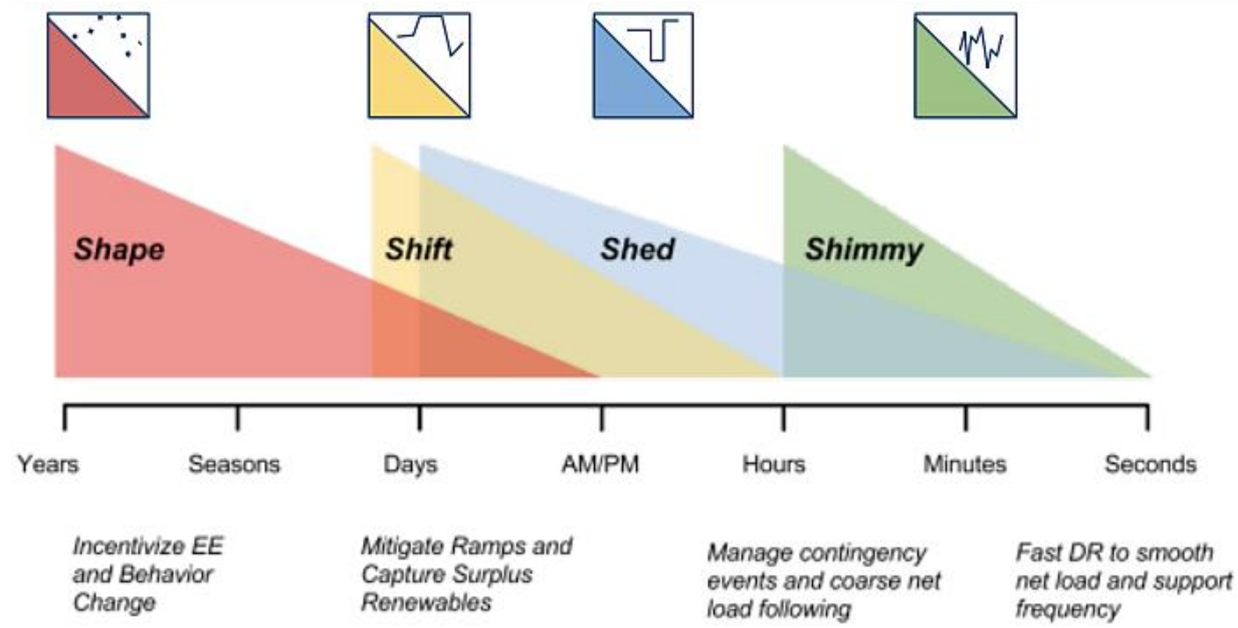
At the time this project was first proposed (2015), third-party residential demand response providers (DRPs) did not have a clear mechanism for marketing their energy reductions or DR resources in an existing energy market. Participation has increased in recent years, however, as new regulations and policies have helped overcome major barriers into the wholesale energy market, especially with establishment of the California Demand Response Auction Mechanism (DRAM). Moreover, California's evolving electricity grid, with its smart meters, high renewable penetration, and distributed-energy resources, has further advanced DR resources, in tandem with the state's ambitious environmental targets.

As the energy industry transforms from a centralized, unidirectional grid to a localized, distributed grid, DR in California is evolving form an emergency reliability resource toward flexible load response that can meet a wider range of operational and policy needs. In the next five years, reports such as the Lawrence Berkeley National Laboratory's (LBNL) *2025 California Demand Response Potential Study* (DR potential study) indicate that demand response will itself change dramatically. The DR potential study was commissioned by the California Public Utilities Commission (CPUC) and conducted by LBNL. Phase I findings were released in 2016, Phase II in 2017, and Phase III in 2018. These reports analyzed the potential for DR to meet California's resource planning needs and operational requirements. The study articulated a taxonomy of DR "types" according to their operational characteristics:

- Shed: Curtailing loads during times of peak capacity to support the system in emergency and contingency event. This mechanism represents all traditional demand-side DR.
- Shift: A movement of energy consumption from high net-demand times of the day (4-9 pm, or in the evening after the sun has gone down) to low net-demand times of the day (1-5 pm, or in the middle of the day when solar generation is high)
- Shimmy: Dynamically adjusting demand to alleviate short-run ramps and disturbances to the energy system on the scale of seconds to a single hour
- Shape: Changing customer load profiles across times of the day that better align with grid needs.

Previously, DR was only associated with shed, represented in blue in Figure 1. However, with the supply-side paradigm, the intention described in the DR potential study is to value and reward energy resources that provide the other products (shape, shift, and shimmy). According to the DR potential study, in the near future the value of DR should move from shed, currently with hundreds of millions of dollars of value per year, to the shift, shimmy, and shape products, which currently have zero dollars of value per year. This project stems from the need for this paradigm shift, and the user, yield, and supply framework is a means to directly empower residential customers to benefit from a new generation of flexible DR products.

Figure 1: Demand-Response Mechanisms



Lawrence Berkeley National Laboratory's *2025 California Demand Response Potential Study* defines four DR mechanisms: shape, shift, shed, and shimmy. These mechanisms provide different energy products that benefit the electric grid.

Source: Lawrence Berkeley National Laboratory

OhmConnect User Acquisition

User acquisition is the act of getting users to sign up with OhmConnect. Acquiring new users to join a third-party DRP like OhmConnect is the foundation for ensuring residential DR successfully impacts California's energy grid, especially when the grid most needs reduced demand. As described above, the more users that are responding to the DR event, the greater the reduced demand will be. For this project, OhmConnect focused on acquiring new users not only to increase residential customers' contribution to DR events, but to also ensure adequate data for residential DR participation incentive experiments.

Residential Demand-Response Participation Incentives

For yield, the University of California, Berkeley (UCB), in partnership with OhmConnect, researched how best to ensure the greatest participation in DR events, as well as to generate the largest electricity-use reductions during #OhmHours. UCB experimented with monetary incentives for DR and evaluated the effectiveness and scope of energy reductions from environmental messaging. This project compared the two approaches for encouraging OhmConnect participants to save energy during DR events, and, more specifically, to examine this project whether yield is greater under financial or environmental incentives. Lastly, this project analyzed the most cost-effective ways to run third-party DR programs with residential utility customers.

Low-Cost Telemetry

To enable new DR energy market supply, this project researched a low-cost solution for telemetry that would increase residential participation in market products like the real-time market (RTM) and ancillary services. Currently, telemetry barriers (like difficulties in receiving real-time residential energy-consumption data), prevent residential utility customers from accessing ancillary services products. Overcoming the telemetry barrier is necessary to expand a suite of market products for residential customers, especially those that require real-time market data. This project created a remote intelligent gateway (RIG)-like software solution that paired real-time energy consumption data from connected devices in users' homes and historical smart meter data to substitute for residential telemetry.

State of the Demand-Response Market

While progress has been made in increasing residential DR market opportunities, additional barriers remain that prevent full integration of residential DR into California's electric grid. These barriers, which include market uncertainty, data inaccessibility, competitive asymmetries, and limited customer retail energy options, hinder residential DRPs' abilities to provide DR services to the California ISO. For OhmConnect in particular, these barriers could dramatically impact its participation as a DRP in the state's wholesale energy market. Existing market mechanisms, including the IOU Demand Response Auction Mechanism (DRAM), Rule 24/32 that allows third parties to participate in demand response markets, and OAuth 2.0 Click-Through, a data standard that allows secure transfer of data, are evolving as the DR industry grows, and existing barriers should not prevent a third-party DRP's success. The research performed during this project required constant monitoring of the evolving DR regulatory structure and addressing policy barriers to ensure a third-party DRP's streamlined entry into California's energy markets as well as a viable business opportunity unencumbered by market uncertainty and high financial risk.

CHAPTER 2: The OhmConnect Platform

OhmConnect's objective is to allow residential utility customers to conveniently reduce their electricity use during periods of high demand and sell those reductions in California's wholesale energy market. For this project, OhmConnect built upon its existing platform, which coordinates residential utility customer demand response events, to attract and enroll users in the research project and incorporate the experimental program needed for the research (described in chapters 3 and 4). OhmConnect also leveraged its platform to coordinate users for #OhmHours, its DR events, as a means of connecting residential utility customers with the California Independent System Operator (California ISO).

For this project, OhmConnect specifically targeted platform modifications that would better educate residential utility customers on the benefits of participating in demand response (DR). OhmConnect also developed a data-sharing function that made it easy for project users to share their electricity consumption data with OhmConnect, which allowed OhmConnect to measure and verify energy reductions during #OhmHours, a key component for demonstrating the reliability of the aggregated customer reductions to the CAISO and utilities.

Connecting Residential Utility Customers to Demand-Response Events

#OhmHours, OhmConnect's grid-based DR events, occurred on a weekly basis over the duration of the project, and the reductions achieved during #OhmHours provided the energy consumption data analyzed in this project. Users were notified of #OhmHours the day and hour before a DR event, and they received both email and text notifications (Figure 2).

Figure 2: #OhmHour User Notifications

#OhmHour notifications via text (left) and email (right) were sent both a day and one hour in advance of the demand-response event.

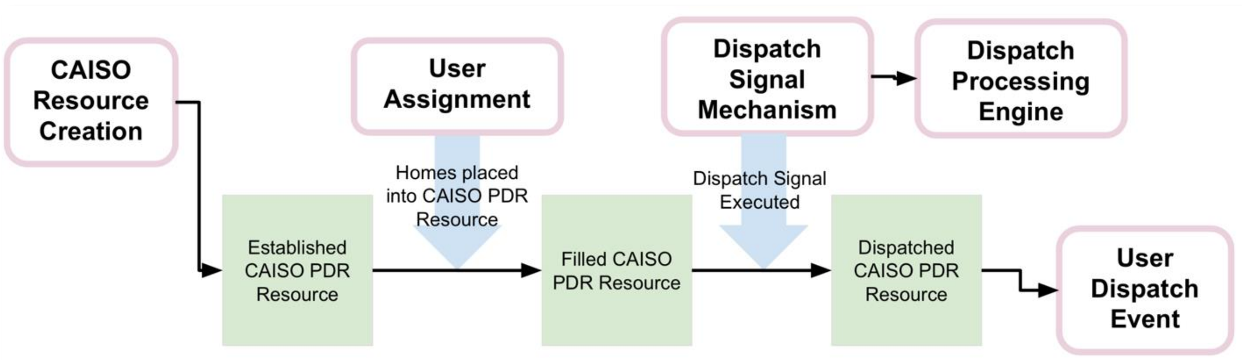
Source: OhmConnect

Each #OhmHour, users responded by making behavioral changes (like turning off lights), as well as by taking automated actions, which involved connecting their smart devices (such as Wi-Fi thermostats and smart plugs) to the OhmConnect platform to create connected devices. Users with connected devices enabled OhmConnect to automatically turn off those devices during #OhmHours, providing even deeper energy savings during DR events. For the biggest #OhmHour of the project, OhmConnect turned off more than 6,000 devices.

#OhmHour User Dispatch

For every #OhmHour, users were notified of the DR event via email and text messages. This notification process was called user dispatch, and on the backend involved three separate forms of dispatch signals: market awards, partner dispatch, and a manual signal. Every signal triggered the #OhmHour planning process, which queued users to receive an #OhmHour notification (Figure 3). Appendix A contains a detailed user dispatch diagram, and the section below provides a high-level overview of the user dispatch diagram used in this project.

Figure 3: OhmConnect User-Dispatch Diagram



OhmConnect notifies users of DR events through a dispatch mechanism that involves internal processes as well as interaction with the California ISO.

Source: OhmConnect

Dispatch Signals

OhmConnect received dispatch signals to trigger the #OhmHour planning process. Therefore, dispatch signals essentially prompted the timing of #OhmHours. OhmConnect leveraged three dispatch signal mechanisms for this project — market awards, partner dispatch, and manual signals — and each mechanism integrated different market and transactive signals to activate #OhmHours.

- Market awards: OhmConnect monitored day-ahead California ISO market prices and used these prices to inform dispatch signals. Specifically, the dispatch signals were an output of market prices and a price threshold that changed hourly. Market-award resources were defined as a collection of users (otherwise known as locations) that all belonged to the same sub-load aggregation point (Sub-LAP). OhmConnect chose which users within a Sub-LAP to assign to which resource. Because resources were geographically based, each resource could experience a different day-ahead market clearing price depending on the location of the resource. Therefore, OhmConnect could receive several market-based dispatch signals for an #OhmHour that spanned the same timeframe (six resources could each independently receive a market award for Friday from 7 pm-8 pm). For this project, OhmConnect monitored California ISO markets for dispatching #OhmHours, but payments came directly from California Energy Commission funds and were therefore separate from the wholesale energy markets.

- Partner dispatch: OhmConnect created a process within its dispatch signals to allow for partner dispatch as a priority between market awards and manual awards. For this project, the primary partner dispatches came from the main subcontractors: the Electric Power Research Institute (EPRI) and UCB.
- Manual signal: OhmConnect planned all manual awards, which were independent of external dispatch triggers. For example, rather than being based on a market signal, OhmConnect determined exactly when internal awards occurred and which users would receive the #OhmHours. Manual signals could dispatch users based on sub-LAP (a geographic indicator), average #OhmHour reductions, or incentive research status (discussed further in Chapter 4). OhmConnect also incorporated an automated top-up process that automatically planned and dispatched #OhmHours when a user had not been dispatched for a specified number of days. These top-ups would help drive high engagement with users by ensuring that they regularly participate in #OhmHours.

Dispatch Planning

When OhmConnect received a dispatch signal, it triggered the #OhmHour dispatch planning process. The planning process identified the starting and ending dates and times for the dispatch, and it identified all users who could be eligible to participate in the #OhmHour. For example, a market-award planning process identified all users who were in the resource that received a market award.

Users were eliminated from the specific #OhmHour dispatch based on set constraints:

- #OhmHour notifications were disabled.
- #OhmHour had already been planned for the same day.
- #OhmHour would exceed the maximum number of #OhmHours a user was willing to receive in a seven-day period.
- Necessary parameters were unknown (such as, zip code).

All other users were eligible to participate in the #OhmHour and therefore comprised the dispatch group. These users were queued up to receive dispatch notifications corresponding to the original dispatch signal.

Dispatch Process

Once a dispatch was planned, its execution involved notifying users of the #OhmHour and ensuring that devices responded to the event. For notifications, users received both an email and text message alerting them to the event both one day and one hour prior to the actual event. The day-ahead notification signaled to users to expect a dispatch in the following day at a specific time and for a specific time interval. The day-of notifications were sent to users generally within one hour prior to the dispatch time and prompted users to take action to lower their energy usage for the duration of the #OhmHour. In addition, the dispatch notification triggered the powering down of any connected devices that users had linked to the OhmConnect platform. The devices would likewise remain powered down for the duration of the #OhmHour. Dispatches of both devices and notifications occurred through a set of auto-scaled Amazon Elastic Compute Cloud (EC2) servers.

When the #OhmHour ended, OhmConnect ensured that all connected devices that were linked to the platform turned back to their original states. For example, any devices that were originally on were turned back on at the end of the #OhmHour. This process also ran via the auto-scaled Amazon EC2 servers.

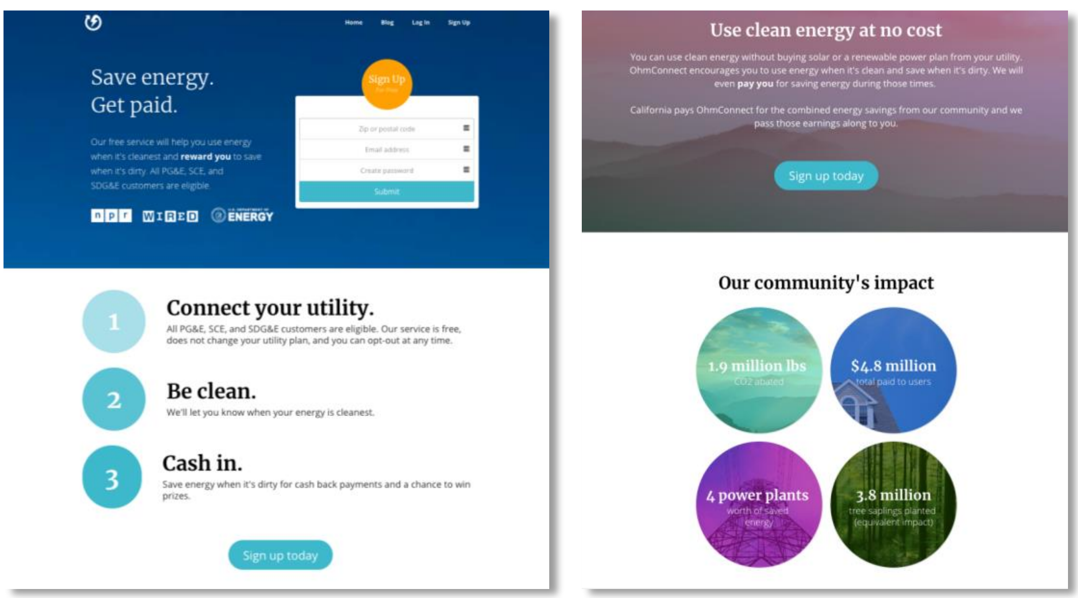
Improving the Platform to Increase User Participation

OhmConnect upgraded its platform for this research to acquire and enroll users in the project, as well as to enable new users to clearly visualize their DR participation and #OhmHour impact. The changes included new developments on the following pages: Landing Page, Dashboard, Teams, Device Connections, and Store.

Landing Page

The landing page — www.ohmconnect.com — was the first interaction that potential new users had with the OhmConnect platform. To successfully drive user participation for this project, OhmConnect designed its landing page to ensure it was engaging and clearly explained how OhmConnect worked. Most importantly, the new landing page established trust between OhmConnect and a new potential user as a way to drive user participation. Figure 4 highlights OhmConnect's most recent landing page, which was designed based on upgrades made to the platform for this project.

Figure 4: OhmConnect Landing Page



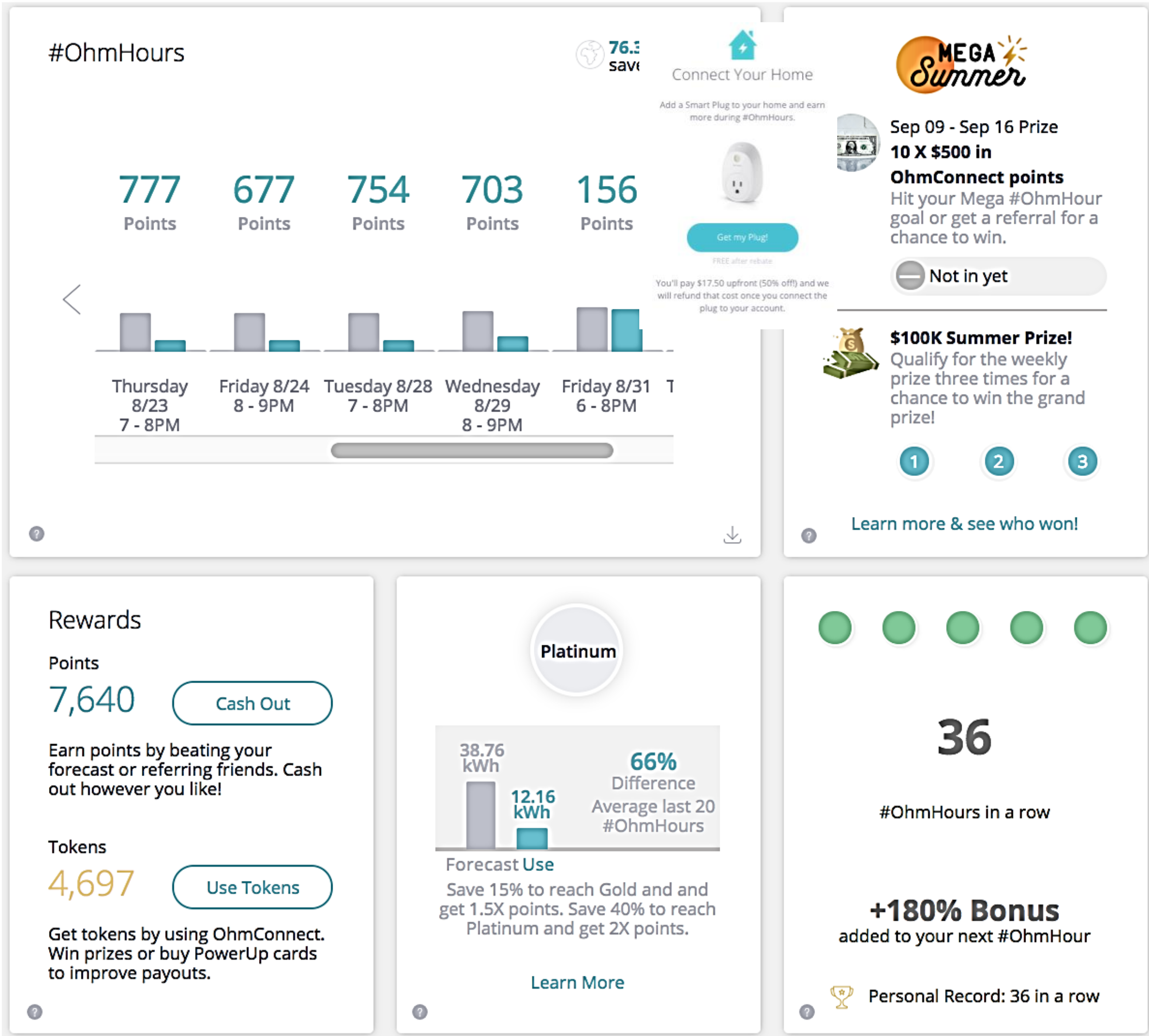
OhmConnect upgraded its landing page for this project**. The top half of the landing page (left) clearly explains how the product works, and the bottom half (right) highlights the environmental and clean-energy benefits of participating in OhmConnect.**

Source: OhmConnect

Dashboard

The dashboard was the main page OhmConnect users referred to when tracking their #OhmHour performances and how much money they had earned to date on the platform (Figure 5).

Figure 5: OhmConnect Dashboard



OhmConnect users who perform well on multiple events in a row receive a Streak (bottom right), which increases with each successful event, and users who performwell on average over the previous 20 #OhmHours increas in Status Level (bottom middle). Streaks and status levels each add a bonus to the number of base points users receive.

Source: OhmConnect

OhmConnect's primary mechanism of customer engagement was based on payouts to users via a point system (Figure 5, top left). In this system, each point was worth $0.01 (provided by a grant with the California Energy Commission [CEC]). Users could request a payout by redeeming their points at any time. Points could be redeemed for cash (via PayPal), OhmConnect store credit, or charity donations.

The payments to users were determined by a combination of energy reductions as well as engagement activities:

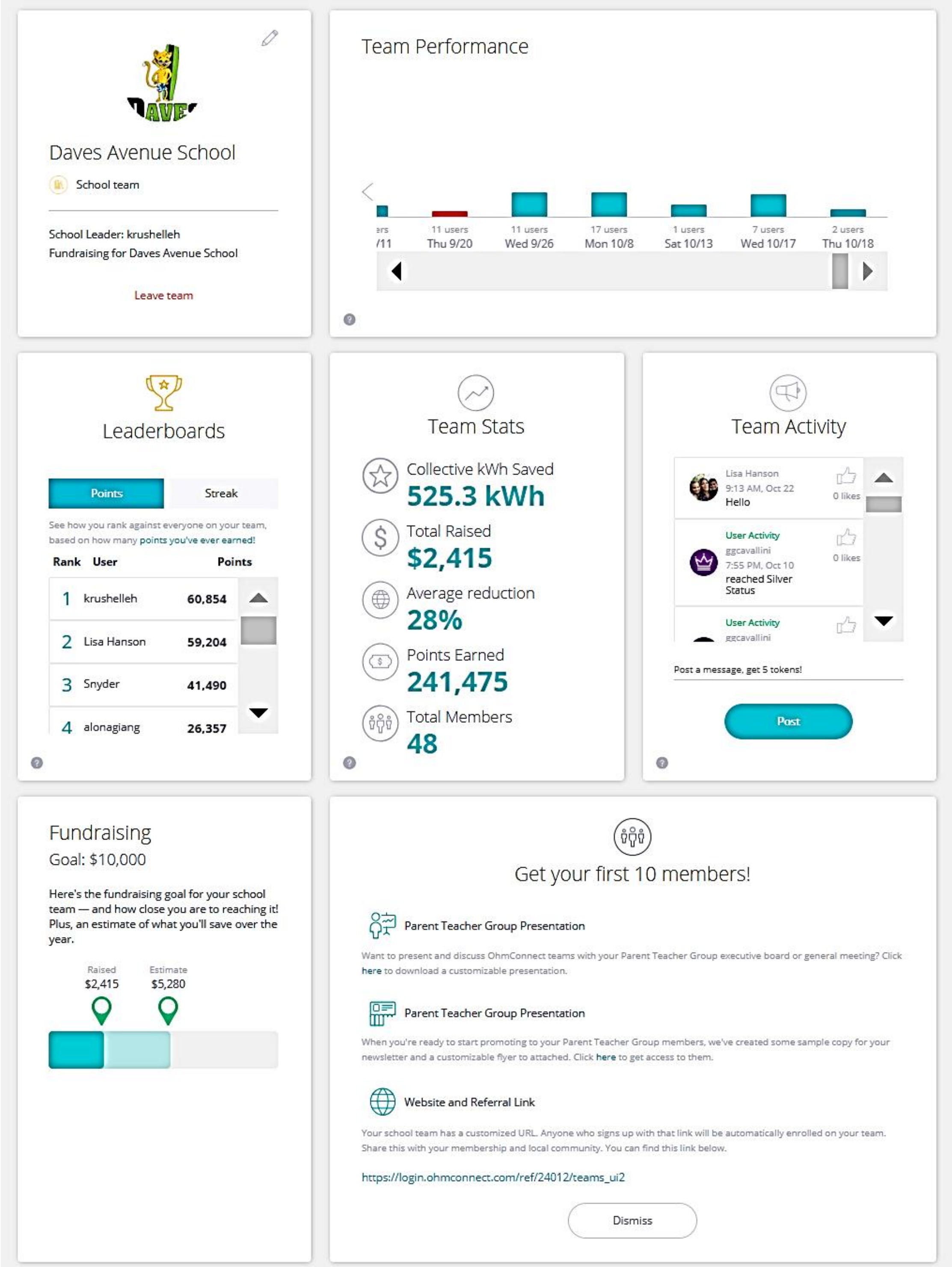
- Engagement payments: These payments were bonuses for users who engaged with the project, and for users who referred others to join the OhmConnect platform. Some examples of these types of payments include payments for reaching certain levels within the platform, responding proactively to other users on forums, connecting additional devices for automation, and referring other users to the platform.
- Energy reduction payments: Users were rewarded per event for each kilowatt-hour (kWh) reduced.

For this project, OhmConnect motivated users by using proven game and affinity mechanics, such as Streaks (the number of events an OhmConnect user performs well on in a row) and Status Levels (a user's average electricity usage reductions across all #OhmHours), both added a bonus to their next payment of #OhmHour point earnings. For example, Streaks (Figure 5, bottom right image) tracked how many #OhmHours in a row a user successfully reduced his or her energy consumption below the baseline. Status levels (Figure 5, bottom middle image), which go from Carbon through Bronze, Silver, Gold, and Platinum, were awarded based on a user's average energy reductions during #OhmHours, with increasing Status at higher average reductions. Both Streaks and Status Levels gave users additional rewards (based on a percentage bonus) on their #OhmHour performance. Data from Status Levels and Streaks were not analyzed for this project but will be relevant in future research on residential DR customer engagement.

Teams

OhmConnect's Teams feature provided a social and donation component to participating in energy reduction events. Sub-features of the team feature included aggregating energy reductions by the team, earning badges specific to teams, and receiving bonuses by growing the team (Figure 6). The Teams feature was key for partners associated with this project, including the Sierra Club, the National Wildlife Federation, the March of Dimes, and local schools, as further described in Chapter 3. Project participants who joined teams could aggregate their OhmConnect earnings and donate them toward a cause, school, or OhmConnect non-profit partner of their choice.

Figure 6: Teams Feature



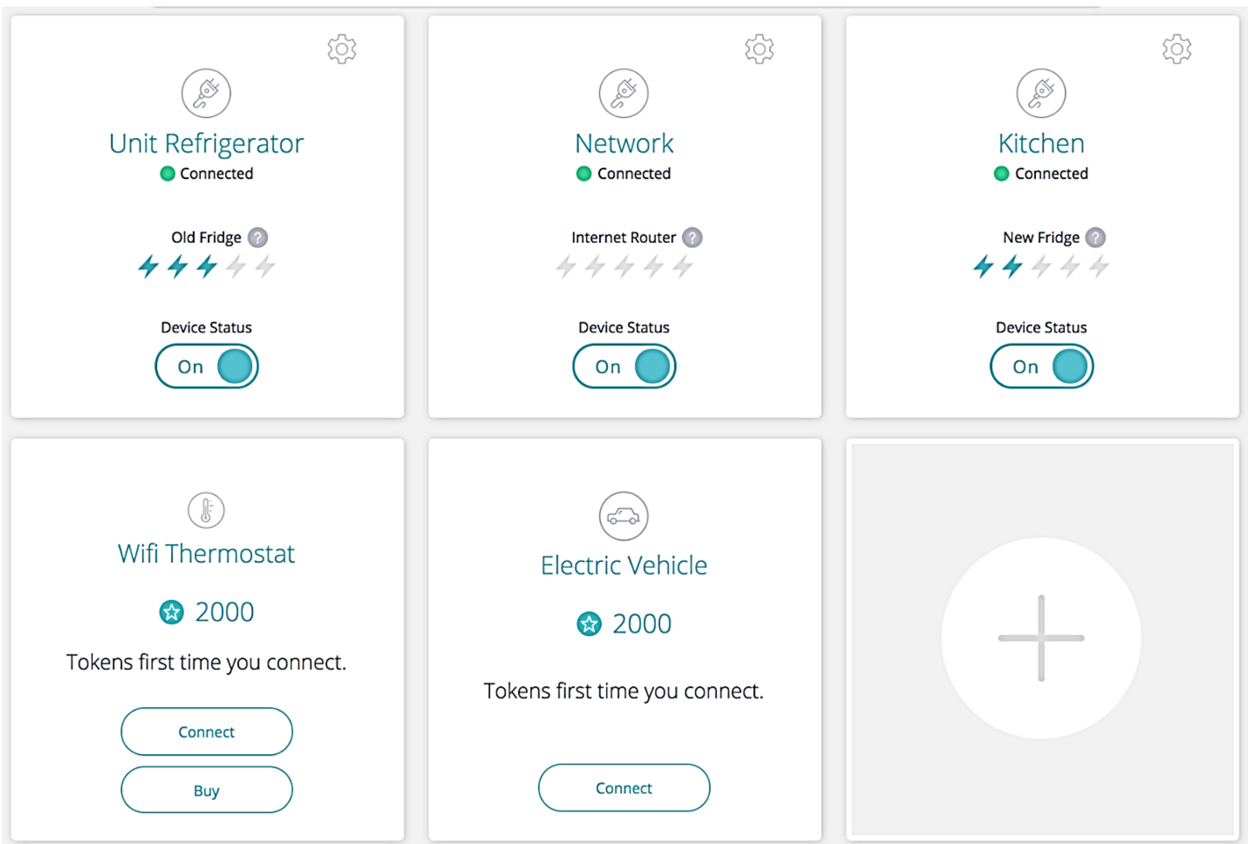
OhmConnect's Teams feature encourages a group of users to join others to increase their impact during #OhmHours. With a team, users are more motivated to save electricity as a community as they work toward a common goal.

Source: OhmConnect

Device Connections and Store

As described above, OhmConnect users could automate their #OhmHours by connecting smart devices to its platform. These devices included smart plugs by TP-Link and Wi-Fi thermostats by Schneider Electric, Honeywell, Venstar, Wiser Air, ecobee, and Energate. Over the course of the project, OhmConnect expanded its connected device page to simplify the automation process for users. In its most recent version (Figure 7), devices show if they are connected to a user's #OhmHour (green "Connected" icon), their reduction potential (blue lightning bolt icons), and their status ("On" slider). While this project provided rebates for smart plugs and Wi-Fi thermostats (described further in Chapter 3), OhmConnect users could also connect electric vehicles and other smart devices to their OhmConnect account for dispatch during #OhmHours.

Figure 7: OhmConnect Connected Devices Page

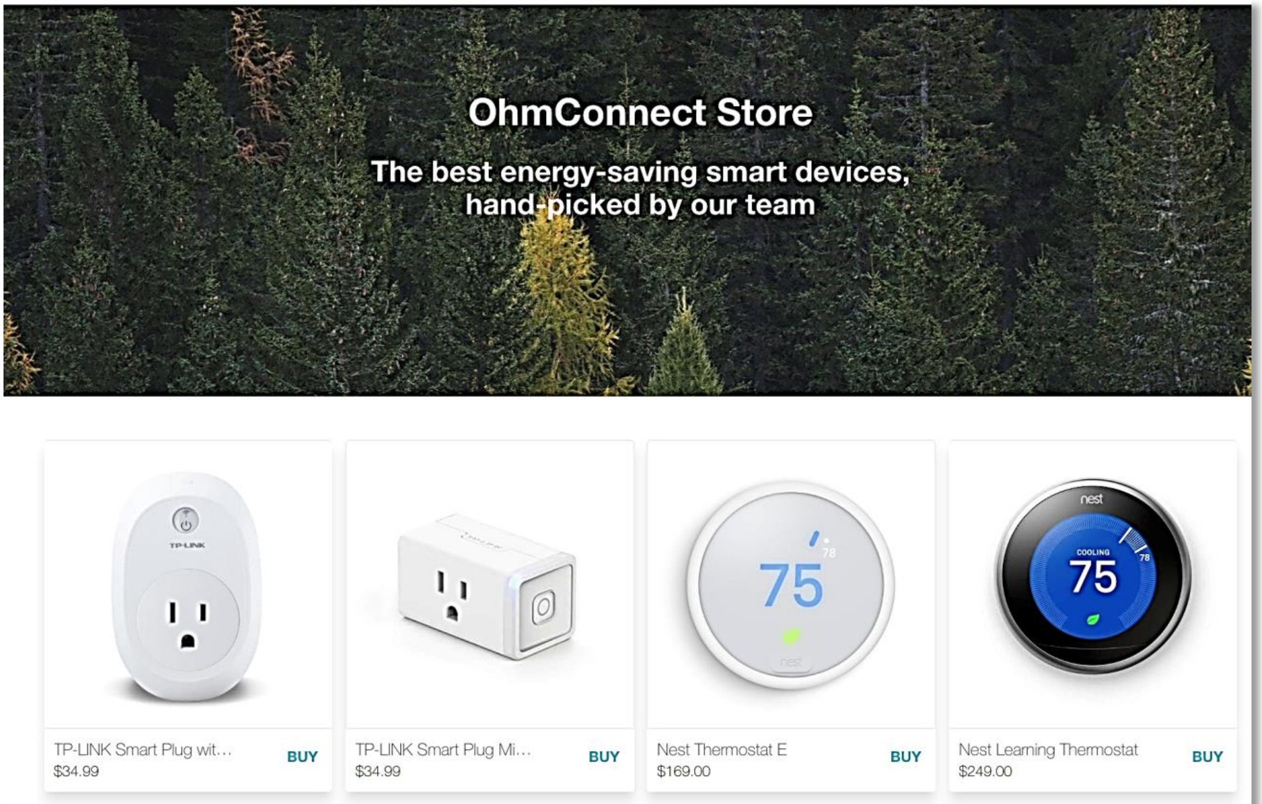


OhmConnect users could connect different devices in their accounts, automating the #OhmHour experience. Devices were highlighted on an OhmConnect dashboard that notified the user of device status, as well as potential energy consumption.

Source: OhmConnect

To encourage OhmConnect users to automate their #OhmHours, OhmConnect upgraded its Store for this project (Figure 8). OhmConnect sold all project energy-saving devices in its OhmConnect Store as a means to simplify the purchasing experience for project users. OhmConnect also streamlined its shopping process. For example, users could cash out their points and automatically redirect those earnings to the OhmConnect Store. Furthermore, OhmConnect emailed users connected device rebate links that automatically redirected users to the store.

Figure 8: OhmConnect Store



The OhmConnect Store sells devices manufactured by different hardware partners.

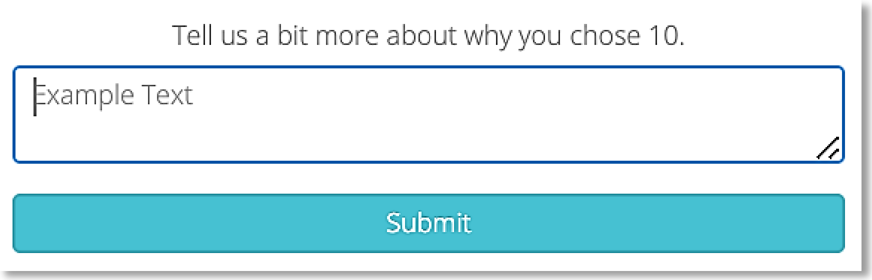
Source: OhmConnect

User Feedback

OhmConnect regularly solicited comments from its users to determine if they would recommend a product, what changes they would like to see on the platform, and how they generally viewed OhmConnect. These comments were submitted to OhmConnect through a Net Promoter Score (NPS) survey, which asked users to rate how likely they were to recommend OhmConnect to others (see Appendix B for a detailed report on how NPS is calculated). Net Promoter Score is a common metric for customer-facing products and provides a quantitative value of a company's customer relationships. It ranges from -100 to 100. Generally, any score above a 0 is a "good" score and anything above 50 is "excellent." Negative scores (i.e., scores below 0) indicate that users are unhappy and thus not likely to refer the product to others. From June 1, 2018 through August 31, 2018, OhmConnect's average NPS was 34.

In addition to the quantitative NPS survey, OhmConnect solicited qualitative feedback from users when they responded to the NPS email prompt. When users selected a quantitative value for how likely they were to recommend OhmConnect, they were redirected to a page that encouraged them to provide more information (Figure 9).

Figure 9: Net Promoter Score Qualitative Feedback



OhmConnect users have the opportunity to provide written feedback after submitting a quantitative response to the NPS survey.

Source: OhmConnect

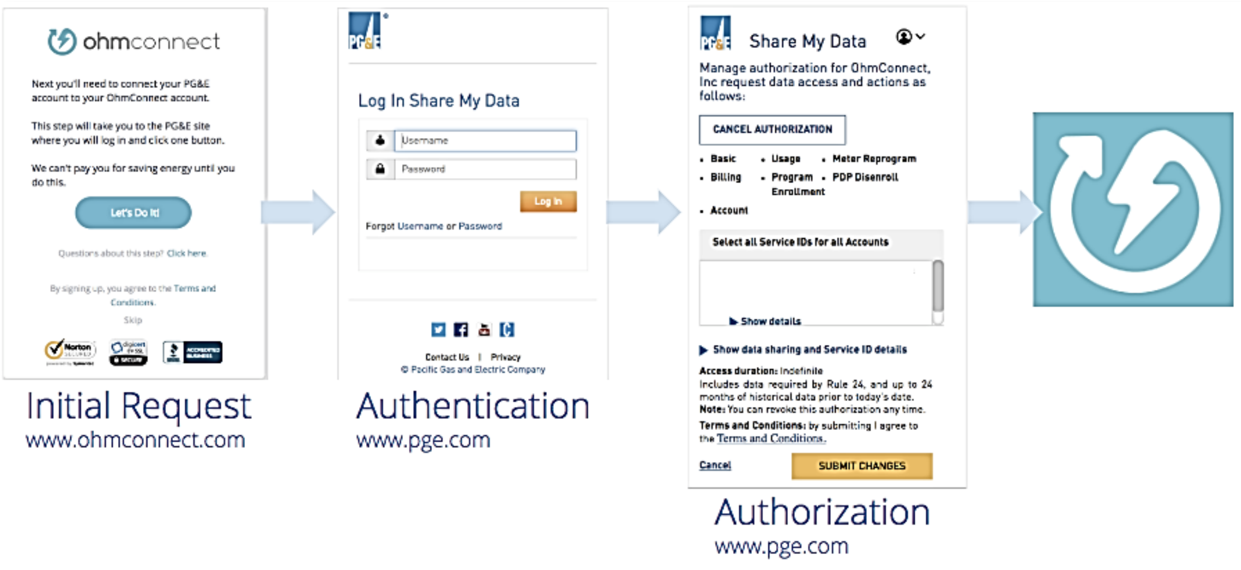
As an open-ended prompt, users responded with a range of feedback. For example, a Silver user who scored OhmConnect at a 10 stated: "It's so easy to get below the forecast for basically free money. Thanks." However, a Gold user who scored OhmConnect at an 8 pointed out: "Some times are just too inconvenient to have A/C off with a small child." Those who scored 6 and below often commented on how #OhmHour baselines were hard to beat, that they occurred at inconvenient times, or that they did not pay out enough money. To sort through qualitative survey responses, OhmConnect tagged NPS feedback and used the comments to guide product changes and improve users' experiences. NPS comments varied across current issues including general positive and negative feedback and confusion with the OhmConnect product (such as, with Streak or Status levels).

Sharing Data for Validation and Analysis

For OhmConnect to quantify reductions during #OhmHours, users had to share their energy consumption data. During the project there were multiple iterations of the data-sharing process (Appendix C for information on Green Button Connect, the original data-sharing method used for this project). The most recent data authorization process, Open Authorization (OAuth), is the most efficient and safest data authorization process to date (Figure 10).

The Open Authorization Click-Through (Click-Through) authorization process, approved by the California Public Utilities Commission in Resolution E-4868, provides customers with a streamlined and simplified means to share their data with third parties. The process provides customers, third parties, utilities, and policymakers with a safe and secure method to authorize smart-meter data sharing. The Click-Through process uses OAuth 2.0 technology and is similar to what many website-service providers use to allow customers to create web accounts using credentials from another service such as Google or Facebook. OAuth 2.0 is incorporated into the Green Button Connect My Data standard and Click-Through simply integrates the best practices of a streamlined user experience.

Figure 10: Click-Through Example



The Open Authorization Click-Through authorization process enabled OhmConnect users to share their energy consumption via their utility in a streamlined fashion.

Source: OhmConnect

OhmConnect observedthat the new Click-Through process has improved customer conversion rates from signups (that is, without utility smart-meter data shared with OhmConnect) to active users (that is, utility smart-meter data shared with OhmConnect and available), due primarily to customer familiarity with an OAuth flow and the automatic approval of the data-sharing agreement once the customer completes his or her authorization. OhmConnect has implemented the Click-Through process for each of the three California investor-owned utilities (IOUs) and recommends that third-party DR providers use Click-Through for future data sharing.

Data Shared

For this project, OhmConnect's analysis used customer energy consumption data, earnings on the OhmConnect platform, geographic location, and connected device status. For the incentive experiments (further described in Chapter 4), the analyses also included DR event messaging.All individual customer data analyzed during the project was anonymized to ensure user privacy.

Specific data included in this experiment is outlined here and described in detail in Appendix D:

- User: ID number, DR earnings, utility, geocoded location, energy usage (15-minute interval data)
- DR Events: Start/end time, type of dispatch, messaging
- Devices: Connected device manufacturer (for example, ecobee, TP-Link), status (on/off)

Data Privacy and Destruction

For all data utilized and analyzed in This projectthis project, OhmConnect signed non-disclosure agreements to make sure any data shared with subcontractors (including UCB and

EPRI) would remain confidential. Moreover, no personally identifiable information was used in this research, and all data shared was used solely within the scope of the project. Finally, OhmConnect aggregated results from this research and analysis to ensure that any findings shared with the California Energy Commission guaranteed user privacy.

All data were stored in secure locations using standard privacy procedures, and OhmConnect ensured that only approved researchers had access to the data. When the data are no longer needed for academic research (finalized and published journal articles), subcontractors remove data from their servers.

Conclusion

By updating the OhmConnect platform to ensure that users remained engaged in DR and, more specifically, during #OhmHours, OhmConnect encouraged residential utility customers to reduce their electricity usage during peak-demand periods and sell those reductions in the state's real-time wholesale energy markets. This user engagement greatly improved OhmConnect's ability to acquire and enroll users in new and innovative ways, allowing OhmConnect to increase user participation in DR events.

CHAPTER 3: OhmConnect User Acquisition

For this project, user acquisition was defined as the act of getting users to sign up for OhmConnect. OhmConnect focused on acquiring new users not only to increase residential customers' contributions to DR events, but, importantly, to ensure that there would be adequate data for the experiments described in Chapter 4. Based on the number and type of experiments conducted, OhmConnect determined the appropriate total sample size for all treatment and control groups to be 12,500.

To meet this goal, OhmConnect structured user-acquisition experiments to determine the relative cost and effectiveness of each method.

This chapter covers both direct and indirect acquisition methods explored in this project, describes the overall acquisition cost of each method, and provides results of the research. In this research, direct-user acquisition methods relate to paid-user acquisition through a variety of channels; indirect-user acquisition relates to referrals.

Direct-User Acquisition Methods

Direct-user acquisition is when OhmConnect acquires new users directly through paid channels. An example of direct-user acquisition is when a new user sees an advertisement for OhmConnect online, clicks on the ad, and is taken to the OhmConnect sign-up page. The implication of direct, therefore, is that a user is directly linked to the OhmConnect home page to create an account. For direct-user acquisition methods, this project experimented extensively with:

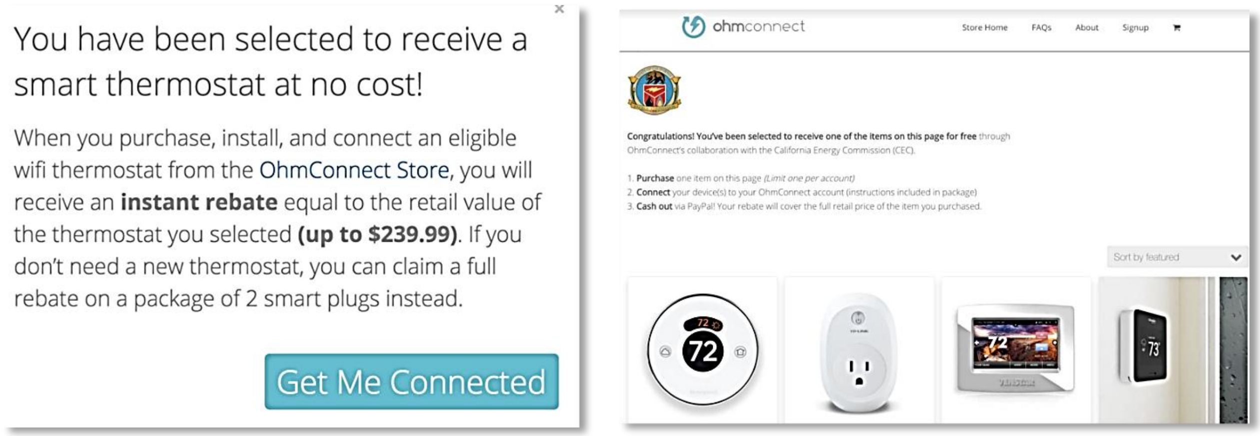
- Automation incentives.
- Social media campaigns.
- Public relations.
- Search engine optimization.
- Paid leads through digital marketing campaigns (sponsored ads).
- Partnerships and localized campaigns.

Automation Incentives

For This project, OhmConnect adjusted device rebates and incentive structures to better encourage residential utility customers to sign up for OhmConnect after purchasing a discounted smart device. Once users purchased devices, they were encouraged to join OhmConnect and connect their smart devices like Wi-Fi plugs and thermostats to the platform to gain deep usage reductions during #OhmHours. With automated devices, users did not have to be present to participate in an #OhmHour event, making participation both easy and effective.

Automation incentives in this project covered rebates for specific brands of Wi-Fi plugs and thermostats sold through the OhmConnect Store. State funding was used to discount hardware devices by TP-Link, Schneider Electric (Wiser), Honeywell, Venstar, ecobee, and Energate.

Figure 11: Messaging for Smart Device Incentive Program



New OhmConnect users were incentivized to purchase smart devices and automate their #OhmHour experiences.

Source: OhmConnect

Automation incentive campaigns were specifically covered in this project.

- Technology incentives encouraged users: OhmConnect launched a promotional giveaway of free devices to encourage users (discussed in detail in Chapter 4). OhmConnect also overhauled its device rebate and incentive structure to attract new users and encourage existing users to purchase and connect their smart devices. Users were incentivized to sign up and get connected by communicating content messages (Figure 11).
- Thermostat Rebate Program: The Thermostat Rebate Program encouraged the purchase of a smart thermostat or smart plugs by allowing qualifying users to get a free smart device. Users received a 50-percent discount on initial smart device purchases and additional 50-percent rebates once their smart devices were installed and connected to OhmConnect.
- Special Campaign: OhmConnect and Schneider Electric announced a partnership to build an intelligent network of Schneider Electric's Wiser Air smart, Wi-Fi-connected thermostats in the Aliso Canyon region in response to a natural gas storage-facility closure. Wiser Air thermostats respond dynamically to changing grid conditions and this effort allowed OhmConnect to pay Southern California utility customers for the resulting reductions.

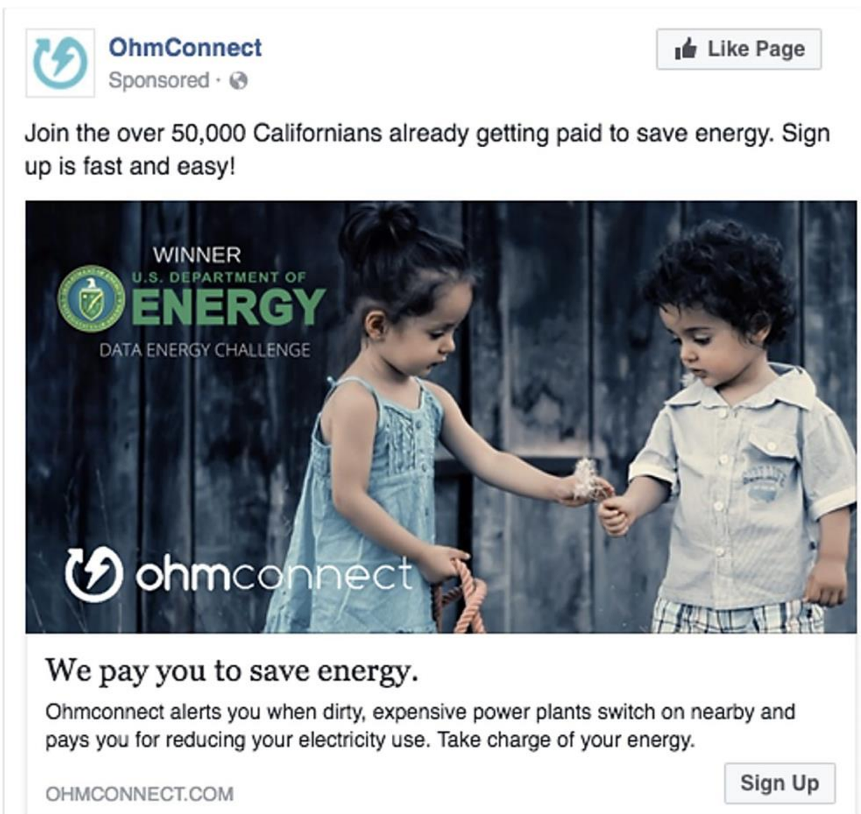
Social Media Campaigns

Social media forums like Reddit and Facebook allow companies to buy ad campaigns that target specific demographics. OhmConnect used these social media campaigns for this project to specifically increase marketing potential, which is marketing that spreads awareness, educates prospects, and cultivates brand or buzz for the product. Top-of-funnel marketing is predominantly content marketing that strives to turn incoming prospective leads into customers by advertising in groups or sites that prospective leads are visiting because they are already interested in a similar topic or product.

Social media campaigns launched as part of this project included:

- Facebook: The Facebook social media campaign approached user acquisition through two ways — advertisement and ease of signup. For ads, Facebook users saw messages highlighting OhmConnect that explained how residential utility customers could get paid for saving electricity while helping the environment (Figure 12). Through this project, OhmConnect placed three targeted ads on Facebook. For ease of signup, OhmConnect developed a framework for the home page that included an option for users to sign up using their Facebook accounts. This signup page procedure saved user time.
- Reddit: Using Reddit advertisements, OhmConnect reached new users who were interested in the latest technology, news, creative ideas, and trends. OhmConnect launched a social media campaign to run advertisements on Reddit that were similar to their Facebook advertisements, focusing on top-of-the-funnel marketing.

Figure 12: OhmConnect Facebook Advertisement



OhmConnect created three advertisements on Facebook

Source: Facebook

Public Relations

To increase awareness around the OhmConnect product and brand, OhmConnect engaged the public through blog posts, conferences, and other forms of media. These direct-user acquisition methods were predominantly in the form of thought leadership and writing articles, which typically do not require marketing fees.

Specific examples of acquisition strategies via public relations applied to this project.

- LinkedIn Articles: OhmConnect posted several blog posts on LinkedIn to promote thought leadership as a consumer-friendly energy company. OhmConnect's CEO, Matt Duesterberg, wrote two articles for this project — *Is the Energy Industry Asking the Right Questions?* and *Understanding what the Customer Wants* — to emphasize the importance of customer participation and experience with their electric utilities.
- Publishers/Press (earned media): Earned media is media gained through news coverage, company press releases, and other forms of publicity that are not directly paid for. This proved to be another useful strategy in direct customer acquisition for this project. In March 2017 a National Public Radio (NPR) news release showcased the work done at OhmConnect (Figure 13). In its news segment an OhmConnect participant described how much his family cut back on its electricity usage. The NPR segment emphasized OhmConnect's high number of users — about 100,000 — and, at one point, described its environmental benefit as getting "the power equivalent of 11,000 homes off the grid."

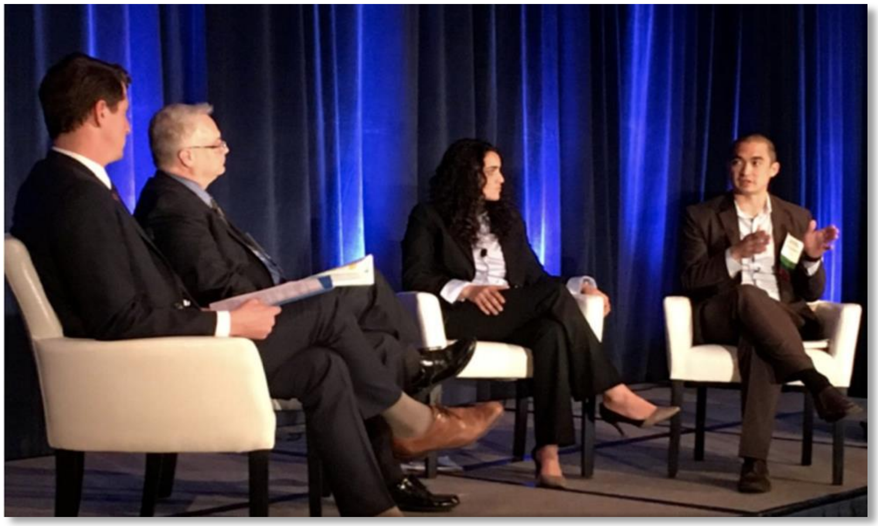
Figure 13: OhmConnect National Public Radio Segment

OhmConnect was featured on NPR's Morning Edition – "Energy Savings Can Be Fun, But No Need To Turn Off All The Lights."

Source: NPR

- Expert Panels: OhmConnect also earned media attention by participating on expert panels to discuss the future of energy and its impact on the grid. OhmConnect's CEO, Matt Duesterberg, participated as an expert in the panel "Putting It All Together: How Advanced Technologies Support an Evolving Grid" at the 2017 Advanced Energy Economy's Pathway to 2050 event (Figure 14). As a result, the online journal *Government Technology* highlighted OhmConnect in its article entitled "How Can Advances in Technology Contribute to Evolving Electrical Grid?"

Figure 14: OhmConnect Featured on Expert Panels



Matt Duesterberg (far right) on the *Advanced Energy Economy's Pathway to 2050* expert panel.

Source: Government Technology

- Instagram: Another social media tool OhmConnect used for customer acquisition was Instagram (Figure 15), a mobile photo-sharing application that allows users to share their photos. OhmConnect used this channel to educate users on ways to save electricity and provided a path for users to sign up directly for OhmConnect.

Figure 15: OhmConnect Instagram Advertisement

Instagram "Energy Saving Tip," which users can access by clicking through the app that connects to OhmConnect

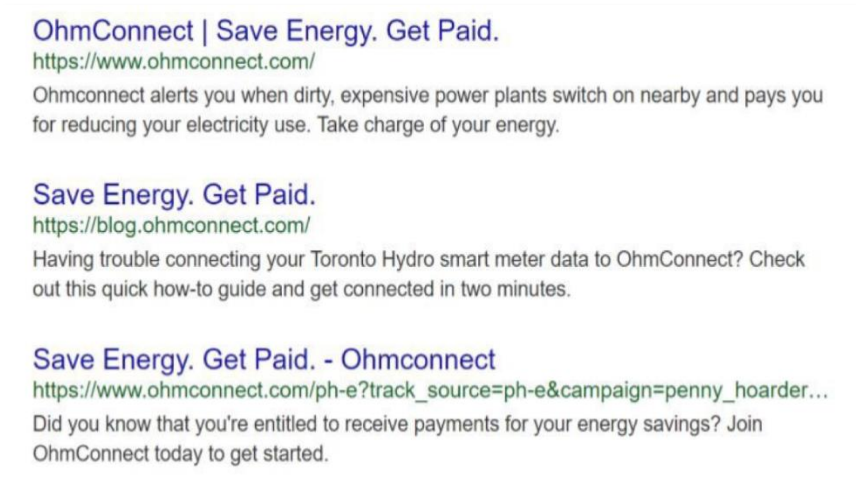
Source: Instagram

Search Engine Optimization

Search Engine Optimization (SEO) tabulates how often OhmConnect appears in online searches through search engines like Google, Yahoo, or Bing. Unlike other social media campaigns or paid leads, this process is free and creates increased natural traffic to the

OhmConnect site. Through this project, OhmConnect increased SEO to enable users to easily find the platform online, which included refreshing the OhmConnect blog. Additionally, OhmConnect updated its content architecture to improve its search-engine capabilities. This maximized the structure and order of links in online searches and prioritizes direct links to OhmConnect's site (Figure 16). This improved OhmConnect's presence on the Internet.

Figure 16: OhmConnect Search Engine Optimization



List of OhmConnect links that appear in an online search through Search Engine Optimization.

Source: Google

Paid Leads

OhmConnect utilized marketing organizations to generate paid customer leads, which is a strategy that targets promising potential utility customers. Paid leads helped identify potential users via social media tools and the marketing service provided data analytics to help focus advertising campaign efforts in channels with higher user-acquisition rates. Paid leads therefore focused on media strategies that helped OhmConnect reach customers at higher return and at a lower price.

Examples of paid leads include 3Q Digital and Clickbooth, both of which are digital advertising-focused customer acquisition sites. Specifically, through paid leads, OhmConnect improved Cost-Per-Action and Cost-Per-Click prices by identifying customers that were more likely to sign up using targeted advertising.

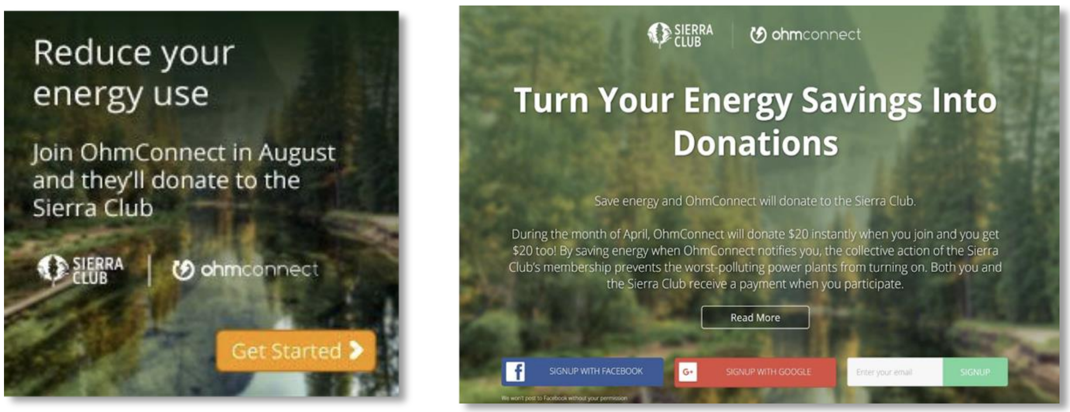
Partnerships and Focused Campaigns

OhmConnect encouraged users to access its "Teams" function so they could work together to donate their points to specific, eligible groups (such as, nonprofits, schools). Through Teams, users were able to strengthen connections with their local communities. The Teams feature also provided a social context for participation in energy-reduction DR events whose proceeds could also benefit causes or local institutions users cared about. As a result, OhmConnect found value in partnerships with nonprofit environmental groups and focused campaigns that used Teams as a means to acquire new users.

For this project, nonprofit partnerships included the Sierra Club and the National Wildlife Federation. OhmConnect collaborated with the Sierra Club to increase awareness and participation in energy conservation. To leverage this partnership, OhmConnect sent a newsletter to the Sierra Club's California email list to join the Sierra Club's OhmConnect team.

Figure 17 shows specific messaging OhmConnect used when marketing OhmConnect to a Sierra Club member. The partnership with the National Wildlife Federation had a similar structure.

Figure 17: OhmConnect Sierra Club Campaign



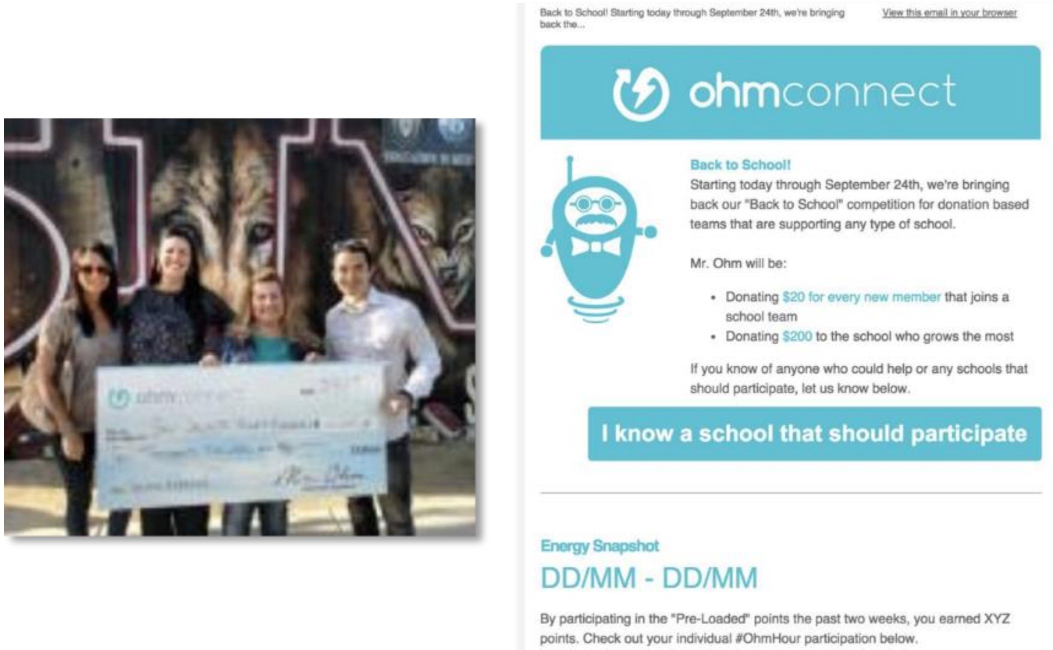
OhmConnect created a dedicated sign-up page for its Sierra Club user acquisition campaign.

Source: OhmConnect

Similar to partnerships, OhmConnect leveraged focused campaigns for this project, targeting a specific group of users and focusing signups on a geographic region. Examples of focused campaigns applied through this project included:

- Back-to-School Fundraising**:** As OhmConnect's Back-to-School challenge, this competition was for donation-based teams supporting schools. This specific campaign was launched at three schools, and at these schools OhmConnect donated an additional $20 for each new user on a school-related team, and also donated an additional $200 to the school that acquired the greatest number of new users on a team (Figure 18).
- South California Localized Campaign: This campaign focused on social media efforts in Southern California to increase awareness and participation in Southern California Edison's (SCE) service territory. This campaign was in response to the Aliso Canyon incident — which limited the natural gas available to generate electricity in one area of the SCE service territory, and its purpose was to galvanize users to save electricity through OhmConnect.

Figure 18: OhmConnect Back-to-School Campaign



Back-to-School Fundraising Campaign, with CEO Matt Duesterberg providing San Jacinto Valley Academy a check for its overall savings from the program (left) and the OhmConnect mascot Mr. Ohm dressed up as a teacher for campaign messaging (right).

Source: OhmConnect

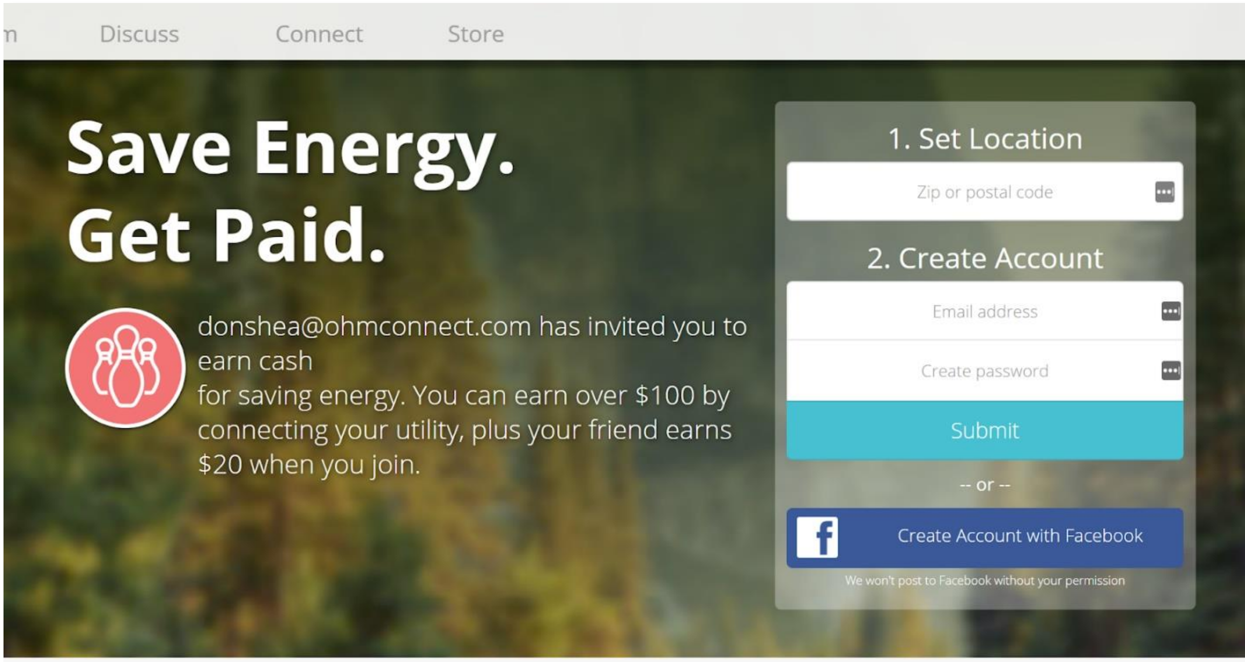
Indirect-User Acquisition Methods

Indirect user acquisition is when existing users refer new users to OhmConnect. For this project, existing users received incentives when their referrals completely activated their accounts; these incentives varied over the course of the project. For indirect-user acquisition methods, this project experimented specifically with a 20/20 referral program, tiered referrals, and a $20 flat referral rate.

OhmConnect Referral Process

- For referrals, existing users were provided a referral link unique to their accounts. They could share this link with their network via email or social media. When potential signups used this referral link, they were redirected to a splash page personalized for the existing user — the referrer (Figure 19). Once new users signed up via the unique splash page, existing active users were internally connected with the new signups, their referees (Figure 20).

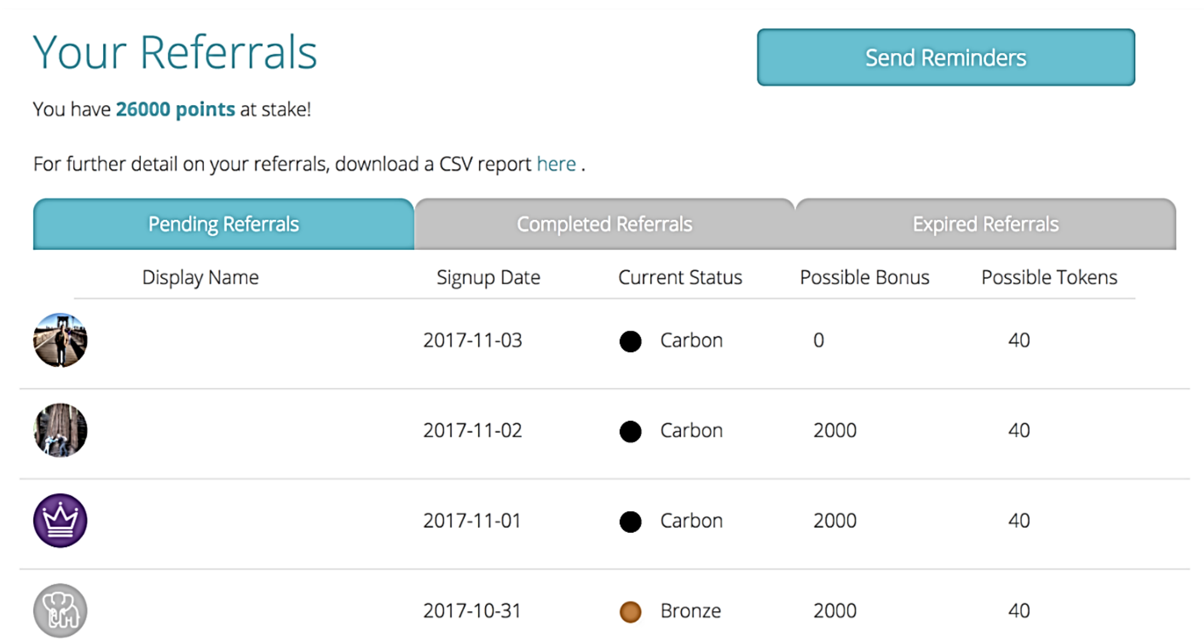
Figure 19: Referral Unique Sign-Up Page



Existing OhmConnect users receive a link to their personalized referral page. When sharing this link with potential new users, it is clear who the invitation was from and what the benefits from signing up can be.

Source: OhmConnect

Figure 20: OhmConnect Referral Dashboard



The OhmConnect Referral Dashboard can help existing users track who they've referred to the platform.

Source: OhmConnect

Referrers can use their referral dashboard to keep track of:

- The person referred.

- When each referral signed up.
- Highest status level (Carbon, Bronze, Silver, Gold, or Platinum) achieved by each referral.
- How many referral points and tokens they earned from each referral.

Once a referee became an active user (with a current status of Silver or greater), the referrer earned a referral bounty, or financial reward. These referral bounty incentives varied over the course of this project.

For this project, OhmConnect used three indirect acquisition methods — 20/20 Referral, Tiered Referral, and $20 Flat Referral — and ran referral experiments to determine the most effective incentive to increase the number of signups and improve the conversion rate to active users. For all three of these methods, existing active users were financially rewarded when they referred new users, though the amount and structure of the referral varied. Importantly, the referral bonus was only awarded when referrals actually connected their utility data to OhmConnect.

20/20 Referral

The 20/20 referral structure awarded the existing user a referral bonus of $20 and the new user a signup bonus of $20, regardless of the number of kWhs a new user saved. The $20 bonus was not awarded to either party until the new user successfully connected his or her utility account to OhmConnect.

Tiered Referral

The tiered referral structure enabled existing users to receive a bonus of up to $75 for referrals if certain criteria were met. This program provided incentives for increased kWh saved and frequent reductions per new user. Specifically, the existing user would receive:

- $5 when the signup converted to an active user, or when a new user reached Silver status).
- $20 when the new user reduced one kWh during a single #OhmHour.
- $50 for successfully saving electricity for 9 out of the previous 10 #OhmHours.

$20 Flat Referral

The $20 flat referral program focused on simplicity (in response to feedback from the tiered-referral program). The major difference between this program and the original $20/$20 program was that only the existing user earns a cash reward; the new signup does not earn a cash reward. This simplified structure of referrals was easier for users to understand and further encouraged them to provide additional referrals.

Results

20,294 users signed up for OhmConnect through the user-acquisition strategies described in this chapter. As of December 21, 2017, 16,363 of those users were still active. The majority of these users (approximately 16,700) came from either direct or indirect user-acquisition methods, while about 18 percent (approximately 3,600) came from organic, or unknown sources. Signup rates from unknown and known sources were correlated, which suggests unknown or organic signups may have resulted from direct or indirect user-acquisition methods, but the user did not identify the connection when signing up.

Marketing costs for direct-user acquisition methods came to $138,334 over 12 months; total cost per signup was on average $16.50, and total cost per active user was on average $44.52. Direct-user acquisition methods yielded a 37 percent conversion rate. Marketing costs for indirect-user acquisition methods, on the other hand, came to $94,981 over 12 months; total cost per signup was on average $11.45, and total cost per active user was on average $23.38. Indirect-user acquisition methods yielded a 49 percent conversion rate.

Table 1 outlines complete results from these user-acquisition strategies.

Table 1: Results From User-Acquisition Strategies

	Spend	Signups	Active Users	Conversion Rate	Cost Per Signup	Cost Per Active User
Direct	$138,334	8,381	3,107	37%	$16.51	$44.52
Indirect	$94,981	8,298	4,062	49%	$11.45	$23.38

OhmConnect's direct and indirect user-acquisition strategies varied in cost.

Source: OhmConnect

In general, paid leads appear to be a strong pathway for customer acquisition; the majority of the direct-user acquisition signups (5,281) came from that marketing channel. However, these users came at a high cost with only a 40 percent conversion rate. Moreover, the conversion rate was comparable with other direct-user acquisition methods so consequently may not be worth the additional cost.

Of the three indirect-user acquisition methods, the $20 Flat Program was most successful, as defined by its high conversion rate of 66 percent. The tiered referral structure had the lowest conversion rate at 40 percent and it also had the highest total spending (Table 2), making it the least successful indirect-user acquisition method.

Table 2: Indirect-User Acquisition Methods and Timelines

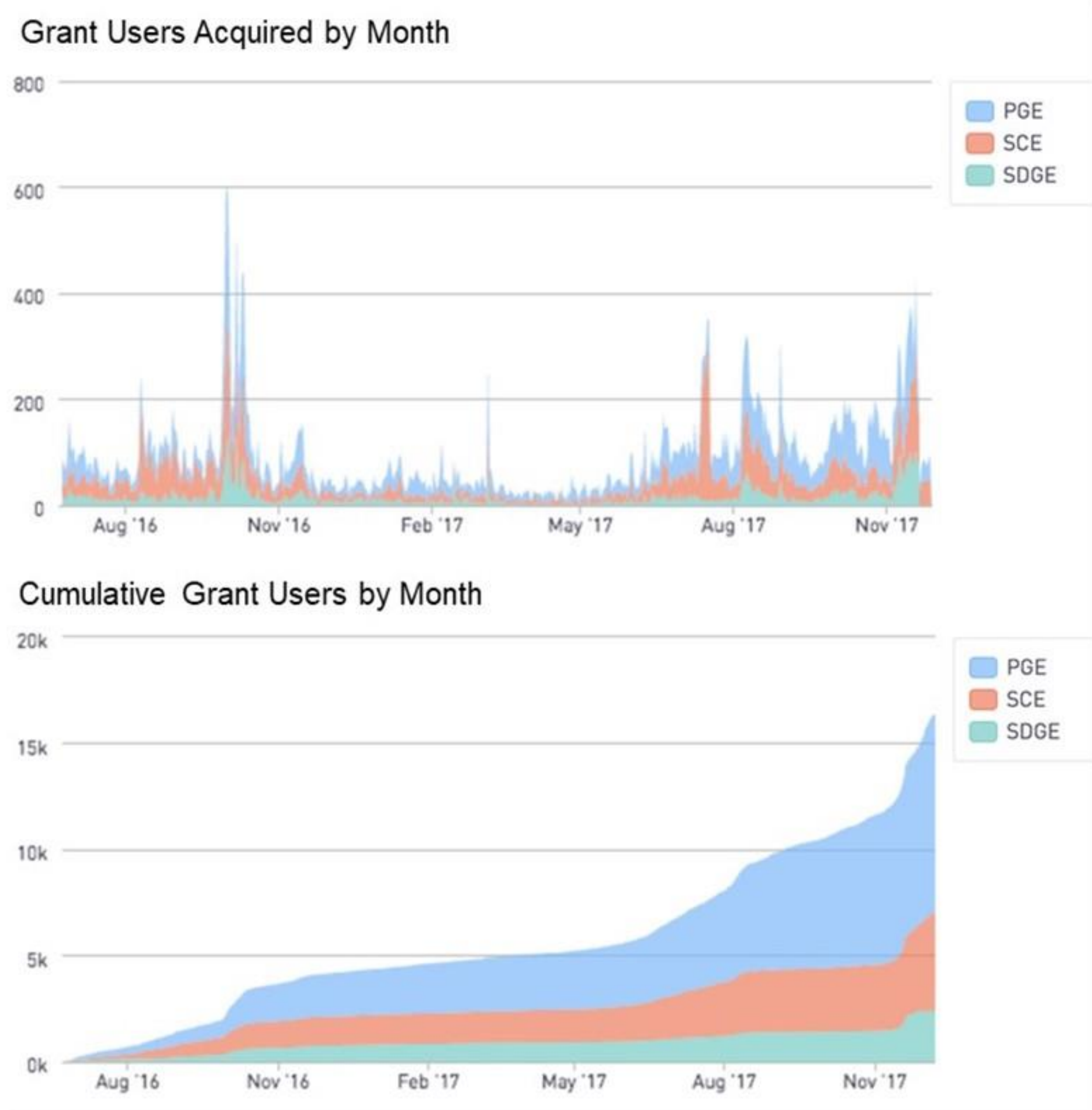
Method	Start Date	End Date	Active Users	Conversion Rate	Spend
20/20	6/24/16	11/16/16	1,436	44%	$27,916
Tiered	11/17/16	5/24/17	1,655	40%	$54,232
$20 Flat	5/25/17	8/6/17	971	66%	$12,333

OhmConnect's referral strategies yielded varying success based on the cost per active user.

Source: OhmConnect

Figure 21 summarizes user- acquisition over time, both by month (top) and cumulatively (bottom). The colors represent OhmConnect's user base in the three IOU territories — PG&E (blue), SCE (red-orange), and SDG&E (green).

Figure 21: Grant-User Acquisition Over Time, by Month



Results for user acquisition monthly

Source: OhmConnect

OhmConnect acquired a relatively large number of users at the beginning of October 2016 due to initial marketing of OhmConnect's product via focused campaigns. These campaigns noted the beginning of 12 one-month-long distinct experiments to research the impact of different direct-user acquisition methods. User acquisition remained relatively quiet until almost a year later in July 2017; this big increase in July is likely due to the push for paid leads at the end of the direct-user acquisition 12 one-month-long experiments. Moreover, a referral promotion after completion of the experiments in October/November 2017 resulted in the recent large number of acquired users (Figure 21, top). This promotion, the "Halloween Refer for Rebate Program" gave users a free smart device if their referrals reached Silver status by October 31, 2017. Of the 5,500 new users who signed up during this period, about 2,000 were from referrals.

The value of referrals is evident in the growing number of cumulative users over time (Figure 21, bottom). Once OhmConnect was able to kickstart user growth through the direct-user acquisition experiments, the indirect referral methods catalyzed organic-user growth over time as the product became more well-known (the more users OhmConnect acquired through a marketing or other direct push, the more OhmConnect users could be referred). Additionally, OhmConnect continued to see strong value in referral promotions similar to the Halloween Refer for Rebate Program and will likely continue to use similar promotions in the future.

Direct User Acquisition Results

To determine the impact of different direct-user acquisition methods, OhmConnect performed 12 one-month long distinct experiments for each acquisition method. Results from these experiments appear in Table 3.

The primary direct-user acquisition methods included Facebook, Instagram, Search Engine Optimization (SEO), and the Sierra Club partnership.

- Facebook: Facebook advertisements reached 145,263 users, driving 3,859 clicks to sign up for the program (this gives a click-through rate of 1.6 percent). Based on these results, the cost per click for Facebook is $0.038, with an overall acquisition cost of $75.
- Instagram: Instagram posts drove 100s of clicks to the OhmConnect Instagram page to learn more about OhmConnect's services, with an average of 6 users per day who landed on Instagram's home page.
- Search Engine Optimization: Through SEO, OhmConnect reduced the number of forms and clicks users need to sign up, register their utility accounts, and become active users of OhmConnect. By continuously redefining SEO, OhmConnect anticipates improving the conversion rate and decreasing conversion costs with more click-throughs.
- Sierra Club and National Wildlife Foundation: Unfortunately, efforts did not result in increased signups or registrations. OhmConnect continues to strategize on various messaging and channels for subsequent campaigns.

Table 3: User-Acquisition Methods and Results by Month

Month	Acquisition Method	Description	Results
July 2016	Automation Incentives	Technology incentives for grant "encouraged" users	<10s of users
August 2016	Focused Campaign	Southern California Localized Campaign	• 100s of users • High cost of acquisition
September 2016	Focused Campaign	Back-to-School	• 100s of users • Concentrated on 1 school
October 2016	SEO		<10s of users
November 2016	Automation Incentives	Holiday Campaign	<10s of users
December 2016	Public Relations	PR Articles	• 260 clicks on "Is the Energy Industry Asking the Right Questions?" • 181 clicks on "Understanding What the Customer Wants" <10s of signups
January 2017	Social Media Campaign	Facebook	• 3,859 Total clicks • $.038 Cost Per Click • 1.6% Click-through rate
February 2017	Partnerships	Co-branded campaign with Sierra Club & National Wildlife Federation	• 30+ users • Large reach (100,000s of emails) but poor open and click-through rate
March 2017	Public Relations	NPR piece	• Nationwide user push -100s of users in California
April 2017	Social Media Campaign	Reddit	<100s of users
May 2017	Public Relations	Instagram ad campaign	<100s of click-throughs but minimal signups
June 2017	Partnerships	Sierra Club push	1,000s of users
July 2017	Paid Leads	Combination of methods described above	1,000s of users but at high costs

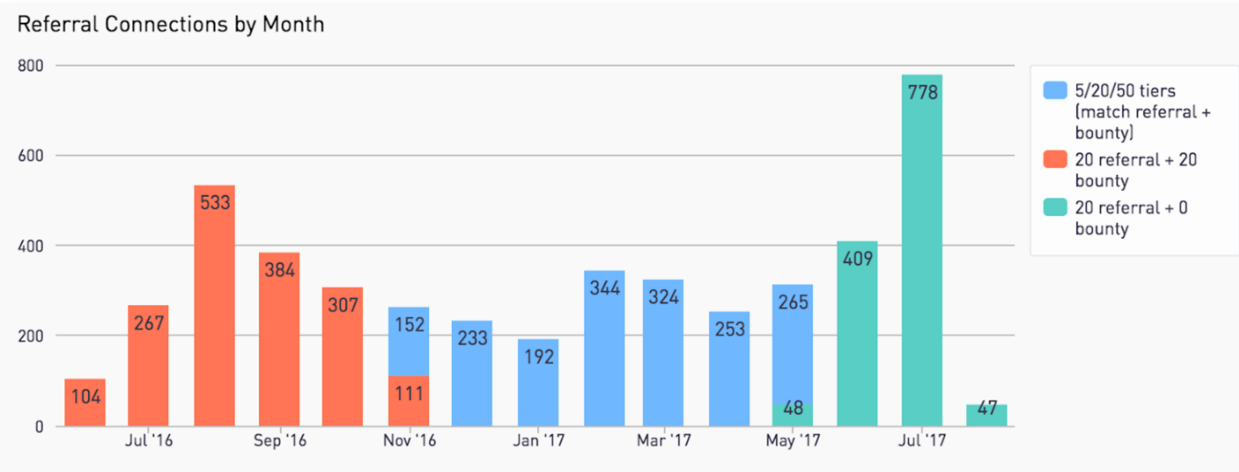
OhmConnect user acquisition strategies and results from July 2016 through July 2017.

Source: OhmConnect

Indirect-User Acquisition Results

Figure 22 shows the number of active users over time who signed up for OhmConnect using a referral link. The different colors refer to the different indirect-acquisition methods: red-orange is the 20/20 program, blue is tiered, and green is the $20 flat.

Figure 22: Referrals by Month, Split by Method



Indirect-user acquisition results by month, based on different referral methods

Source: OhmConnect

The primary indirect-user acquisition methods, as previously described, included the 20/20, tiered, and $20 flat referrals.

- 20/20 Referral: Technically, the cost for a new user via this program was $40 per user ($20 for the referrer and $20 for the referee), but the implementation on average cost less at $19.44. This is because either many users did not cash out, or they reinvested their earnings into other items like devices.
- Tiered Referral: While the overall incentive for this program was much higher (users earned on average $32.77 per referral), the program was much less successful than the other programs as evidenced by the low conversion rate. The primary objection users brought up regarding the tiered program was the complexity of the program. Users felt confused about what was happening, often wondering why they did not receive $75 immediately after their referrals reached Silver status. Some users felt "cheated" out of their referral payments.
- In kicking off this program, OhmConnect provided some blog posts along with other information. However, the complication of the multi-tiered approach proved to be a bigger barrier, even though payouts were much higher than in other programs.
- $20 Flat Referral: This $20 flat referral program proved to be the most effective indirect-customer acquisition method, most likely because of its simplicity and upfront payment.

Conclusion

OhmConnect primarily focused its user selection and enrollment on social media marketing. Acquiring new users to join OhmConnect was not only key for greater energy reductions during

DR events, was also foundational for ensuring adequate data for the experiments described in Chapter 4. Based on these research results, OhmConnect recommends further experimentation with marketing strategies to enroll potential users through the direct methods described in this chapter since those methods are both the most effective and lowest cost.

CHAPTER 4: Residential Demand-Response Participation Incentives

OhmConnect employed two key novel product features to increase customer participation. OhmConnect calls DR events, #OhmHours, once or twice a week throughout the entire year, typically with one-day and one-hour notice. For this experiment, only hour-ahead notice of DR events was provided. That is more frequent and shorter notice than previous day-ahead DR studies, which focused on critical peak pricing during a limited number of summer events. Second, OhmConnect offers users a way to automate their #OhmHour experience by connecting smart devices to the OhmConnect platform. While direct load control (remotely controlling an energy-related device) is not a new concept in DR, there has been little work on automation technologies with such features in a residential setting. With these novel features, the UCB research team designed three experiments to address questions around increasing DR participation. Specifically, the questions covered monetary incentives, impacts of automation, cost-effectiveness of user payout, and moral suasion through environmental messages.

Phase 1 was concerned with two main questions: how participants respond to varying monetary incentives during DR events, and how does adopting automation affect those responses. Phase 2 of the experiment attempted to answer the question of whether or not the incentives sent during Phase 1 could be modified and targeted to improve program efficiency. For example, could OhmConnect reduce DR costs (that is, payouts to users) by identifying the largest responders and sending them lower incentives? Phase 3 was concerned with the potential of using messages with moral persuasion in the form of green and environmental messaging rather than financial incentives. It also explored how these effects varied by automation status.

For the full UCB report, see Appendix E.

Phase 1: Monetary Incentives and Automation

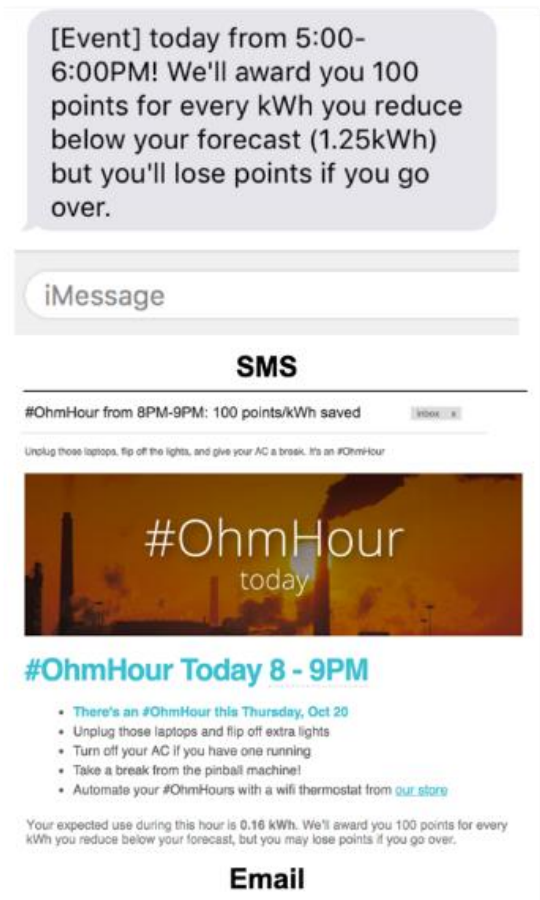
To answer these questions, UCB varied incentive levels and automation on DR responses. First, users were assigned to three groups that varied along two treatment dimensions.

- Pricing Events: Users received an average of 25 #OhmHours over 90 days communicated via email and text. (see Section 3 for more details). Each incentive level for a particular DR event was selected at random, with equal 20 percent probability from the set of all possible reward levels (including 5, 25, 50, 100, or 300 points per kWh).
- Automation Rebate: Users were offered a rebate of up to $240 for purchasing a smart-home automation device, which was paid out to users upon successful connection of the device to their utility account.

Users were assigned to three treatment groups upon enrolling with OhmConnect. Users had a 40 percent probability of being placed in the Standard Enrolled (Standard) experiment, which was the standard OhmConnect experience where users received Pricing Events and had the option to connect their connected devices to OhmConnect. Users also had a 40 percent probability of being placed in the Enrolled + Encouraged (Encouraged) experiment, which, in addition to the Standard experiment, provided users with the automation rebate. Finally, users had a 20 percent probability of being placed in the Control group where, instead of receiving the pricing or automation treatments, users received an email stating they would not receive any DR events.

Figure 23 shows sample event language for the Phase 1 DR events by Standard and Encouraged respondents.

Figure 23: Phase 1 Experiment Language



The forecast was calculated consistent with the California ISO 10-in-10 methodology. The methodology could generally be replicated by the evaluation team but did show some non-systematic differences. These should not affect the estimation of the causal effects reported below but is worth noting.

Source: UC Berkeley

Note that the incentive level was randomized between levels of 5, 25, 50, 100 and 300 points per kWh across Standard and Encouraged users. For the Control email, emails were specifically informed that: "Due to overwhelming demand for our service, there will be a delay before we can send you #OhmHours. We estimate this delay will last approximately 3 months. In return for your patience, we'll issue you an extra $10 bonus when your account delay is over."

The other dimension of randomization during Phase 1 was assignment to an automation encouragement. To measure the causal effect of adopting an automation technology, OhmConnect offered the Encouraged users a rebate for the full purchase price of a new connected device (up to $240 in value). Upon creating an account, these users saw a pop-up notification in their OhmConnect platform, in addition to receiving an email notifying them that they had been selected to receive a rebate for purchasing a new smart device. The user could choose between three smart thermostats, ranging in retail prices from $198 to $240, or one package of two smart plugs with a retail price of $80. OhmConnect notified these users that they would have the purchase price equivalent of points added to their balance when they connected the device. This process was to ensure the users connected the devices to their OhmConnect platform, thus encouraging full automation of their #OhmHours.

On average, users in the Standard and Enrolled treatments (that is, users who were fully enrolled in the OhmConnect experience), reduced 0.12 kWh (approximately 13 percent) more than the Control group across all incentive levels. Furthermore, users reduced electricity on the order of 12 to 14 percent per DR event. This amount was largely independent from the actual incentive level, suggesting that users were insensitive to prices or that electricity consumption followed a binary decision model (turning lights off or not). Typically, variations in electricity consumption resulted from changes in air temperature and automation status.

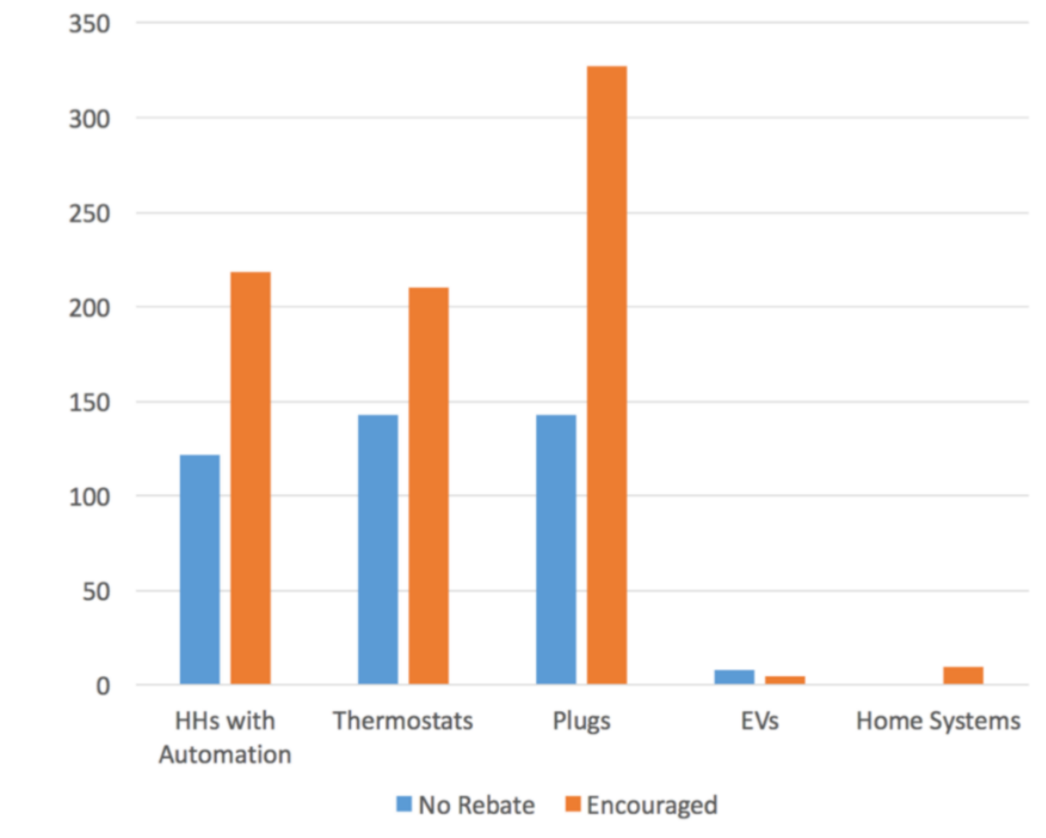
Automation Results

For automation, connected users (those with a connected device in their OhmConnect account) reduced about 25 kWh (approximately 25 percent) more than the Control group. Non-Connected users, on the other hand, reduced around 0.07 kWh (approximately 7 percent) more than the Control group. Furthermore, adopting automation yielded an additional 0.567 kWh reduction, meaning Connected users reduced their electricity consumption 16 percent more during DR events than those who did not use a connected device.

The rebates resulted in a sharp increase in connected device adoption (Figure 24). Specifically, the fraction of automation take-up increased a statistically significant amount of 83 percent, with 53 percent of Standard users and 97 percent of Encouraged users purchasing and using connected devices.

Interestingly, the rebate was disproportionately taken up by users in the bottom quartiles of consumption (on average they only reduced 0 to 0.34 kWh each DR event). This has an important implication: the response from users who accepted the rebate to take up automation provided significantly greater load reductions than those who did not take advantage of the rebate. The causal adoption estimates therefore may not be representative of causal estimates for the users who signed up without a rebate. The significant increase in smart devices used by the bottom quartile was driven by the adoption of plugs, and the increase in the top quartile was driven by thermostats. These differences are intuitive if thermostats were typically used in larger households while plugs were more appropriate for households without central heating or cooling.

Figure 24: Smart Device Adoption Across Treatments



The UCB study analyzed smart device adoption rates for five different devices.

Source: UC Berkeley

Financial Incentive Results

For financial incentives, OhmConnect users in the Standard and Encouraged groups reduced their energy consumption during #OhmHours more than the Control group. At the 5-point-per-kWh ($0.05/kWh) incentive level, users participating in DR events reduced 0.125 kWh (approximately 12 percent) more than the Control group. At the 300 point per kWh ($3/kWh) incentive, they reduced -0.145 kWh (approximately 14 percent) more. This price insensitivity was not driven by automation; in fact, Connected users appeared to be more price sensitive than their non-Connected counterparts.

Temperature Results

Connected users reduced consumption by 1 kWh (approximately 53 percent) more during DR events when the temperature was higher than 95˚F relative to the baseline. Non-Connected Users also reduced significantly more on hot days, showing responses on the order of 0.25 kWh (~18 percent). The results show a pattern that is consistent with the interpretation that cooling load drives larger responses.

Phase 2: Targeting User Incentives

Once Phase 1 was completed, *Standard* and *Encouraged* users moved forward to Phase 2, which researched how targeting users based on estimated responses (that is, a user's potential reduction during #OhmHours) could improve the efficiency of DR dispatch. UCB assigned users to a *Targeted* or a control *Non-Targeted* group. UCB ranked *Targeted* users as most or least responsive and then sent either low or high incentives accordingly. On the other hand, *Non-Targeted* users continued to receive all five incentive levels in same fashion as they had been receiving during Phase 1.

Phase 2 investigated whether the incentives sent during Phase 1 could be modified and targeted to improve program cost efficiency. UCB developed the targeting strategy to reduce costs by identifying the largest responders and sending them lower incentives.

To causally estimate the effect of the targeting strategy UCB employed, *Non-Targeted* users continued to receive event messaging in the same fashion as Phase 1, receiving 5, 25, 50, 100, and 300 point per kWh incentive levels with equal probability. The *Targeted* group received a limited set of incentive levels based on their responsiveness ranking. Given the insensitivity documented in the previous section, UCB pursued a strategy that sent the most responsive users lower incentive levels (5, 25, and 50 points per kWh) and the least responsive users the highest incentive levels (100 and 300 points per kWh).

Results

The results showed on average all participants received 6.3 points per event in the *Non-Targeted* group and that the *Targeted* group decreased this payout by 3.1 points, a point payout reduction of 49 percent. Users designated as most responsive were paid 8.7 points per event in the *Non-Targeted* group, and targeting (offering only 5, 25, and 5 point per kWh incentives) reduced this payment by 6.3 points in the *Targeted* group, lowering the payout by 72 percent. Conversely, the least responsive users in the *Non-Targeted* group received 3.8 points per event on average and targeting (offering only 100 or 300 point per kWh incentives) did not significantly change payouts.

These results suggest the cost of payouts could be dramatically reduced by sending lower incentives to those designated as most responsive and the reduced payouts would have little effect on the amount users reduce during #OhmHours. This research suggests that DR payouts to the most responsive types could be reduced to 26 points per kWh. Further, the least responsive types have a cost of 107 points per kWh, making them less cost-effective to a third-party DRP like OhmConnect.

Phase 3: Incentives Versus Moral Suasion

Phase 3 was the final phase of the experiment and researched if moral suasion and environmental messaging had a differential effect from financial incentives on yield. Specifically, Phase 3 asked: Are DR event reduction responses to financial incentives different from responses to messages with moral suasion in the form of green and environmental messaging?

After Phase 2 users completed the incentives experiment, UCB pooled them into an experience where each event was randomized between four treatments with an equal probability:

- Control: Users did not receive a DR event.
- Price: Users received a DR event with a 100 point/kWh reward level and the same language as in Phase 1 and 2.

- Moral: Instead of receiving an event with financial reward, users in the Moral treatment received event notifications that included language such as: "Environmental #OhmHour today from 6PM-7PM! Saving energy now could keep a dirty power plant turned off!"
- Price + Moral: Users received an event that had environmental messaging language as well as a 100 point/kWh financial incentive.

Results

Moral suasion had a smaller impact on consumption than the messages with the monetary incentives. Therefore, the estimates from Phase 3 implied moral suasion yields smaller reductions than financial incentives. Furthermore, there is something unique to the monetary incentives in residential DR. However, reductions were driven in large part by the non-Connected users who were making active decisions about whether or not to reduce usage during #OhmHour events. Consequently, the fact that Connected users responded to all messages reflect the default effect of automating response.

Survey

A web-based voluntary survey was offered to participants at the beginning of Phase 3 for Standard and Encouraged participants and two weeks after receiving their first #OhmHour for the Control group. The survey focused on automation and studied how connected-device ownership changed as a result of the rebate offer. Introduction to the survey was made via email with the following language:

> Subject: Tell us what you think and Earn $5 Plus a Chance to Win $11 More
>
> Body: We're conducting a survey and we'd like your feedback. You'll get 500 points ($5) guaranteed when you complete this survey and you could earn an additional 1,100 points ($11) depending on your answers. The survey should take 5-10 minutes of your time.

The survey was designed be look consistent with the OhmConnect interface design to reduce non-response.

Results

In total, 672 users responded to the survey. In general, the demographic variables for the ZIP codes for the survey participants were not significantly different. Furthermore, it was apparent that the respondents tended to have lower average baseline consumption during #OhmHours prior to joining OhmConnect, and they came from cooler areas with significantly more heating-degree hours and significantly fewer cooling-degree hours. It is therefore likely that responses were not representative of the participant population.

Based on survey responses, connected-device ownership was double to three times the rate of automation via OhmConnect, meaning users already owned energy-efficient devices that were not connected to the OhmConnect platform. This indicated that 10 to 15 percent of users could automate their #OhmHour experience without purchasing new connected devices. The survey also asked users to score aspects of their usage on a scale of 1 (Never) to 5 (Always):

- How often in the last 7 days they recalled reducing in non-Connected ways: The average consumer reduced in non-Connected ways more than half the time, which was consistent with the rates of connected-device take-up.
- How often in the last 7 days they recalled DR events, serving as reminders to turn off appliances they accidentally left on: The average consumer was reminded to turn devices off more than half the time. This suggested that many of the survey respondents were not being attentive in their electricity consumption.

Lastly, the survey asked users why they joined OhmConnect (based on a set of choices). Financial gain was the dominant choice, with over 61 percent of respondents choosing it as the top reason, and the second highest was environmental motivations, at 22.36 percent (Figure 25).

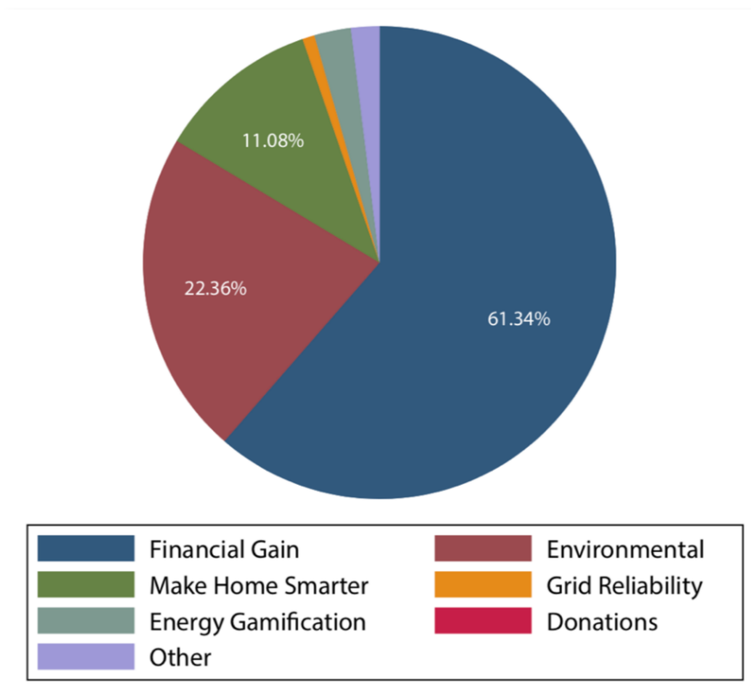
Economic Valuation

For the final portion of this experiment, UCB analyzed the economic value of the DR events studied in this project. The project researched the value of DR to users and the energy market as well as the payback period for smart devices.

Value of Events to Users

First, UCB calculated the value of DR events to the participant. The value to the user was quantified based on points paid for reductions and the avoided retail-electricity costs, considering the value during event periods only. UCB assumed an average price of electricity of $0.16/kWh. Results are in Table 4.

Figure 25: User Reasons for Joining OhmConnect



UCB Surveyed OhmConnect users and asked them their primary reason for joining the program.

Source: UC Berkeley

Table 4: Demand Response Event Value to Residential Participants

	Experimental Events (90 days)	Average Wholesale (Annual)	Maximum Wholesale (Annual)	Number of Users
Full Sample	$3.36	$1.82	$4.80	4,448
Non-Automated	$1.96	$1.06	$2.80	4,108
Automated	$7.28	$3.95	$10.40	340
Auto Adopters	$17.84	$9.68	$25.48	96
1st Quartile (lowest) (0 kWh—0.34 kWh)	$2.66	$1.44	$3.80	1,132
2nd Quartile (0.34 kWh—0.56 kWh)	$2.94	$1.60	$4.20	1,119
3rd Quartile (0.56 kWh—0.90 kWh)	$3.36	$1.82	$4.80	1,103
4th Quartile (highest) (0.90 kWh—5.96 kWh)	$6.13	$3.33	$8.76	1,094

Results of UCB experiment on the value of DR events to OhmConnect users

Source: UC Berkeley

Row 1 (Full Sample) shows the average financial savings across all users in the experiment who participated in DR events (and therefore were not assigned to the Control group). Rows 2 and 3 report the average savings during Phase 1 of the experiment for non-Connected and Connected users. Row 4 reports the averages based on the causal effect of adopting connected devices, and rows 5 through 8 report the estimates by consumption quartile (average energy consumption prior to joining OhmConnect).

Generally, the calculations show that financial savings were reasonable for Phase 1 of the experiment, but that these incentive levels represent higher-than-average prices. The two hypothetical programs show more modest annual savings for the frequency of events called. Furthermore, connected users do save more, and adopting connected devices provided substantial savings, even with the lower assumed wholesale prices. Lastly, the largest savings accrued to the largest consumers with the top quartile, representing a significant portion of the savings.

Value of Events to the Wholesale Energy Market

To calculate the value of DR to procurement and capacity costs, UCB assumed a DR user value of 5 points per kWh per event, a frequency of 100 events per year, and a kWh reduction per event using estimates from Phase 1. Results are in Table 5.

Table 5: Demand Response Event Value to the Wholesale Energy Market

	Average Wholesale Event Price DAM ($/MWh)	Average Wholesale Event Price RTM ($/MWh)	Maximum Wholesale RTM ($/MWh)	Value from DAM	Value from RTM	Upper Bound on Value
DR Value (~100 events)	$39.10	$35.13	$365.37	$0.17	$0.13	$3.96

Results of UCB experiment on the value of DR events to wholesale energy markets. (MWh=Megawatt-hours)

Source: UC Berkeley

Columns 1 through 3 show the price variation considered using day-ahead (DAM) and RTM market values, which informed values in columns 4 through 6. DAM and RTM whole-event prices (columns 1 and 2) are average market prices, whereas column 3 shows maximum prices from the RTM, providing an upward bound for results. Based on an average of 100 DR events per user, the value of DR to the wholesale energy markets would be $0.13 to $0.17 on average, with a hypothetical upper bound of $3.96. This highlights the importance of targeting the highest-value hours for achieving the greatest impact. Additionally, the value scales proportionately with responsiveness, so for the largest consumers who respond nearly twice as much as the average, the value approximately doubles. Thus, targeting larger consumers and responders will likely increase the average value of the program.

Automation Adoption Payback Periods

As a final exercise, UCB calculated the payback periods (how long it would take to be cost-neutral based on energy savings) of purchasing energy-efficient smart devices. Estimates only considered energy savings and did not count comfort or utility that the user may have received from the connected device.

A customer paying the full cost of $80 for two smart plugs and facing prices consistent with when the DR events in the experiment were called (about 100 events per year on average) will earn discounted savings equal to the upfront cost in 12.3 years. If DR events are targeted during the highest-price periods, the payback period is reduced to 3.6 years, a 71-percent reduction. Thermostats, on the other hand, are much more expensive (around $198), and for actual wholesale-market prices, there is no positive payback period. Conversely, for the highest-price periods, the payback would be around 11.2 years, which is generally within the lifespan of a thermostat. If the DR program ran 150 events annually, the smart plug would be paid back within 2.3 to 7.1 years (with the range based on low-to-high DR-event market prices), and the thermostats would be paid back in 6.5 to 33.9 years.

Recommendations

Based on the results from these yield experiments, UCB makes the following residential DR recommendations:

- DR Event Notification: OhmConnect users responded to hour-ahead DR events by reducing their consumption on the order of 12 to 14 percent, showing the potential for very short #OhmHour notice.
- Price per kWh Information: Users appeared to be insensitive to the variable pricing researched in this project. This suggests that without innovation with the messaging, there is little opportunity for varying incentive levels to marginally change user consumption. Future work should strive to understand if either conveying relative value or providing information on the dollar value of a kWh could change this insensitivity.
- Heating and Cooling Demand: Heating and cooling load were the primary drivers for responses, confirming the general motivation of many residential DR programs to induce customers to reduce their cooling loads in the summer.
- Automation Rebates: Offering rebates increased take-up of connected devices, and this automation caused significantly larger responses to DR events. Future work should explore whether the generally low take-up rates were due to the rebate design or if there were other costs or barriers to consumers when they consider adoption.
- Cost Efficiency: Targeting events using an initial set of interventions (user average baseline, for example) could dramatically lower the cost of the program. Future work should incorporate the persistence of these types of targeting strategies.
- Social Value of DR: Lastly, the social value of the DR events calculated here was small, but this number could change if DR events were targeted more effectively to high-price hours. Future work should include more elements of the social value calculation to understand the feasibility of targeting events.

Conclusions

On average, OhmConnect users earned $2.66 to $6.13 for the 90 days of Phase 1. Expanding this to a DR program that would call 100 events per year and set incentives consistent with wholesale prices, average user savings could range from $1.82 to $4.80 annually. Savings would be larger for connected users, ranging from $3.95 to $10.40 over 100 #OhmHours, and according to this research, adopting connected devices increases savings by $9.68 to $25.48 annually in the hypothetical programs considered.

UCB's estimates on the short-run avoided costs from energy procurement and other externalities ranged from $0.17 to $3.96 per user per year in a hypothetical 100-event program. The wide range comes from assumptions about whether events were called during the highest-price periods. On average, the DR events for the experiment were called during periods when wholesale prices were about $0.04/kWh. These estimates did not include the capacity value of the resource, which may increase the value of the programs considered.

Lastly, UCB calculated the private payback period and the discounted social value of connected device adoption. Payback periods for the two smart plugs ranged from 3.6 to 12.3 years depending on wholesale market valuation. Thermostat payback periods were longer due to higher upfront costs, ranging from 11.2 years to no finite payback period. The discounted social value was also sensitive to assumptions about wholesale market valuation, ranging from $24 to an upper limit of $147 for a 5-year device life span (plugs) and $47 to $289 for a 12-year life span (thermostats). These numbers used experimental estimates on the effect of adopting connected devices and also made assumptions about future energy prices and externalities that could affect the results.

CHAPTER 5: Low-Cost Telemetry

Currently, residential demand response resources cannot participate in the California ISO RTM or its ancillary services market. Without the ability to communicate in real time between homes and the California grid, residential customers cannot provide adequate information regarding precisely how much energy they are consuming. Consequently, residential customers do not meet requirements for wholesale energy products. This is a missed opportunity to utilize a large potential resource — connected devices in homes.

Many OhmConnect users already have connected devices that are communicating with the grid. These connected devices not only respond immediately to DR events, but also directly track real-time device consumption. Therefore, leveraging these devices is key to designing a low-cost telemetry solution that meets requirements for supply-side services.

Telemetry is automated data transfer between remote equipment and a central location. This data transfer is often in real time and can be costly depending on the complexity of the equipment. In energy, telemetry is often wireless, and the equipment data is transmitted to the California ISO. This data can be used to quantify flexible resources in the wholesale-energy market and provide impactful real-time energy products.

The goal of this task was to design and implement a low-cost telemetry solution that could overcome the barrier of providing real-time data to the California ISO. OhmConnect collaborated with EPRI to create a viable solution that could enable residential telemetry that both provides sufficient information to meet participation requirements for wholesale energy products and aggregates small customer ancillary services. Consequently, this work could facilitate participation by residential-demand response resources in the California ISO's RTM and ancillary services markets.

This chapter describes the methods tested to implement residential low-cost telemetry, as well as an evaluation their viability as a breakthrough technology.

Telemetry Requirements

Data Collection and Aggregation

The project team conducted extensive research on California ISO telemetry data requirements and came up with a proposal for data collection and aggregation. This research focused on the current standard business practice manual and relied on the California ISO's Expanding Metering and Telemetry Options stakeholder initiative. One of the most discussed aspects of the project was the calculation of the instantaneous kW consumption from individual residential homes, which can be found in the following Proposed Methods section.

OhmConnect and EPRI identified seven steps for the data collection and aggregation process. Three key terms were used in these steps:

- Location: An end-use electric customer enrolled in OhmConnect's DR service

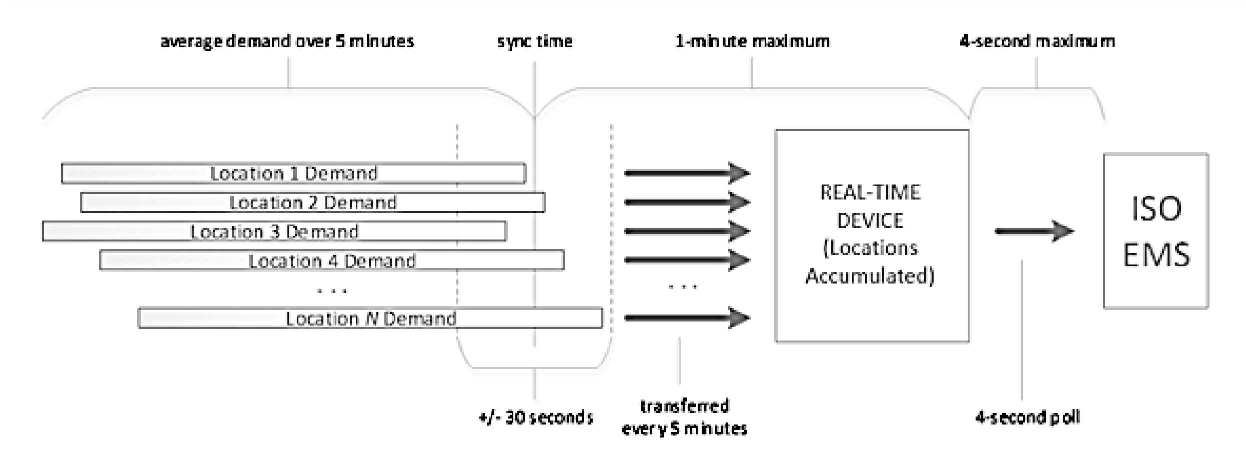
- Resource: A California ISO market resource comprised of many locations
- Connected device: An Internet-connected device, such as a Wi-Fi thermostat, which can control load at a location and, in some cases, communicate with a utility smart meter.

The seven steps are:

1. For each telemetered location, establish necessary communications between in-home connected devices, utility smart meters, and OhmConnect.
    a. OhmConnect can poll connected device status at least once per minute.
    b. OhmConnect can interrogate the utility smart meters at least once per minute.
2. Calculate average instantaneous kW consumption over 1-minute periods at each telemetered location.
    a. Location-specific 1-minute periods must all end within +/- 30 seconds of the sync time in step 3.
    b. Both:
        i. Method 1 (smart meter interrogation): Calculate the simple average of meter values at locations collected during 1-minute periods.
        ii. Method 2 (connected-device status): Poll status ofconnected devices once during the 1-minute period to calculate kW consumption at a location.
3. Aggregate location-level consumption data from Step 2 at sync time.
    a. Sync time is timestamp for Resource-level telemetry value: sync occurs every 1 minute.
    b. At sync time, for both methods 1 and 2, add location-level values from Step 2 across all telemetered locations with non-missing data.
    c. If, at sync time, all telemetered locations have missing data, use the aggregate value from the previous sync time.
4. Scale aggregate data from Step 3 to Resource level.
    a. Let M_i be the number of telemetered Locations in the Resource with non-missing data in Step 2 (i=1 for Method 1 and i=2 for Method 2), and let N be the total number of locations in the Resource.
    b. Multiply the aggregated values in Step 3 by N/M_1 and by N/M_2 for methods 1 and 2, respectively.
5. Adjust data in Step 4 to account for distribution system losses.
    a. Multiply values in Step 4 by the applicable Distribution Loss Factor (DLF) to obtain measurements at point of interconnection to the California ISO-controlled electric grid.
6. Transmit Resource-level data from Step 5 to a remote intelligent gateway (RIG).
    a. Maximum 1-minute latency between sync time and receipt by RIG of data.

7. Transmit data from Step 6 to the California ISO Energy Management System (EMS) every 4 seconds.
    a. RIG scans for Resource-level telemetry value every 4 seconds

Figure 26: Process Flow Diagram for Data Collection and Aggregation

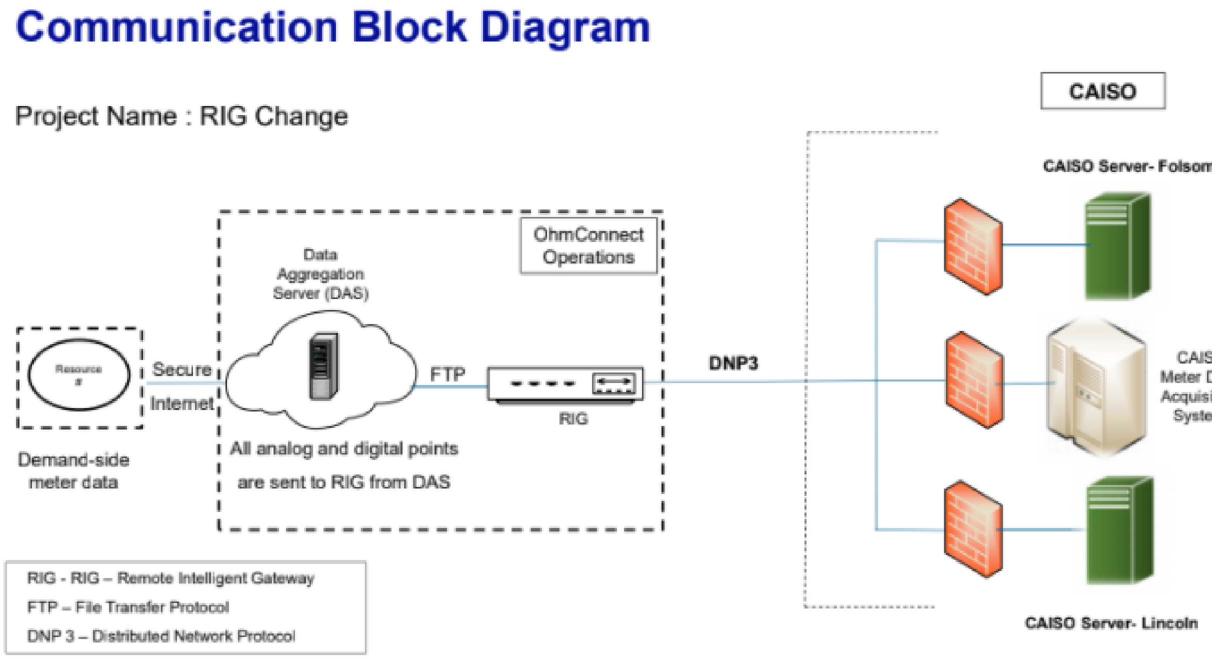


This is a process-flow diagram for steps 2 through 7 of the data collection and aggregation process. The real-time device represents the RIG.

Source: California Independent System Operator

The seven steps discussed above follow the California ISO business practice manual flow diagram for direct telemetry to obtain data for the ISO's EMS from a number of different locations. Because this project will send data for tens of thousands of residential customers from individual locations, the demand will not be synced across all locations. Therefore, the demand at any location is averaged over one minute and synced within a 60-second timeframe (30 seconds on each side of the sync time). Every minute, updated data will be transferred to the RIG (Figure 26). The ISO's EMS will then poll the value stored by the RIG every 4 seconds. Figure 27 shows how these seven steps relate to OhmConnect users' homes.

Figure 27: Process Flow Diagram for Data Communications from Each Individual Home to the California Independent System Operation Energy Management System



This diagram shows data collection and aggregation steps 1 through 7 as data flows from individual users' homes through OhmConnect and the RIG to the California ISO.

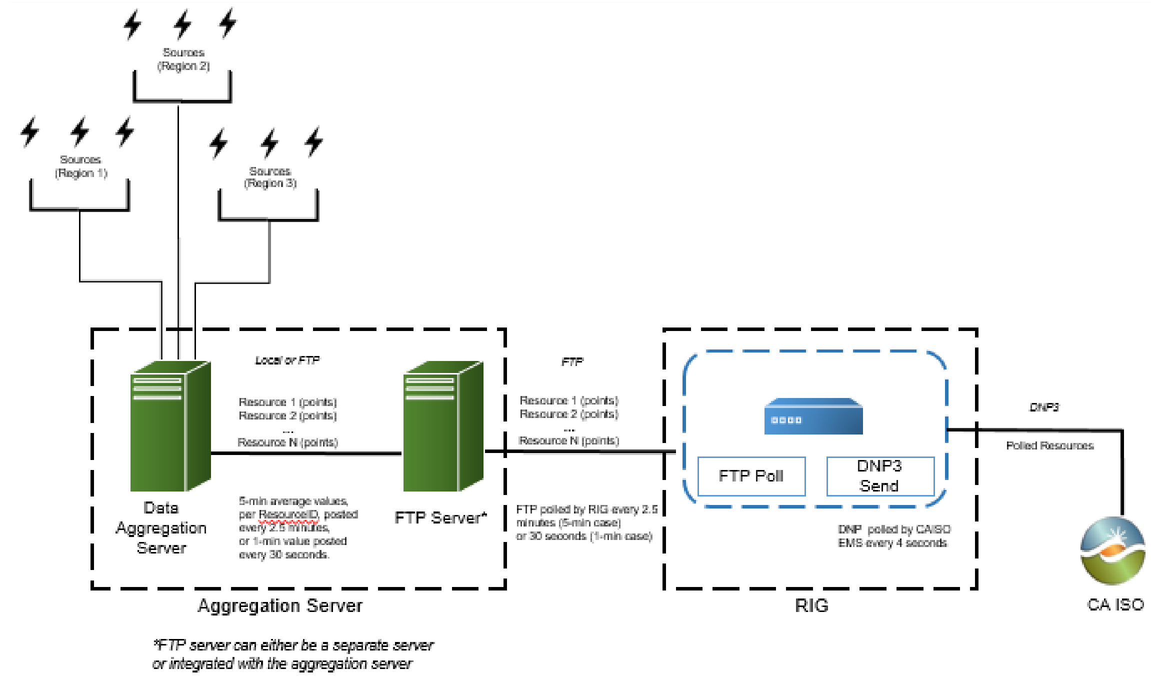
Source: OhmConnect

Remote Intelligent Gateway Interface to California Independent System Operator

For interfacing the data aggregation server to the EPRI-provided RIG interface with the California ISO, the project team identified a short-term solution to get a system up and running quickly using the Secure File Transfer Protocol (SFTP) The SFTP site can either be hosted on the aggregation server, or on another server in the overall system.

Figure 28 illustrates a method to interface an aggregation server with a RIG, which will interface with the California ISO. The proposed approach is for the required resource-level data to be provided via a text file and transmitted via SFTP from the data aggregation server. The SFTP site can either be hosted on the aggregation server, or on another server in the overall system.

Figure 28: Architectural Diagram of the Remote Intelligent Gateway



This architectural diagram illustrates a method to interface an aggregation server with a RIG.

Source: EPRI

For more information on telemetry interface requirements, see Appendix F.

Telemetry Using Residential-Connected Devices

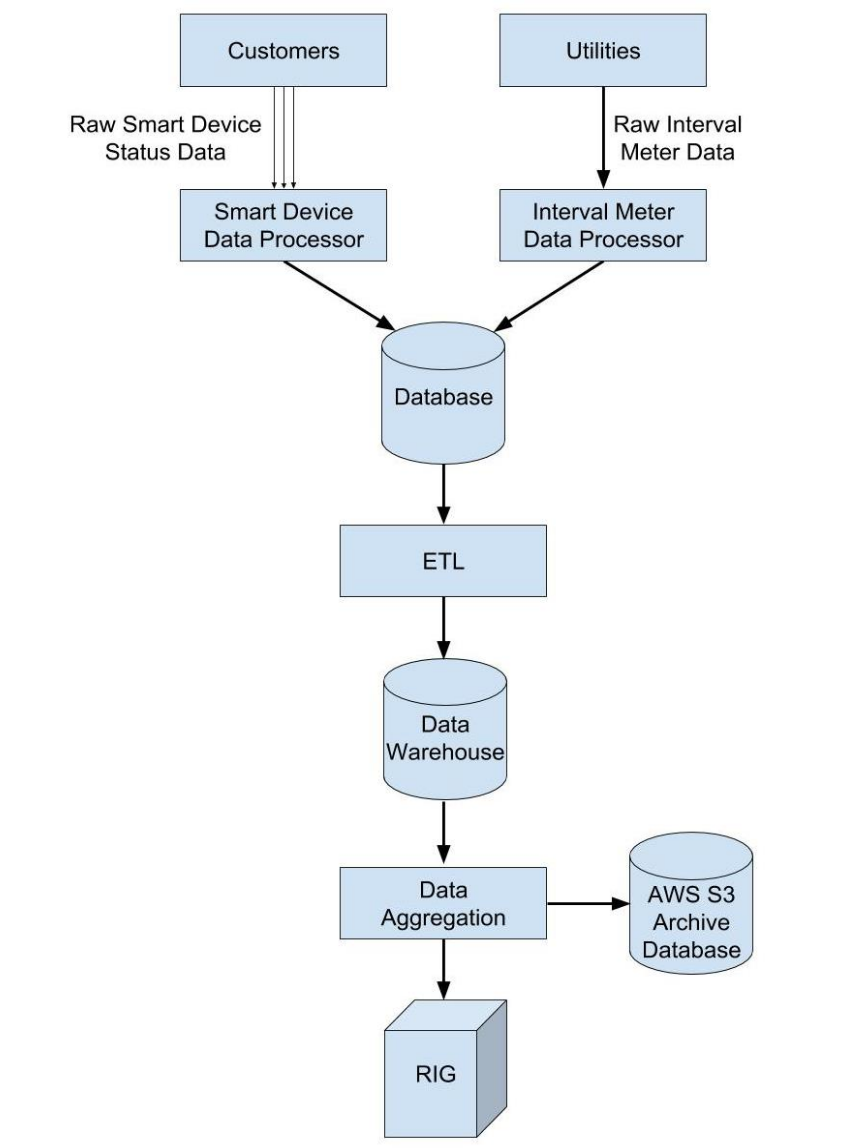
Initially, this project anticipated relying on two pathways to calculate consumption for individual households in real time (Appendix G describes these pathways in detail). The first pathway, using Zigbee-connected devices to communicate directly with the smart meter, was unsuccessful based on low residential-adoption rates of the Zigbee devices. The second pathway is a novel approach using statistical modeling and sampling to bypass the need for direct connectivity with the meter. This pathway relies on historical data of the settlement quality meter data along with real-time data for each connected device. The data provided to California ISO is based on a historical model of each individual home's response to certain inputs. From the connected devices and other data feeds, a significant number of data points existed for each individual home. The goal is to model each home and produce an estimate of its typical energy consumption, which over large numbers of users should be reflective of actual consumption within a certain threshold.

Data Aggregation Process

The goal of the data aggregation process is to estimate the total instantaneous electricity usage of a group of households. California ISO refers to this data as a proxy demand resource. This measure must be continuously calculated and transmitted to the California ISO by Resources wishing to participate in the RTM or to provide ancillary services.

Figure 29 provides a flow diagram of the key steps to this data-aggregation process.

Figure 29: Data-Aggregation Process



Flow diagram of the data aggregation process to transfer user consumption data from individual homes (via smart meters and connected devices) through to the RIG.

Source: OhmConnect

Two customer-specific data streams serve as inputs to this aggregation process: (1) interval electricity-usage data (at 15-minute or 60-minute intervals), and (2) connected device status data (at 15-minute intervals). First, customers' raw interval electric usage data is received from the utility in XML format on a daily basis, typically 24 to 48 hours after the fact (after customers have "consumed" the energy and it has transmitted through and been read by their smart meters). The Interval Meter Data Processor scans the raw data for missing or erroneous values and replaces those values with estimates based on the California ISO's 10-in-10 baseline formula. The resulting "clean" interval electric usage data (data without missing or erroneous values) is then written to OhmConnect's database.

Second, customers' connected devices are polled every 15 minutes for their current status. The Smart Device Data Processor scans the raw data for connected devices for which current status is not available (that is, "on" or "off" data is missing) and assumes in such instances that connected device status is unchanged from the last successful poll. It also standardizes the format of on-or-off data received from different makes and types of connected devices. The resulting clean-status data is written to OhmConnect's database.

Next, an extract, transform, and load process is applied to the clean-interval electric usage and connected-device status data to generate the necessary input to the data aggregation routine. This input data set is written to OhmConnect's Data Warehouse.

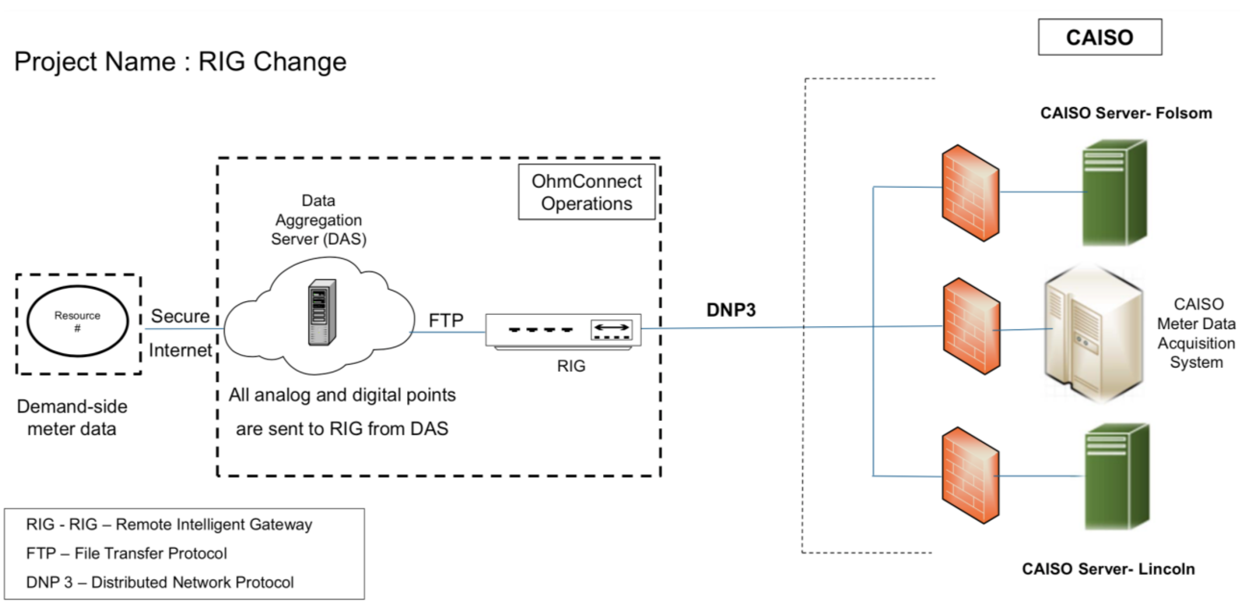
The data aggregation routine first estimates each customer's instantaneous electric usage based on current connected-device status and the historical correlation between connected-device status and electric usage. Then, these customer-specific values are added up to produce an estimate of total instantaneous electric usage at the Resource level. This estimate is stored in a data-aggregation server.

Finally, the current estimate of resource-level instantaneous electric usage is transmitted from the data aggregation server to the RIG via a SFTP and also archived in OhmConnect's database.

Telemetry Solution Implementation

All data in the RIG is distributed to California ISO's Meter Data Acquisition System using a distributed-network protocol (Figure 30). Prior to fully deploying the RIG, OhmConnect acquired a signed certificate installation for the RIG, which enabled transference of real-time data to California ISO. This certification was a key step in the implementation process.

Figure 30: Telemetry Solution

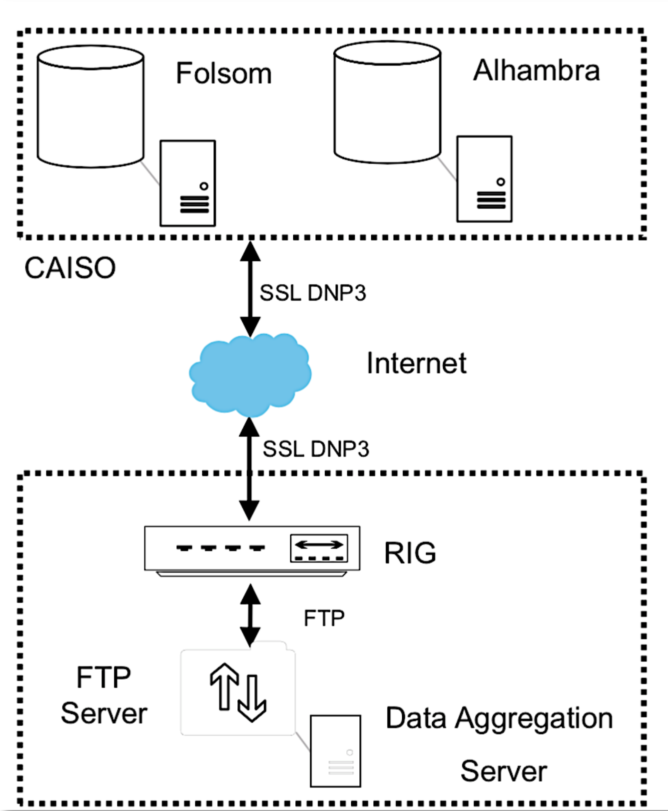


All data in the RIG is distributed to California ISO's Meter Data-Acquisition System using a distributed network protocol.

Source: EPRI

The first RIG test demonstration verified communications and equipment operations from OhmConnect to the RIG, which was initially located on site at EPRI. Once this test was successful, EPRI moved the RIG to OhmConnect and began testing for telemetry deployment (Figure 31). The RIG deployment test verified communications and equipment operation from the RIG to California ISO facilities (Folsom and Alhambra in Figure 31).

Figure 31: Remote Intelligent Gateway Deployment Test



The RIG deployment test verified communications and equipment operation from the RIG (located at OhmConnect) to California ISO facilities (Folsom and Alhambra).

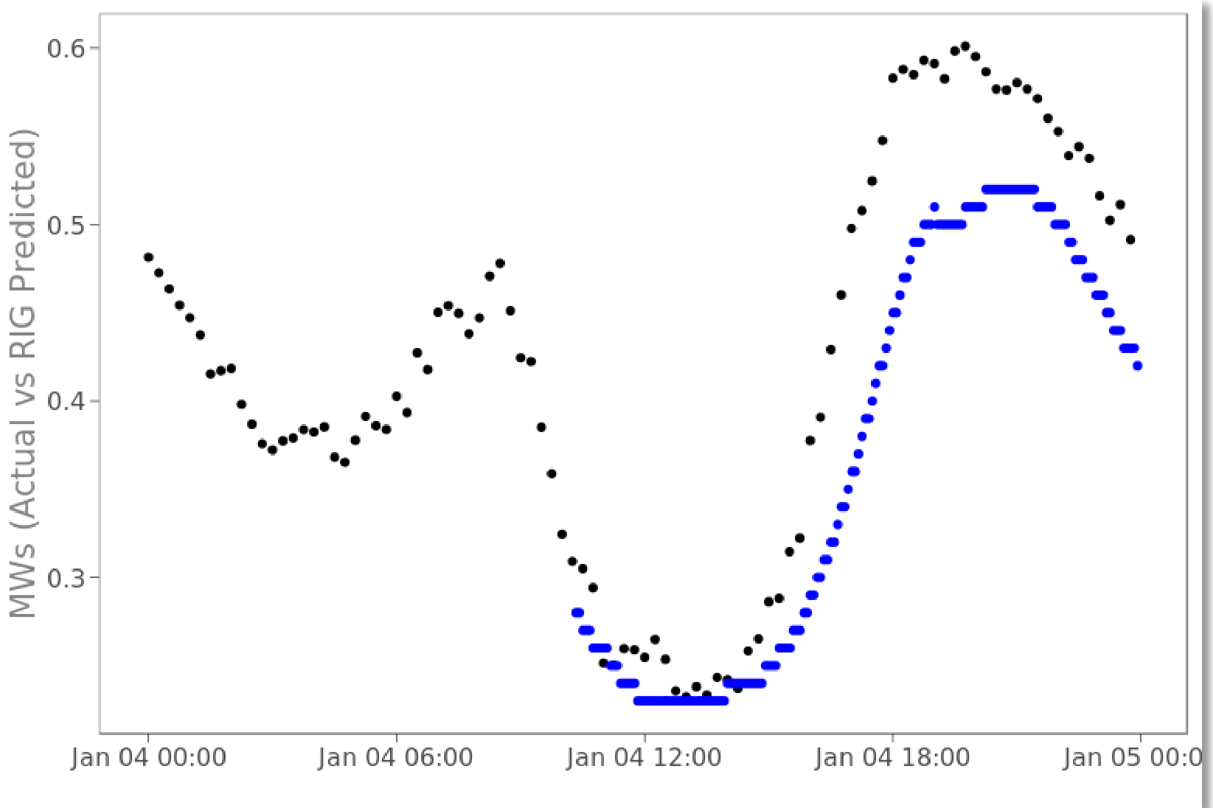
Source: EPRI

For more information on solution implementation, including the initial demonstration and the full RIG deployment, see Appendix H.

Results

OhmConnect collected data from the RIG and analyzed how real-time energy consumption estimates compared with smart-meter consumption data. Based on data collected across 725 users on January 4, 2019, the RIG data followed a pattern similar to the actual consumption data (Figure 32).

Figure 32: Remote Intelligent Gateway versus Actual Energy Consumption Data

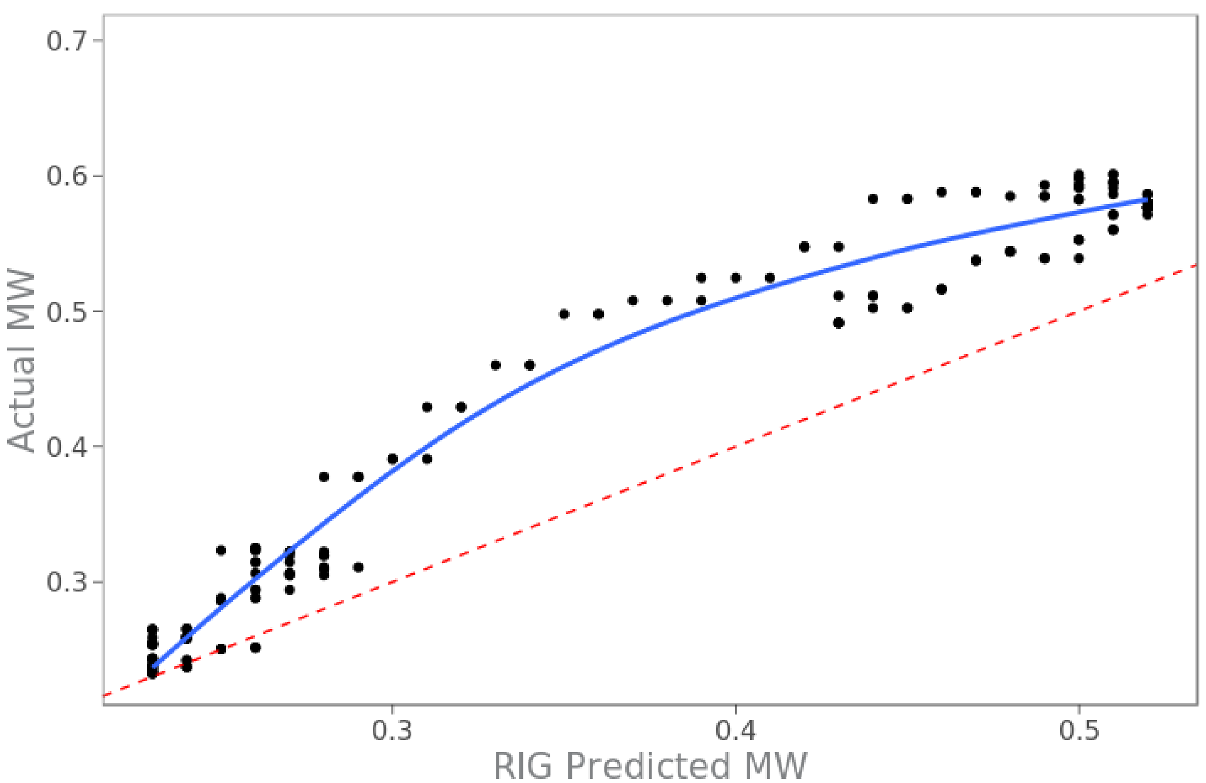


The RIG delivered energy consumption data (blue) is slightly lower than the actual consumption (black) as quantified using smart meter data.

Source: OhmConnect

While the actual consumption value is slightly higher than the RIG data, a model shows that the RIG-predicted energyconsumption data (in blue) is closely aligned with actual consumption (Figure 33). For more analysis results, see Appendix I.

Figure 33: Remote Intelligent Gateway Predictive Data versus Actual Data



The RIG-predicted energy-consumption data (blue line) aligns closely with actual consumption data (black dots). Taking a linear model, the slope of the Loess Prediction Function is 1.19 and the R^2 value is 0.949.

Source: OhmConnect

Overall, the total number of data points were insufficient for drawing strong conclusions. However, the data points available showed a high degree of accuracy between the estimated RIG data and actual consumption. Therefore, more relevant data is needed before concluding whether this low-cost telemetry solution is effective in transmitting real-time energy-consumption data to the California ISO.

Conclusion

This low-cost telemetry project with EPRI described technological alternatives that could lower telemetry costs for mass-market DR participation in California's wholesale energy markets. In sharing this work with various stakeholders (including with the California Energy Commission, California ISO, and other RIG vendors), EPRI conducted research on ways to further lower telemetry costs. Ideas included making the telemetry system remotely manageable, using a public networking infrastructure when possible, supporting plug-and-play installation of hardware, and simplifying the process when possible. Future research on low-cost telemetry should not only target these potential methods to lower costs because there is also a need to continue analyzing the data provided in the RIG output. This study reviewed results for a short period, so understanding the long-term effectiveness of the data could be beneficial in proving this specific telemetry process.

CHAPTER 6: State of the Demand Response Market

When this project was first proposed, third-party residential DRPs did not have a clear pathway to provide energy reductions or DR resources into existing wholesale energy markets. However, recent years have seen an increase in participation as new regulations and policies have helped overcome major barriers to DRP participation in wholesale energy markets, especially with establishment of the California DRAM. California's evolving electricity grid — with smart meters, high renewable penetration, and distributed energy resources — paired with the state's policy objectives of affordability, decarbonization, and reliability, have further created the opportunity for DR resources to contribute.

While progress has been made in opening up residential DR market opportunities, additional barriers remain that prevent full integration into the California grid. These barriers, which include market uncertainty, data inaccessibility, competitive asymmetries, and customer retail energy options, impede residential DRPs' abilities to provide DR services to the California ISO. For OhmConnect in particular, these barriers could dramatically impact participation in the state's wholesale market.

Throughout this project, OhmConnect participated in regulatory activities that advanced third-party DR market adoption and addressed these barriers. For example, data-sharing was key to accurately quantifying how much participants reduced their electricity use during #OhmHours. OhmConnect's involvement in California's regulatory landscape during this project enabled users to easily and securely share their energy consumption data with third parties through frameworks like Click-Through. Similarly, the DR market mechanism in California, the DRAM, was a key policy focus for OhmConnect as it navigated and evaluated ways to ensure that third-party residential DRPs became sustainable and profitable in California. Due to the nature of the data analyzed as well as research performed around Users, Yield, and Supply, OhmConnect was actively engaged in regulation that ensured the market would adopt third-party DR.

Appendix J describes these barriers and potential solutions in depth and Appendix K catalogues OhmConnect's regulatory engagement. The following chapter highlights these two key market adoption efforts OhmConnect pursued.

Demand-Response Auction Mechanism

Currently, third-party residential DRPs have one main avenue through which to sell their products to California's IOUs and bid into the California ISO wholesale market: the DRAM pilot. The DRAM was designed and approved under the direction of the CPUC. As a CPUC construct, the DRAM is currently only conducted by IOUs; not all energy providers in California have obligations to procure residential DR.

The CPUC conducted an initial DRAM auction in 2015 for delivery of DR resources in 2016, and conducted a second auction in 2016 for delivery in 2017. Even though the pilot was initially intended to cover just 2016 and 2017, in June of 2016 the CPUC chose to extend the pilot program for additional procurement, with delivery of procured DR in 2018 and, optionally, in 2019. Notably, the third auction retained essentially the same dollar-per-year level as the preceding auction ($27 million over two years versus $13.5 million over one year) instead of increasing the available funding to continue to grow the market. Although the CPUC initially rejected two petitions for modification that would have either increased the procurement for 2018 and 2019 or accelerated the launch of the permanent DRAM to 2019, ultimately the CPUC approved an additional auction for delivery in 2019. The CPUC has further extended the DRAM until 2022 but has declined to make it a permanent mechanism.

Market Uncertainty

The fate of the DRAM for 2022 and beyond has not yet been finalized by the CPUC. As described in D.16-09-056 and D.19-07-009, the CPUC recently conducted an independent analysis of the first three auctions. The results came back inconclusive, and as a result the CPUC in D.16-09-056 voted to not authorize a permanent DRAM procurement mechanism until further analysis was performed. The unclear future of a permanent DRAM has introduced an element of uncertainty for all market participants. This uncertainty coincides with the phasing out of other IOU legacy programs such as the Aggregator Managed Portfolio. If a permanent DRAM is not approved, this could result in stranding DR resources, functionally leaving residential DR providers without a means to sell significant levels of DR to the utilities.

To address this market uncertainty barrier, OhmConnect recommends that the CPUC approve a permanent DRAM. Decision 17-10-017 states that "as a policy matter the [CPUC] adopted the demand response auction mechanism as the primary tool to fulfill its goals of expanding the role of demand response and third-party providers." In the absence of DRAM, the alternative for DRPs is to participate in utility programs or other all-resource solicitations. However, the CPUC decision finds that the present procurement paradigm without DRAM would present barriers to third-party participation, noting that "although some utility programs remain available to non-utility providers, even with other solicitation opportunities pointed out by the parties, business opportunities in 2019 for third-party demand response providers are limited without a 2018 auction." Furthermore, the CPUC was persuaded by California ISO comments that "providing continuous annual funding for utility programs with no solicitation for competitively procured demand response in 2018 may harm third parties' ability to compete on a level playing field and cause the nascent competitive market to wither." In summary, the absence of a permanent DRAM will not improve market certainty; rather, the likely outcome is that many DR providers will be frozen out of California.

Rule 24/32

To operate and offer their full suite of services, third-party DRPs must obtain access to their customer's energy data through their smart meters. In California, the IOU generally serves as the custodian of the customer's energy data. Therefore, data sharing between a customer and a DRP necessitates an additional agreement with the IOU, and the IOU has the ultimate responsibility to deliver the customer's data to the DRP. Electric Rule 24 (PG&E and SCE) or Electric Rule 32 (SDG&E) (Rule 24/32) are the terms and conditions for sharing a customer's energy-consumption data between a third-party DRP and an IOU.

Rule 24/32 has two key provisions: (1) the IOU must provide to a customer's designated third-party DR provider all data (including interval meter data) necessary for that customer to participate in DR at the California ISO, and (2) the IOU may not deny a customer's request to participate in a third-party provider's California ISO DR program without good cause (for example, customers are required to t disenroll from a conflicting IOU DR program).

Data Inaccessibility

The data-sharing process has varied since the beginning of this project, and the process often seemed lengthy and cumbersome for utility customers. Moreover, the energy-consumption data, which is supposed to be provided in an automatic, machine-readable format, is often inconsistent across IOUs, with varying formatting and delivery processes. As a result, this existing three-party data-sharing process has introduced several challenges, which are frequently exacerbated due to a lack of accountability for breaks in the process.

While the user-friendly Click-Through solution described in Chapter 2 has been implemented across all three IOUs, delays notwithstanding, it does not improve data-quality issues such as inconsistencies across formatting and delivery that OhmConnect experienced throughout this project. Moreover, data essential for properly integrating the residential customer into California ISO's wholesale market are occasionally not provided by the IOU (such as non-static factors and interval data at 5-minute granularity). In some of the worst cases, IOUs simply fail to deliver data. Without this data, OhmConnect is unable to quantify its users' reductions during #OhmHours, which in turn delays user payouts and ultimately impacts user engagement.

To address the barrier of data inaccessibility, OhmConnect recommends that IOUs be held accountable for meeting deadlines for rolling out their Click-Through solution, and that the California Energy Commission or the CPUC empower a third-party watchdog to centralize data issues across third parties and provide a platform to communicate between third parties and utilities. For IOU accountability, the CPUC should enforce its regulatory oversight regarding the quality of data sent from the IOUs to the DRPs following customer authorization. Furthermore, it should continue to be willing to expand the data set as the needs of the DRPs and the needs of the DR market evolve, and it should ensure that future changes to Rule 24/32 reflect these needs. For centralizing data issues, the CPUC can facilitate data resolutions either directly or through a third-party watchdog that can assist with tracking-data issues via complaints that have come through either the customer or the third party. This would improve accountability and efficiency in the data-sharing process.

Dual Participation

CPUC rules generally prohibit customers from participating in both a third-party DR program and an IOU DR program. For this reason, third-party and IOU DR programs effectively compete against each other for customers' participation.

Competitive Asymmetries Between Investor-Owned Utilities and Demand Response Programs

Asymmetries give the IOUs unfair advantages over third parties in the form of lower marketing costs to potential customers and greater incentive payments to participating customers. For example, IOUs have ready access to interval-meter data, rate schedules, and billing histories for all customers. This enables the IOUs to undertake highly targeted marketing campaigns for their own DR programs. In contrast, third-party DRPs cannot access this information about a customer until after he or she provides an explicit data authorization and the DRP adopts some form of sunk cost to recruit that customer. This not only increases costs to third-party DRPs for customer recruitment, it also means that many high-potential residential utility customers remain unaware of DR programs.

To address this barrier of competitive asymmetry, OhmConnect recommends that IOUs provide a level, competitive playing field by enabling third parties to access information used by IOU programs to identify potential participants. This would open technology incentives to any participant in a DR program and use approved ratepayer marketing dollars to support third-party programs equally with IOU programs.

Both the issue of marketing to customers and eligibility of incentive payments were taken up in the CPUC proceeding Application (A.) 17-01-012 et al, which sought approval of IOU DR programs from 2018 to 2022. Furthermore, as part of D.17-12-003, the CPUC ordered the IOUs to provide technology incentives to participants of any supply-side demand-response program (regardless of DRP) and to begin a marketing push to inform customers of all demand-response options. However, implementation of this direction from the CPUC has been neither expedient nor smooth, and OhmConnect requested that the CPUC continue to direct IOUs in ways that promote a level playing field between IOUs and third parties.

Community Choice Aggregation

Traditionally, electric customers in California were served by either one of the three IOUs or by a publicly owned municipal utility, In 2002, however, the California Legislature passed Assembly Bill 117, which enables municipalities and counties to assume responsibility from IOUs for procurement of electricity on behalf of their constituent residents and businesses — a system called Community Choice Aggregation (CCA). Customers located in the territory serviced by a CCA are automatically opted in to the CCA upon its formation. However, they may opt out and rejoin the IOU if they wish. Though the CPUC is the local regulatory authority (LRA) for the three IOUs, the CPUC has limited jurisdiction over CCAs. Instead, the LRA for a CCA is the municipal or county government for the territory serviced by the CCA, or a joint powers authority, comprised of two or more such governments, if the CCA spans multiple jurisdictions.

Expansion of Retail Energy Options and Difficulties for DR Programs

While CCAs provide utility customers the opportunity to select electricity sources outside of the traditional IOU structure, Rule 24/32 is not sufficient to guarantee unbundled customers like CCAs the ability to participate in California ISO DR programs. Because Rule 24/32 does not directly apply to CCAs, a CCA may deny a customer's request to participate in a third-party provider's California ISO DR program. Furthermore, only IOU customers who participate in California ISO energy markets are fully able to participate in DR. This barrier exists for a variety of reasons, chiefly that: (1) customers of non-IOUs do not have smart meters, and (2) these non-IOU retail energy providers do not purchase DR in a centralized market the way that the IOUs do via the DRAM. So, presently, millions of customers (those served by a municipal utility) cannot provide DR to California's energy markets.

To address the barrier of third-party DRP participation in CCAs and other retail energy options, OhmConnect recommends the following:

- Legislation should mandate inclusion of unbundled customers into services such as third-party demand response.
- Electric providers that do not participate in the California ISO energy markets should install smart meters and set up a mechanism that allows customers to share their usage data to procure DR services.

Market Adoption

The policy and market engagement pursued in this project has empowered third-party DRPs to increase and grow throughout California. According to the DRAM Evaluation, the number of residential customers signed up for third-party DR programs has dramatically increased in the past few years, with valuable knowledge gained from user acquisition and participation incentive research, OhmConnect developed new ways to engage residential utility customers in saving electricity during high peak-demand periods. Before this project few OhmConnect users thought about their electricity usage outside of paying their utility bills. Moreover, OhmConnect directly connected these customers to California's wholesale electricity market, ensuring that they benefitted both financially and environmentally from their participation in DR events.

To make the findings from this research available to regulators and other stakeholders, including other third-party providers--, OhmConnect regularly participated in regulatory proceedings and met with relevant policymakers. This activity involved the California Energy Commission, the California Public Utilities Commission, the Load Shift Working Group, the Supply Side Working Group, and the California ISO. From regulatory proceedings to stakeholder meetings, this project helped ensure that third-party DRPs have a viable market-based solution to reduce demand on California's grid. Importantly, this project proved the value of user engagement in ensuring the success of residential DR in California, and all of the analyses performed in this project greatly contributed to successfully pushing the state's third-party DR market forward.

OhmConnect has published its public comments on relevant DR proceedings, all of which can be found online; Appendix K also contains the complete list of OhmConnect's policy and market engagement activities.

Conclusion

OhmConnect's ongoing regulatory and energy market activities during This project both complemented and improved the research being conducted. Not only was proactively participating in California's energy policy discussions key to removing existing barriers to third-party residential DR in the California ISO; California's mandated DR targets also aligned with the specific goals of this research. For example, just as this project focused on enabling a new market model for DR in the state, the Demand Response Auction Mechanism was actively being piloted. As a result, OhmConnect was able to leverage the results from this project into policy discussions with the CPUC and California ISO to provide relevant, data-based examples on how to ensure the success of third-party residential DR in California. Utilizing this research also benefitted other DR stakeholders as it often provided key evidence in arguments supporting the evolving DR market in the State. Lastly, OhmConnect continued to emphasize the value of customer engagement through its comments and across regulatory proceedings, directly sharing project results with DRPs and other stakeholders.

By addressing existing barriers to the growth of the residential DR market, California will be able to better meet its energy and environmental goals. Especially with the recent passing of Senate Bill 100, carbon-free resources will be crucial in balancing the dramatic influx of intermittent renewables. The majority of recommendations described in this chapter target the CPUC, California ISO, and California's state legislature, and when implemented, these actions could catalyze the efficiency and permanence of DRPs' participation in California ISO's wholesale energy markets. Addressing these recommendations will facilitate market success for third-party residential DRPs like OhmConnect while supporting policies that encourage California's grid to be affordable, decarbonized, and reliable.

This project set out to prove the viability of a third-party residential DR provider in California's energy market, and OhmConnect figured out innovative ways to engage utility customers and get them excited about saving energy. The research performed in this project helped create new energy market mechanisms in California for DR, and the work in User, Yield, and Supply catalyzed OhmConnect's growth and user connectivity to the California grid. Most importantly, the opportunity to transfer this research into DR proceedings and policy communications supported OhmConnect's ability to flourish and accelerated the growth of residential DR in California.

CHAPTER 7: Benefits to Ratepayers

OhmConnect delivered significant financial, environmental, grid, and community benefits from this project. Participants earned money by responding to DR events and saved electricity during times of peak demand, reducing stress on the grid and offsetting the need to ramp up natural gas peaker plants. The design of the OhmConnect platform (as described in Chapter 2) also contributed to significant community engagement around DR and its positive environmental impacts. OhmConnect also had strong penetration in California's disadvantaged communities, an area for future user growth and positive social impact for residential DR.

Financial Benefits

Lower Costs

This project lowered costs in two ways: by reducing peak demand on the state's energy generation facilities and electric grid, thus avoiding the need for expensive peaker plants; and by increasing energy efficiency across IOU territories, reducing electricity costs for participants in this project. On average, OhmConnect users reduced their annual energy consumption by five percent, and with this residential efficiency utility customers likely experienced lower utility bills

Economic Development

This project allowed OhmConnect to overcome existing barriers to facilitate residential aggregation of DR, which in turn enabled users to receive payment for participating in DR events. Over the course of this project, OhmConnect users earned over $668,000 for reducing a total aggregated 27.8 MWh during the times when the grid needed reductions the most.

Additionally, OhmConnect paid users for referrals within their communities. As a result, OhmConnect witnessed dozens of users making participation a part-time job, primarily driven by these incentivized referrals. Referral mechanisms included $20 for each referral, tiered referrals, and $5 per referral marketing schemes (discussed in Chapter 3). Because users earned revenue for each referral that activated his or her account, OhmConnect users earned as much as tens of thousands of dollars annually for promoting the DR platform. In total, OhmConnect paid its users approximately $200,000 for referrals over the course of this project, yielding 8,900 new users on the OhmConnect platform.

Environmental Benefits

Greenhouse Gas Emission Reductions

For this project, OhmConnect avoided 9 metric tons carbon dioxide equivalent (CO_2e) of greenhouse gas emissions.

Grid Benefits

Greater Reliability

By utilizing a DR software platform, this project created half of a virtual power plant that did not run the typical the risk of failure associated with transmission and distribution lines and traditional generators. Moreover, as a residential DR aggregator, the technology developed in this project allowed residential participants to access energy markets and engage with the electric grid, providing value through individual load reductions and increased pools of accessible-grid resources. Lastly, having the option to crowd-source grid services increased the grid's options, enabling it to gain a novel, versatile, and reliable service while decreasing its reliance on carbon-fueled peaker power plants.

Energy Savings

OhmConnect users saved 27.8 MWhs over the course of this project.

Smart Home Connectivity

OhmConnect enabled customers to utilize energy-saving smart devices to actively and passively respond to #OhmHours. These platform-connected devices, which automatically responded to DR signals, increased user yield during DR events, improving how much a user earned during #OhmHours. Alternative to cash, users were provided the opportunity to purchase smart devices using their OhmConnect earnings, and for this project, users often received these technologies at a discounted price, often even for free. Across all users, a total of over 13,000 devices (including Wi-Fi thermostats — ecobee, Venstar, Wiser, and others — and smart plugs – TP-Link) were shipped to create a seamless #OhmHour experience where devices automatically respond to DR events. A total of 6,000 devices was deployed during one #OhmHour event, setting the record for connected energy-efficiency devices for this project.

Community Benefits

Consumer Appeal

As described in Chapters 2, 3, and 4, platform upgrades, user-acquisition strategies, and participation incentives were geared toward consumer appeal for a software-based approach to residential DR. Specifically, this project leveraged consumer-appeal approaches to User and Yield needs to increase user participation and residential usage reductions in DR events. For example, Chapter 2 covered platform design that stimulated the user acquisition methods described in Chapter 3. Similarly, Chapter 4 described different messaging and incentive structures to keep users engaged in #OhmHours.

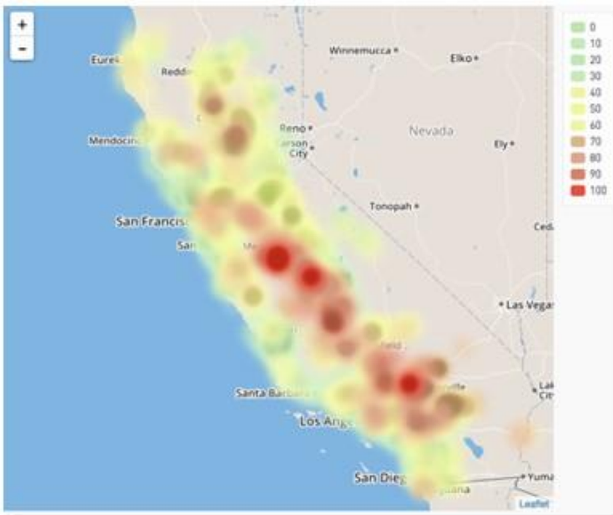
Disadvantaged Communities

OhmConnect has a strong appeal for disadvantaged communities through this project: over 15 percent of OhmConnect's California user base participating in this project was considered highly disadvantaged, based on CalEnviroScreen data from the Office of Environmental Health Hazard Assessment. Because the residential DR platform allowed customers to choose to maximize energy savings, OhmConnect gains increased utilization from DAC low-income households for whom this benefit was most material. Figure 34 breaks down the concentration of users by CalEnviroScreen scores; users shaded in orange and red tones mark those with a

CalEnviroScore in the 75th percentile or greater. Notably, OhmConnect has many users in the San Joaquin Valley, an area with high concentrations of DACs.

Currently, the number of users in DACs is in the tens of thousands, and in the past two years the percentage of users in DACs has nearly doubled (Figure 34, right). This increase occurred in parallel with this project (announced in March 2016) and reflects two key successful communication strategies identified in this project: referrals, which account for 49 percent of DAC user signups; and channel partners that target low-income users, which account for 25 percent of DAC user signups. Based on research from this project, successful communication strategies (such as referral incentive structures and leveraging on-the-ground community partners to educate DACs on the benefits of DR and energy efficiency) are key to close the gap in DAC engagement in DR technologies.

Figure 34: OhmConnect Disadvantaged Community Users



OhmConnect user base concentration by DACs (left) and percentage of users in DACs (right).

Source: OhmConnect

Teams and Donations

A community-focused tool, Teams enabled users to increase their connections with the local community by creating group-based teams for #OhmHour goals (see Chapter 2). Teams could be donation-based (such as earning points for school fundraisers) or simply conglomerates of like-minded users. Teams would have a consistent engagement with an energy-and-cost-saving program whose proceeds benefit causes or local institutions of a team's choosing. Examples of teams created in this project include both Sierra Club and National Wildlife Foundation teams, where users' financial benefits are aggregated and donated to those respective nonprofits, as well as multiple schools across California. OhmConnect Teams in this project donated an estimated $65,000 to non-profit organizations and local institutions.

Conclusion

The ratepayer benefits of this project spanned financial, environmental, grid, and community issues. Reducing over 27.8 MWhs over the course of this project, OhmConnect project users earned $668,000 from California's IOUs and donated an estimated $65,000 to non-profit organizations and local institutions. The project avoided 9 metric tons of carbon emissions in California, lowered ratepayer costs and increased grid reliability. These reductions were due in part to the 13,000 energy-efficient smart devices connected to the OhmConnect platform during this project, with as many as 6,000 devices deployed during one #OhmHour.

Noteworthy results from this project include research on device uptake in disadvantaged communities (DACs). OhmConnect observed a much greater yield for users with smart devices, and automated users are also more likely to remain more engaged in OhmConnect over time compared with users who do not connect devices. This project examined different ways of encouraging users to purchase smart devices, experiment with different rebate structures, incentivize users to purchase smart plugs or Wi-Fi thermostats, and connect them to the OhmConnect platform. While the devices were often provided at no cost or as a reward for participation, there was a lag in smart-device uptake, particularly in DACs. Currently, the number of users in DACs is in the tens of thousands, and in the past two years, the percentage of users in DACs has nearly doubled. The increase in the number of users in DACs is not matched proportionally by the number of connected devices in DACs, thus suggesting that there are unexplored barriers to smart-device uptake in DACs.

These project benefits serve as an example of how third-party DR providers will benefit ratepayers, especially as barriers to residential DR are addressed and DRPs like OhmConnect successfully participate in California ISO’s wholesale market.

CHAPTER 8: Conclusion

Demand response in California is not a new concept; commercial and industrial facilities and utility-based residential DR programs have been part of California's energy portfolio for decades. Existing programs, however, have not evolved with modernization of the electric grid. Smart meters, energy-efficient Wi-Fi appliances, and access to real-time information in residences can provide high potential value to the grid, but many of these technologies remain underutilized because of the existing gap between the traditional, one-way grid of the past and the more modern, two-way-communication grid of tomorrow.

As the Internet-of-Things space has evolved, smart, communicating technologies have become instrumental in ensuring the efficiency and reliability of the grid. Moreover, these technologies have the ability to directly connect residential utility customers to the grid, . facilitating residential customer contributions to meeting grid needs. With this improved communication, clean-technology companies can better engage residential customers to reduce their electricity usage during high-demand periods when the grid is stressed. Powerful, repeated messaging can prompt residential utility customers to quickly reduce their consumption by turning off lights or taking other simple actions like not running their washing machines.

Through this research, OhmConnect has shown the value of customer-centric behavioral actions in reducing residential energy consumption during times of peak demand. OhmConnect additionally found that focusing on the customer in its platform development engaged them and encouraged participation in the program. Data from this project on users, yield, and supply also returned valuable results for third-party DRPs participating in California's wholesale energy markets.

The OhmConnect Platform

Updating the OhmConnect platform to ensure that residential users remained engaged in DR both encouraged residential utility customers to reduce their electricity usage and connected those reductions to California's energy markets.This user engagement greatly improved OhmConnect's ability to acquire users in new and innovative ways and allowed OhmConnect to increase user participation in DR events.

OhmConnect User Acquisition

OhmConnect focused its user acquisition on marketing, predominantly in social media. Acquiring new residential customers for OhmConnect was not only key for greater energy reductions during DR events but was also foundational for gathering adequate data for the experiments described in Chapter 4. Based on results from this research, OhmConnect recommends ongoing experimentation with marketing strategies for acquiring users through the direct methods described in this report.

Residential Demand Response Participation Incentives

On average, OhmConnect users earned $2.66 to $6.13 for the 90 days of Phase 1. Expanding this finding to a DR program that would call 100 events per year and set incentives consistent with the wholesale energy price, average user savings could range from $1.82 to $4.80 per year. Savings would be larger for connected users, ranging from $3.95 to $10.40 over 100 #OhmHours. Adopting connected devices increases annual savings by $9.68 to $25.48 in the hypothetical programs considered.

The UCB estimates on the short-run avoided costs from energy procurement and other externalities ranged from $0.17 to $3.96 per user per year for a hypothetical 100-event program. This broad range is based on assumptions about whether events were called during high-price periods. On average, DR events for the experiment were called during periods when wholesale prices were about $0.04/kWh. These estimates did not include the capacity value of the resource, which may increase the value of the programs considered.

Lastly, UCB calculated the private payback period and the discounted social value of connected device adoption. Payback periods for the two smart plugs ranged from 3.6 to 12.3 years depending on wholesale market valuation. Thermostat payback periods were longer due to higher upfront costs, ranging from 11.2 years to no finite payback period. Discounted social value was also sensitive to assumptions about wholesale market valuation, ranging from $24 to an upper bound of $147 for a 5-year device life span (plugs) and $47 to $289 for a 12-year life span (thermostats). These numbers are based on experimental estimates of the effects of adopting connected devices, and also assumed future energy prices and externalities that could affect the results.

Low-Cost Telemetry

This low-cost telemetry project with EPRI describes technological alternatives that could lower telemetry costs for mass-market residential DR participation in wholesale energy markets. EPRI included key stakeholders including the California Energy Commission, The California Independent System Operator (California ISO), and other remote-intelligent gateway (RIG) vendors, in its effort to develop telemetry solutions that would lower costs. Ideas included managing the telemetry system remotely, using a public networking infrastructure, supporting plug-and-play installation of hardware, and simplifying the process wherever possible. Future research on low-cost telemetry should not be limited to these potential methods for lowering cost; there is also a need to continue analyzing the data provided in the RIG output. Though this study reviewed results for a short period, understanding the data for long-term effectiveness could be beneficial in understanding how to better streamline the streamlining telemetry process.

State of the Demand-Response Market

OhmConnect's ongoing regulatory and energy market activities both complement and improve research performed throughout this project. Not only was proactively participating in California's energy-policy discussions key to removing existing barriers to third-party residential DR in the California ISO; California's policy DR targets also aligned with the research's specific goals. OhmConnect's efforts to develop a new market model for DR in California coincided with the Demand Response Auction Mechanism pilot. As a result, OhmConnect was able to results from this project to inform policy discussions with the CPUC and California ISO by providing relevant, data-based examples on how third-party residential DR could succeed in California. This research also benefitted other DR stakeholders since it provided key evidence in arguments about how to structure the state's evolving DR market. Lastly, OhmConnect continues to emphasize the value of customer engagement, a key finding from this project, through its public comments and across regulatory proceedings, thus directly communicating and sharing project results with other DRPs and stakeholders.

By addressing existing barriers to the necessary growth of the residential DR market, the results of this project support the argument that California will be able to better meet its energy and environmental goals through greater utility customer participation. Given California's ambitious timeline for reducing the greenhouse gas emissions that contribute to climate change, greater amounts of carbon-free renewable-resource generation will be crucial for meeting the state's mandated environmental targets. Firming those resources using carbon-free load reduction resources is critical to achieving that goal and minimizing costs. The bulk of recommendations in this report include participation by the CPUC, California ISO, and the California Legislature and, when implemented, could enshrine the efficiency and permanence of DRP residential customer participation in California ISO's wholesale energy markets. Adopting these recommendations will facilitate market success for third-party residential DRPs while advocating for policies that would ultimately make the state's electric grid more affordable, reliable, and less carbon-intensive.

This project set out to prove the viability of third-party DR residential participation in California's wholesale energy markets. The project's research promoted creation of new DR energy market mechanisms in California for DR and jump-started both growth of DR participation and user connectivity to California's electric grid. Importantly, transferring the results of this research to DR proceedings and policy communications has helped accelerate institutional change that will result in residential DR growth in the state.

Benefits to Ratepayers

The ratepayer benefits of this project spanned financial, environmental, grid, and community organizations and markets. Reducing over 27.8 MWhs over the course of this project, OhmConnect project users earned $668,000 from California's IOUs, and donated an estimated $65,000 to non-profit organizations and local institutions. The project resulted in an avoided 9 metric tons of carbon emissions in California, lowered ratepayer costs, and increased grid reliability. These reductions were due in part to the 13,000 energy-efficient smart devices connected to the OhmConnect platform during this project, with as many as 6,000 devices deployed during a single #OhmHour.

Other noteworthy results from this project include updated information on device uptake in disadvantaged communities (DACs). OhmConnect has observed a much greater yield for users with smart devices, and automated users are more likely to remain engaged in OhmConnect over time compared with residential customers who do not use connected devices. This project conducted research on how to encourage users to purchase smart devices, and experimented with different rebate structures to ease the financial burden of purchasing and connecting smart plugs or Wi-Fi thermostats. Even when these devices were free, there was a shortfall in smart device uptake, particularly in DACs. Currently, the number of DAC users numbers in the tens of thousands, and in the past two years, the percentage of users in DACs has nearly doubled. Yet this increase is not matched by the number of connected devices in DACs, suggesting that unexplored barriers still exist to smart-device uptake in DACs.

These project benefits are but a microcosm of the full spectrum of potential project impacts across California. These benefits are examples of how third-party DR providers can benefit ratepayers, especially as barriers to residential DR fall and more DRPs successfully participate in California ISO's wholesale energy markets.

Recommendations

OhmConnect's methods of encouraging residential utility customers to reduce their electricity usage during DR events greatly enhanced its ability to enroll users in new and innovative ways. Taken one step further, OhmConnect discovered through its research that the best way to improve yield during DR events was to not only pay users a set financial incentive but also to encourage them to automate their DR responses with energy-efficient smart devices. Lastly, OhmConnect evaluated other means of incentivizing participants through the state's wholesale energy markets, including implementation of low-cost telemetry.

Residential DR brings strong value to California as the state strives to meet its mandated greenhouse gas reduction goals. As a flexible resource, DR can help balance supply and demand on the grid as additional clean renewable-resource generation is brought online to meet the state's ambitious environmental goals. DR is now ranked first in California's loading order, further underscoring the urgent need for more research like that performed in the course of this project. This research provides value not just to other third-party DR providers, but also to the effort to achieve California's clean-energy policy goals.

While DR has made great strides in the past few years and this project shows promising potential for third-party residential DR, there are still barriers to successful, widespread third-party DRP success. Data access remains challenging, and many IOUs still prevent residential customers from easily sharing their customer usage data. Even when the data is shared, there are often gaps in the data or issues that prevents third-party providers from paying residential customers for their participation. To ensure that third-party DR remains viable in California, OhmConnect will continue sharing its research findings and in future policy discussions. Additionally, further research on customer responses to real-time energy-saving events and smart-device impacts to the grid will continue to increase third-party residential DR in California.

GLOSSARY AND LIST OF ACRONYMS

Term/Acronym	Definition
#OhmHours	OhmConnect's grid-based demand response events
1 point	OhmConnect earnings. 1 point is equivalent to one cent, or $0.01
California ISO	California Independent System Operator
CBP*	Capacity Bidding Program
CCA	Community Choice Aggregators
CISR-DRP	Customer Information Service Request for Demand Response Providers
Click-Through	Open Authorization Click-Through authorization Process
Connected Devices	Smart home automation for energy-related devices. Users can connect these devices to their OhmConnect platform.
Connected User	OhmConnect users with a Connected Device
CO_2e	Carbon Dioxide Equivalent
CPUC	California Public Utilities Commission
DAC	Disadvantaged Communities
DAM	Day-Ahead Market
DLF	Distribution Loss Factor
DR	Demand Response
DR potential study	Lawrence Berkeley National Laboratory's *2025 California Demand Response Potential Study*
DRAM	Demand Response Auction Mechanism
DRP	Demand Response Provider
EC2	Elastic Compute Cloud, or Amazon's Virtual Server Hosting Services
EMS	Energy Management System
EPRI	Electric Power Research Institute
ESDER	California Independent System Operator Energy Storage and Distributed Energy Resources Initiative
In-Home Device	An internet-connected device, such as a Wi-Fi thermostat, that can control load at a Location and, in some cases, communicate with the utility smart meter.
IOU	Investor-Owned Utility
kW	Kilowatt, a measure of electrical power
kWh	Kilowatt-hour, a measure of electrical energy, often referred to in terms of consumption
LBNL	Lawrence Berkeley National Lab
Location	An end-use electric customer enrolled in OhmConnect's DR service

Term/Acronym	Definition
MW	Megawatt, a measure of electrical power. One MW equals 1,000 kW.
MWh	Megawatt-hour, a measure of electrical energy, often referred to in terms of consumption. One MWh equals 1,000 kWh.
PG&E	Pacific Gas and Electric
RAM	Renewables Auction Mechanism
Resource	A California ISO market resource comprised of many OhmConnect Locations
RIG	Remote-Intelligent Gateway, used in the low-cost telemetry experiment
RTM	Real-Time Market
Rule 24/32	A key regulatory element that enabled Third-Party Residential DR to access smart meter data
SB	Senate Bill
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SEO	Search Engine Optimization
SFTP	Secure File Transfer Protocol
Status Level	A fun component on OhmConnect's platform that provides users with a bonus on how much they earn based on their average energy reductions
Streak	A fun component on OhmConnect's platform that provides users with a bonus on how much they earn based on if they perform well on multiple events in a row
Sub-LAP	Sub-Load Aggregation Point, a geographic region on California's electric grid
Supply	Wholesale market products available to monetize the energy reductions from DR. A primary pillar of residential DR.
UCB	University of California, Berkeley
Users	The number of residential utility customers participating in DR. A primary pillar of residential DR.
Yield	How much individual residential utility customers reduce during DR events, which in aggregate result in negative energy on the electric grid. A primary pillar of residential DR.

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