PGE Testbed Proposal

October 2018

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Tables, Figures, and Charts

Acronyms

AIDA.... Awareness Interest Desire Action model
AMI ..... Advanced Metering Infrastructure
AWEC.. Alliance of Western Energy Consumers (formerly ICNU)
BAU..... Business as Usual
BIS....... Battery Inverter System
BPA ..... Bonneville Power Administration
C&I...... Commercial and Industrial
CTA...... Consumer Technology Association
CUB..... Citizens Utility Board; Oregon
CVR ..... Conservation Voltage Reduction
DER ..... Distributed Energy Resource
DLC...... Direct Load Control
DLCT.... Direct Load Control Thermostat
DMS .... Distribution Management System
DOE..... United States Department of Energy
DR .... Demand Response
DRAG... Demand Response Action Group
DRRC... Demand Response Review Committee
DRMS.. Demand Response Management System
DRP ..... Distribution Resource Planning
DSM .... Demand-Side Management
EE........ Energy Efficiency
EV........ Electric Vehicle
FERC.... Federal Energy Regulatory Commission
FTE...... Full-Time Equivalent
GMP.... Green Mountain Power
HB .... House Bill
HVAC... Heating, Ventilation, and Air Conditioning
ICNU.... Industrial Customers of Northwest Utilities (now AWEC)
IRP....... Integrated Resource Plan
IT......... Information Technology
kWh..... Kilowatt Hour
LCFS..... Low Carbon Fuel Program
MFR..... Multifamily Residence
MW..... Megawatts
NEEA ... Northwest Energy Efficiency Alliance
NWPCC Northwest Power Conservation Council
O&M ... Operation and Maintenance Costs
OEM .... Original Equipment Manufacturer
OPUC... Public Utility Commission of Oregon
PAC...... PacifiCorp
PGE...... Portland General Electric Company
PII........ Personal Identifiable Information
PNNL... Pacific Northwest National Laboratory
PTR...... Peak Time Rebate
PV........ Photovoltaic
RMI...... Rocky Mountain Institute
SB .... Senate Bill
SCADA. Supervisory Control and Data Acquisition
SFR ...... Single Family Residence
SIC .... Standard Industrial Code
SMB..... Small-to-Medium Business
SoHi..... South Hillsboro Land Development Project
T&D..... Transmission and Distribution
TE........ Transportation Electrification
TOU..... Time-of-Use
TRC...... Total Resource Cost Test
UoP ..... University of Portland
VPP...... Virtual Power Plant

Key Terms and Concepts

Demand Response (DR) – "Changes in [energy] usage by end-use customers from their normal consumption patterns in response to changes in the price of [energy] over time, or to incentive payments designed to induce lower [energy] use at times of high wholesale market prices or when system reliability is jeopardized."[1]

Demand Response Testbed – a geographically-defined set of communities in which "to rapidly accelerate the development of viable demand response programs and demonstrate its ability to function as a resource." The Public Utility Commission of Oregon directed that the PGE Testbed "target multiple customer segments, consider current infrastructure capabilities, costs, potential penetration levels, and availability of other distributed energy resources."[2]

Flexible Load – a more dynamic type of DR identified as a necessary resource in a decarbonization study. Flexible load is a dynamic form of DR capable of providing valuable grid balancing services. Grid balancing services are necessary for integrating high levels of renewable or variable energy resources. To supply gird balancing services, these demand-side resources must be available to grid operators throughout the day and capable of supplying several different types of energy products beyond peak load shifting.

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[1] FERC National Assessment and Action Plan on Demand Response, https://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential.asp.

[2] Commission Order 17-386, Docket LC 66. Available at https://apps.puc.state.or.us/orders/2017ords/17-386.pdf

Executive Summary

Portland General Electric Company (PGE or Company) is pleased to file this Testbed project, which was collaboratively conceived and is a first-of-its-kind research project. It is meant to advance PGE's collective understanding and development of DR. The purpose of the Testbed is to gain insight into how we could provide a demand-side resource capable of substituting for more economically (and environmentally) costly supply-side resources.[3] The Public Utility Commission of Oregon's (OPUC's or Commission's) Order No. 17-386 directed PGE to A) establish a DR Testbed by July 1, 2019; B) establish an oversight committee (i.e. the Demand Response Review Committee or DRRC); and C) acquire at least seventy-seven and sixty-nine megawatts (MW) of winter and summer DR capacity, respectively.[4] This proposal is the result of stakeholder engagements and input. PGE estimates that the total cost for the Testbed project will be approximately $5.9 million. In conjunction with this pilot, PGE plans to file an application for deferred accounting to recover these costs. In response to the Commission's direction for PGE to acquire DR at scale, PGE's goal is to acquire approximately six megawatts of DR capacity. PGE plans to achieve this via a 66% residential participation rate and a 25-40% commercial participation rate in the Testbed pilot. PGE has set aggressive participation goals compared to the 5-10% national residential adoption rate for DR programs.[5] PGE proposes a two-and-a-half year pilot to commence at Commission approval. PGE plans to leverage DR pilots to establish an engaged customer relationship for Testbed customers. PGE plans to explore how to establish a new customer service paradigm, which will differ from traditional one-way communication where consumers and their equipment work collectively with–even at times autonomously from–their energy company to support more economical and environmental operations of the energy grid.

The primary goal of the Testbed is to explore how to accelerate the development of DR as a cost-effective resource replacement to help address the 2021 resource capacity need identified in PGE's 2016 Integrated Resource Plan (IRP). This strategy is similar to energy efficiency (EE) in that DR requires customer participation and is primarily located on the distribution system. In addition, PGE aims to capture other attendant benefits in the Testbed, with Phase I gathering learnings about: A) how to structure future DR program offerings; B) best methods to engage customers in DR; C) customers' participation in, motivations for, and comfort levels with DR; D) best ways to coordinate with technology providers and program implementers; E) the effect DR has on the energy delivery system; F) how best to develop flexible loads (a more dynamic type of DR identified as a necessary resource in PGE's decarbonization study[8]); and G) resource planning practices.

In Phase I, PGE plans to research the customers served by each of the three targeted substations, engage those customers, and present an opt-out pricing option with a Peak Time Rebate (PTR) incentive. This is planned as a voluntary response pilot in which participants receive rebates for reducing energy usage during ten to twenty DR

[3] The Commission issued its Order on the Testbed in conjunction with a requirement that the Testbed be developed. The Commission undertook these actions to address a 2021 capacity need found in the 2016 IRP. The original submittal of the PGE's 2016 IRP called for the purchase of a significant amount of supply side generation. The Commission's response was for PGE the accelerate its development of DR because it was likely a cost-effective alternative to supply side generation. An additional benefit of DR is that the resource does not produce environmental pollution.

[4] Supra Note 2.

[5] Federal Energy Regulatory Commission, 2017 *Assessment of Demand Response and Advanced Metering Report*, available at https://www.ferc.gov/legal/staff-reports/2017/DR-AM-Report2017.pdf

[8] Available at https://www.portlandgeneral.com/-/media/public/our-company/energy-strategy/documents/exploring-pathways-to-deep-decarbonization-pge-service-territory.pdf?la=en

events annually. To establish the Testbed, PGE plans to use a "platform approach" as detailed in Section 3.1, and to leverage the following residential DR pilots:

- **Direct Load Control Thermostat (DLCT) Pilot**, offered through PGE's Tariff Schedule 5, is a pilot of a DR technology that enables customers to better control their overall energy costs via a device that is both an EE measure and a DR technology. As a DR technology, DLCTs grant PGE the ability to achieve automated load control among residential customers. That is to say that PGE can communicate with the Thermostat about opportunities to support the grid. The device then responds to the request as per the customers' performance preferences. The device allows customers to set performance parameters, after which it automatically responds to a PGE DR request. This pilot was one of two residential DR pilots proposed in OPUC Docket No. UM 1708 (Two Residential Demand Response Pilots, also known as UM 1708) and is described in more detail in Appendix A.1.
- **Multiple Family Residence (MFR) DR Water Heater Pilot**, offered through PGE's Tariff Schedule 4, targets MFR housing because of its high concentration of electric water heaters. This pilot was proposed in OPUC Docket No. 1827 and is described in more detail in Appendix A.2 .
- **Residential Pricing Pilot (Flex Pricing)** PGE's Tariff Schedule 6 offers a series of pricing alternatives to help PGE explore issues based on the types of residential customer load shape profiles. This pilot was the other DR pilot proposed in UM 1708 and is described in more detail in Appendix A.4.

In addition to the above, PGE also plans to coordinate Phase I of the Testbed with other related customer offerings. These may include investments in pilots and programs for energy storage and residential, public, workplace, and fleet electric vehicle (EV) charging, as well as new construction and single-family water heater pilots. Piloting these offerings within the Testbed is expected to provide insights into interactive effects between products, as well as an opportunity to coordinate PGE's product and program offerings with those of the Energy Trust and the Northwest Energy Efficiency Alliance (NEEA).

By using an opt-out peak time rebate (PTR) as the primary engagement tool, PGE expects to have an opportunity to conduct the necessary research to identify the many customer value propositions of DR. This research is primary to the Testbed and we believe will be important to increasing DR program participation across the service territory. Identification of the customer value proposition or propositions was first identified through work with the DRRC.

Roughly half of the Testbed's costs ($3.3 million) are associated with delivering PGE's current, cost-effective DR pilots at scale. The remaining $2.6 million in costs are towards the accelerated development of DR through outreach, education, engagement, research, new program development, and evaluation. These costs are reflected in the Testbed's 0.58 Total Resource Cost Test (TRC) benefit-cost ratio.[12] Another way to view these costs is as the means to accelerate development of a resource that would otherwise progress iteratively over many pilot cycles; an approach which OPUC Staff (or Staff) questioned in their final comments on PGE's 2016 IRP.[13] Although not cost effective, PGE believes that the Testbed should be viewed as an investment accelerating the pilot-to-program cycle that is anticipated to save customers money over the traditional pilot cycles of resource development. By

[12] See Section 3.6 Cost Effectiveness.

[13] Public Utility Commission of Oregon Docket LC 66, Staff Final Comments.

hitting the “at scale” participation goal, PGE expects subsequent development and delivery efforts to be more cost-effective.

PGE’s Testbed strategy is centered on the implementation of opt-out PTR for Testbed participants. This pilot is similar to the Flex Pricing pilot’s PTR opt-in pricing option. However, where Flex Pricing participants are given the option to opt-in, Testbed participants can choose not to participate by opting-out of the pilot. PTR is a non-firm DR pilot that operates like a traditional rate schedule with incentives paid when customers respond to DR events for each heating and cooling season. PGE plans to offer participating customers the opportunity to respond to an event by reducing loads when we notify them through their preferred channel. Upon verification of their response, PGE’s plan is to pay the customer a set rebate for each kilowatt hour (kWh) of reduction. PGE expects no change in or risk to the cost of service (our traditional per kWh pricing) for customers who are unable to respond.

When PGE reviewed potential methods to reach “at scale” participation, we determined that only using marketing and outreach was not feasible because it would be prohibitively expensive. Instead–and with the DRRC’s understanding and support–PGE chose to leverage opt-out PTR because it is the most cost-effective means to achieve the “at scale” customer DR participation and deliver project learnings.

The goal of this engagement strategy is to advance the energy service from the present paradigm of one-way service based on volumetric billing to a new paradigm where customers are both the consumer and producer of energy services. This new paradigm has been defined as the rise of the “prosumer”[14], a term adopted within smart grid development communities to refer to a customer capable of both taking service from and providing services to the energy company. Thus, the prosumer both consumes *and* produces energy. We expect the Testbed pilot will be an intense effort to develop prosumer energy resources and behaviors. The Testbed is meant to research into and work towards establishing the best customer value proposition(s) for DR and–if extended into Phase II–distributed energy resources (DERs).

PGE’s goal is for Testbed participants–and eventually all customers–to “get it, love it, do it, and not think about it.”[15] The strategy of using PTR to recruit participants is only part of the customer journey. PGE plans to offer technology programs to our customers that automate their responses to DR events. The customer journey’s “migration-to-automation of customer response” stage is important for several reasons:

- Direct load control (DLC) DR is considered a firm resource and therefore more reliable for grid operations; this makes the demand-side resource more viable as a replacement for traditional generation resources.[16]
- DLC programs and the enabling technology are sophisticated enough that customers are often unaware that their devices are even providing grid services. To provide an example, PGE’s MFR DR Water Heater Pilot can operate the resources multiple times per day without any recognition by or inconvenience to the customer. Our algorithms and operational parameters are designed to supply the grid with energy services

[14] https://www.energy.gov/eere/articles/consumer-vs-prosumer-whats-difference

[15] During the DRRC retreat to the Rocky Mountain Institute’s E-Lab Accelerator, the Team identified this goal as part of the customer journey and helps to define the goal of the Testbed.

[16] Direct load control programs provide grid operators with a level of control similar to traditional thermal generation. Rate-driven DR is considered non-firm DR because it is not controllable by the grid operator. The value of DR to the system increases with the ability of grid operators to visualize, communicate, and control the resource to extract different grid services.

without interrupting the customer's supply of hot water. Our thermostat pilot operates in much the same way.

- PGE believes that DLC is important for the development of the distributed / digitized / flexible grid of the future. In PGE's Decarbonization Study, the scenarios that met the 2050 GHG target relied on approximately 2,000 MW of flexible loads by 2050 to help balance renewables and meet peak load.[17] In the High Electrification pathway, the study estimated that these flexible loads may reduce peak load by approximately 900 MW in 2050. The study helped guide our understanding that PGE would need to develop flexible load in order to provide the necessary grid balancing services to bring on a high number of supply side and distributed renewables. This "flexible load" is related to DLC DR in the sense that it is a "prosumer" service available to the grid every hour of the year.

In this application, PGE proposes a project to accelerate the development of DR as a replacement for more costly supply side resources. While the approach is novel, ambitious, and complex, the project budget and timeline are limited (albeit with the option to extend if benefits can be identified and value realized). The DRRC advised PGE on the development of the approach, the theory of the pilot, as well as its budget and activities. The Rocky Mountain Institute (RMI) helped focus and accelerate the pilot's development. PGE leadership supports the coordination of activity and recognizes the value that investment in the Testbed will provide. PGE plans to coordinate and co-locate new pilots and programs such as behind-the-meter energy storage, EV charging, and distribution system upgrades as they are rolled out.

PGE recognizes the proposed Testbed is both novel and complex. PGE's goal is for this proposal to be transparent and collaborative. This proposal reflects a detailed discussion of PGE's planned development activities within the Testbed: a list of benefits can be found in Section 3.5 (page 33); the cost effectiveness evaluation can be found in Section 3.6 (page 36), with a further in-depth analysis in Appendix E (page 194); a recap of each of the DRRC meetings and the presentation materials in Appendix D (page 88); a discussion of how we selected the three substation sites can be found in Section 3.3 (page 18); a timeline for the ten quarters of work can be found in Section 3.4.1: (page 32); maps of site can be found in Appendix C (page 85).

Lastly, PGE proudly recognizes the integral role of the DRRC in the development of this proposal. We thank DRRC members for their gracious and invaluable review of, edits to, and feedback upon this proposal. We look forward to ongoing collaboration with our community of stakeholders on this and subsequent undertakings.

Section 1 Background

1.1 State Policy

Oregon advanced policy around distribution-sited grid assets in House Bill (HB) 2193, 2015 Legislation Session.[22] In September of that year, the Commission opened OPUC Docket No. UM 1751 to implement HB 2193. The orders

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[17] "Exploring Pathways to Deep Decarbonization for the Portland General Electric Service Territory Available", 2018, https://www.portlandgeneral.com/-/media/public/our-company/energy-strategy/documents/exploring-pathways-to-deep-decarbonization-pge-service-territory.pdf?la=en

[22] House Bill 2193, 78th Oregon Legislative Assembly 2015.

filed in this docket adopted guidelines and a framework for proposed energy storage projects.[23] PGE submitted its Energy Storage Proposal and Revised Energy Storage Potential Evaluation in OPUC Docket No. UM 1856 and PacifiCorp (PAC) in OPUC Docket No. 1857. With the passage of Senate Bill (SB) 1547 (Coal to Clean Bill)[24], the 2016 Oregon Legislature advanced Transportation Electrification (TE) policy and created an energy resource loading order. Section 19 of SB 1547 placed EE and DR on the top of the loading order stating that no energy company shall make investment in generation without first procuring cost-effective EE and DR.[25]

The OPUC is developing Demand-Side Management (DSM) policy for energy storage and EVs and is expected to investigate distribution system planning. The Commission opened a proceeding to address SB 978[26] from the 2017 Oregon Legislature and is exploring questions about the regulatory paradigm and importance of customer-sited energy resources.

The Testbed, as authorized by the Commission and conceived here-in, is a response to these policy dynamics and structured to inform issues and questions raised by these proceedings, orders, legislation, and rulemakings. As national and state regulators look to the future and the imperative to reduce our carbon footprint while containing costs, they are looking to the resource, system, and Information Technology (IT) advancements emerging on the distribution system. The Testbed is an opportunity for the Commission to accelerate these advancements in a controlled and contained manner, as well as ask questions to guide policy development and investments for long-term system development that extracts the greatest number of benefits for the greatest number of people.

1.2 Stakeholder Involvement and Guidance

OPUC Order 17-386 required PGE to establish a Testbed by July 2019.[27] The stated purpose of the Testbed is to accelerate the development of DR capacity resources, to acquire DR "at scale," and to demonstrate the ability of DR to function as a grid resource.[28] The Order also acknowledges the significant action required of PGE to achieve its 2021 DR goal of 77 MW (winter) and 69 MW (summer), with a reach goal of 162 MW (summer) and 191 MW (winter).[29]

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[23] On December 28, 2016, the Commission adopted specific guidelines and requirements, in OPUC Order No. 16-504, for PAC and PGE's energy storage project proposals. Later, on March 21, 2017, in OPUC Order No. 17-118, the Commission adopted a framework for PAC and PGE's Energy Storage Potential Evaluations that includes seven elements. On July 14, 2017, PGE filed its Draft Energy Storage Potential Evaluation. Staff and stakeholders reviewed this draft and made recommendations to the Commission through a Staff Report. In OPUC Order No. 17-375, the Commission adopted the following schedule: (1) by January 1, 2018, PGE and PAC were to file draft project proposals and updated draft potential evaluations that incorporated the improvements outlined by Staff in its Report; (2) by April 2, 2018, the utilities were to file final project proposals and final potential evaluations; (3) no later than April 2, 2018, the Commission would begin review of the final filings.

[24] Senate Bill 1547, 78th Oregon Legislative Assembly 2016.

[25] Senate Bill 1547, Section 19(3)(a) & (b) – "As directed by the Public Utility Commission by rule or order, plan for and pursue the acquisition of cost-effective DR." Similarly (a) "Plan for and pursue all available EE resources that are cost effective, reliable and feasible."

[26] Senate Bill 978, 79th Oregon Legislative Assembly 2017.

[27] Supra Note 2, at page 9.

[28] See Public Utility Commission of Oregon, Docket LC 66 Final Staff Comments, Appendix A (May 12, 2017).

[29] Supra Note 2, Appendix B, Page 15.

Additionally, the Commission required the establishment of the DRRC subject matter expert group to advise PGE on the development of the Testbed.[30] The Order required PGE to convene the DRRC by July 2018, which PGE established in February of 2018. Further, the Commission directed that DRRC membership include the Energy Trust, NEEA, Pacific Northwest National Lab (PNNL), Citizens Utility Board; Oregon (CUB), Oregon Department of Energy, Alliance of Western Energy Consumers (AWEC, formerly known as Industrial Customers of Northwest Utilities or ICNU), Northwest Power Conservation Council (NWPCC) staff, and OPUC Staff. Throughout, PGE has maintained an open and transparent process and sought candid and open discussion and feedback.

In June, the DRRC approved the membership of the Cities of Portland, Milwaukie, and Hillsboro, each of which are expected to host a Testbed site. The Cities of Hillsboro and Milwaukie were part of the PGE Testbed's RMI E-Lab Accelerator Team. In May 2018, the former Chair of the Federal Energy Regulatory Commission (FERC), Jon Wellinghoff, contacted PGE and asked to be part of the effort to conceive and implement the project. While Mr. Wellinghoff is not formally part of the DRRC, his inclusion in meetings and discussions with both the DRRC and PGE has been helpful based on his deep interest in DR and experience at the Federal and State levels.[31]

PGE has convened the DRRC on four occasions in 2018 (i.e. February, April, May, and June)[32] and has included a subset of DRRC members in the RMI E-Lab Accelerator event detailed in Appendix D .

Table 1 highlights the material discussions and decisions made at DRRC meetings. Additional details on DRRC meetings can be found in Appendix D .

Table 1 Overview of Stakeholder (DRRC) Meetings

Date	Major Discussions / Decisions
February 2018	- PGE presented potential Testbed sites; DRRC agreed to geographic approach to siting. - PGE presented a "platform approach" to participation strategy that leverages existing pilots to manage costs. - DRRC discussed the meaning of "at scale" (initially pegged at ≥ 25% participation). - PGE presented "two-phase" approach; DRRC advised to focus on establishing the Testbed. - DRRC asked PGE to return with a proposal for three substations.
April 2018	- PGE recommended three Testbed sites – Milwaukie, Hillsboro, Portland. - PGE presented preliminary budget based on 25% residential participation (not 66% as proposed in this application). - DRRC asked PGE to return with estimated cost to acquire 70% and 90% participation.
May 2018	- PGE and a subset of DRRC members discussed the Testbed project at RMI's E-Lab Accelerator: o Team refined understanding on city goals, project goals. o Team articulated that customer value proposition was a key to project success. o NEEA, Energy Trust, and PGE commitments to continue new program development. o Realization that an opt-out PTR may be necessary to assure sufficient participation to deliver project goals.

[30] Ibid.
[31] Mr. Wellinghoff is not under contract with PGE. Mr. Wellinghoff initiated contact with PGE asking to be part of the activity. Mr. Wellinghoff is using his own resources to support his engagement with the project. Mr. Wellinghoff explained to PGE that he is interested in the project because he believes the project to be unique and to represent great potential to add to the national discussion around DR and DER. PGE hopes to meet Mr. Wellinghoff's expectations.
[32] Presentations from each of these meetings can be found in Appendix D .

June 2018	- PGE presented new strategy to achieve maximum-achievable participation by using an opt-out PTR pilot for residential Testbed customers, rebates, and migration to DLC pilots (which include DLCT and residential water heater pilots). - PGE presented a revised $5 million three-year budget with the potential for five to six megawatts of load impact. - Milwaukie highlighted the need for embedded PGE representatives to facilitate deployment at each site. - PGE presented draft approach of research and evaluation. - PGE presented new offerings to be included in the Testbed. - PGE presented a draft Hosting Capacity study for each substation.
September 2018	- PGE issued a draft of the Testbed proposal to DRRC members on the 14th of September. PGE extended the comment period until September 28th and received comments from the NWPCC, OPUC Staff and the Energy Trust.

1.3 From Concept to Proposal

OPUC Staff's provided a high-level statement of need for the implementation of a Testbed in their Appendix A: Demand Response Testbed Overview.[33] Staff also wrote a proposal (adopted in Order 17-386) requesting that PGE establish a Testbed where the proposition of DR "at scale" could be tested on a limited population to:

1. Anticipate penetration rates;
2. Test program designs and customer recruitment strategies;
3. Establish the required mix of customer types; and
4. Test the acceptability of dispatching DR with the frequency and duration needed to achieve large offsets and project costs at scale with a high level of confidence while limiting customers' financial exposure.[34]

PGE has developed this proposal to meet both: A) the requirements in Order 17-386, and B) the white paper issued by OPUC Staff. The definition of an "at scale" DR program evolved over the course of several DRRC discussions before landing on the proposed 66% participation rate.[35] This target would be a milestone in DR, developing data and learnings about how to increase participation in DR programs throughout the service territory.

PGE's proposed Testbed strategy encourages residential customers to participate in PGE's DLC offerings (i.e. DLCT or smart thermostat; and residential water heater pilots). These programs enable customers to provide a firm resource to the grid *without* requiring the customer to change any aspect of their daily routine. The customer should not be inconvenienced by their energy service or energy service provider. Properly structured DR programs can be available to grid operators with greater frequency than traditional DLC. This type of advanced DR is described as "flexible load" and the Testbed is in part designed to understand how to develop these flexible load resources. Flexible load resources are demand-side distributed assets capable of providing various types of grid services throughout the day (e.g. in response to weather events or energy grid operation for such services as wind balancing).

[33] Public Utility Commission of Oregon Docket LC 66, Staff Final Comments, Appendix A.
[34] Staff Comment in OPUC Docket No. LC 66 Appendix A: Demand Response Testbed Overview, page 41.
[35] See Section 3.1 for details.

PGE is piloting the creation of a "flexible load" resource for the advanced grid operation demands of the future. This strategy could save customers from potentially-costly, long-term investments in large-scale generation assets. Lastly, the strategy should provide learnings about customer recruitment and participation and "flexible load" program design.

Section 2 Purpose, Goals, and Phasing

The purpose of the Testbed is to accelerate the development of DR capacity resources, to acquire DR "at scale," and to demonstrate the ability of DR to function as a grid resource. To deliver on these goals, PGE proposes a two-phase concept, with Phase I focused on establishing high levels of participation in DR pilots and programs.

The activity in Phase I is designed to improve PGE understanding of DR. This includes understanding the customer's relationship with DR. Phase I is expected to help PGE understand how to best establish a relationship with Testbed participants through various DR pilot and program offerings. Understanding this foundational relationship is expected to inform PGE's pilot and program development and lend insights into how we accelerate the acquisition of DR capacity.

Phase I is primarily focused on the customer value proposition. PGE plans to begin Phase I by conducting research and surveys to identify possible value propositions. PGE plans to increase engagement among residential customers by placing customers on an opt-out PTR. This form of engagement should grant PGE additional research options to help identify customers' DR value propositions. Technology-based pilots such as smart thermostats and smart water heaters are expected to help PGE test differing messaging, approaches, and engagement models. This is due in part to the different grid services that PGE can extract from these devices, as well as the different customer experience associated with owning and enrolling a thermostat or a water heater in a PGE DR offering.

An important part of the engagement activity beyond the opt-out PTR is PGE's request for funding of a community engagement representative to be embedded at each of the Testbed sites. PGE and several members of the DRRC believe that community engagement will be an important factor in better understanding customer motivation and the customer / utility relationship. This community engagement approach is not new: it was successfully employed in the 1980 Hood River Conservation Project, which sought 100% customer participation in EE within a discrete geographic area. Energy Trust also plans to employ this community engagement approach to address equity concerns and underserved customers.

Phase II is necessarily less defined. Conceptually, Testbed activity will allow PGE to understand the technical and market potential of DR as well as the potential of DERs to serve long term system needs. This conceptualization is in line with results of PGE's Decarbonization Study, which highlighted the need to develop a dynamic form of DR, termed "flexible load", for PGE to reach our carbon reduction goals. The large potential for flexible loads in the Decarbonization Study was driven by high adoption rates of new electric technologies like electric vehicles and heat pumps, coupled with high participation rates in DLC programs. As a result, flexible load programs in the Decarbonization Study comprised 45-70% of the new flexible resources that were added between now and 2050 across the three low-carbon pathways, which helped drive down the costs of meeting the 2050 Green House Gas target.

Learnings from Phase I will help PGE comply with Order 17-386 direction to procure cost effective EE and DR resources before investing in additional generation assets. PGE agrees and is delivering on the OPUC's direction and developing the Testbed pilot under the guidance of the DRRC. PGE's Testbed strategy encourages customers to participate in our DLC pilots, which we expect will enable a firm grid resource without inconveniencing the customer.

PGE will use current DR offerings to establish the Testbed megawatt savings and customer participation. PGE is utilizing this approach for several reasons. Firstly, PGE has experience with these offerings and has gained insights into how they are received by customers, and thus, how they perform. This mitigates failure risk and allows PGE to focus on identifying how to modify its approach to acquiring DR. Secondly, the approach limits the cost risk of establishing a venue wherein research can be undertaken. Thirdly, the approach allows PGE to build upon existing customer relationships, which we expect will be critical to meet the Commission's direction for "at scale" participation. Fourthly, this approach helps PGE deliver on the Commission's call for swift action. Finally, leveraging known, cost-effective offerings lowers the long-term cost of the endeavor, limiting customer exposure to risks associated with pilots of limited duration and applicability.

PGE plans for Phase I to consists of an initial two-and-a-half year funding cycle starting upon Commission approval. Phase I includes two years of field activity, to be bracketed by a preceding and following quarter for research and evaluation. Phase I will span three substation sites in three cities and include approximately 20,000 customers. The goals of Phase I are as follows:

1. **Identify, develop, and communicate the customer value proposition of DR to PGE's customers.** PGE expects that achieving this goal will require survey activity undertaken prior, during, and after Phase I. In addition, PGE expects to coordinate with the Energy Trust and NEEA to develop appropriate strategies. As PGE's plan is to use opt-out PTR to establish Testbed engagement, PGE's plan is to use this engagement to collect information from participants to meet this goal.

2. **Work with customers to establish and retain a high level of customer participation in DR programs.** PGE expects that this will be a challenging aspect of the Testbed work. We believe that using an opt-out approach to establish engagement will mean that the act of participation is dependent on PGE's ability to provide an experience valued by the customer. Additionally, we believe that customer retention will likely turn on more than just monetary value. PGE expects that engaged customers will help us identify some of the other values supporting retention.

3. **Learn how to recruit and retain customers' participation and translate these learnings into development of cost-effective strategies across the service territory.** PGE plans to identify additional engagement, recruitment, and retention strategies through Testbed activities. We expect this exploration will be driven by the research, education, and outreach activity. Furthermore, we expect that collected data and discourse will provide learnings regarding customer motivation and barriers to adoption. Currently, PGE relies on monetary incentives. However, where the Testbed can provide insight about other participation drivers, we expect that it will inform development of new approaches to program recruitment and retention.

4. **Collect information on DR potential, which we expect to inform future potential studies.** As of this filing, PGE's IRP DR potential forecasts are informed by historical DR acquisition activity both within PGE's service territory and nationally. PGE expects that the Testbed will provide new insights into customer value propositions, motivation, engagement, and participation. Should this be the case, PGE expects that these insights will factor into new DR potential studies for PGE.

5. **Create new program offerings that can quickly translate to broad deployment program offerings.** The Testbed is meant to not only develop an understanding of the customer relationship with DR, but also to accelerate learnings from new program offerings. PGE expects the level of customer engagement and multiple customer touch points funded through the Testbed to help PGE gather insights about new program offerings at an accelerated rate. Our goal is for this feedback and data to inform program rollouts to the entire service territory.

6. **Coordinate on new program development with other demand-side measure providers such as the Energy Trust and NEEA.** PGE understands that EE and DR are related in technology, channel to the customer, and acquisition. PGE understands that NEEA and the Energy Trust's established channels and strategies to acquire EE could be leveraged for DR development and acquisition. PGE wants to coordinate program work with the Energy Trust and NEEA. PGE expects that the Testbed and PGE's new Demand Response Advisory Group (DRAG) will be venues for this coordination. Both the DRAG and Testbed have been charged with program development and roll-out coordination. We expect to identify coordination opportunities, and where possible, how to acquire program and customer benefits.

7. **Study and understand the system operational implications of high levels of DR, as well as gain insight into the implications that the high levels of flexible load necessary to meet PGE's carbon reduction goals will have upon PGE's grid.** One reason that PGE's DR acquisition lags behind other resource development is that operation and operational implications have not been clear to our grid operators. This is because until recently, PGE did not have the granular data and visibility into the distribution system to take advantage of DR. With the recent identification of flexible load as a major future resource, PGE plans to leverage the Testbed to gain A) the insights necessary to familiarize grid operators with flexible load's potential and future value, as well as B) experience operating flexible load with more granular control and visibility.

Phase I targets high levels of DR participation–66% of residential meters, and 25-40% of commercial meters–resulting in approximately six megawatts of capacity. In addition to continuing to accelerate the development of DR in Phase II, PGE plans to expand efforts into DER development and advanced control schemes, as well as the operation of all DSM resources. Note that PGE *is not* requesting funding for Phase II at this time.

The following sections develop the case for PGE's Testbed proposal by laying out the work that PGE has completed to date, including stakeholder involvement, PGE's proposed approach, and concluding with details on the underlying pilots that PGE plans to leverage to meet the above Testbed goals.

Section 3 Proposed Approach to the Testbed

3.1 Testbed Strategy

Order 17-386 and OPUC Staff's Testbed white paper identify the main purpose of the Testbed as accelerating DR development in terms of megawatts procured and programs developed so that DR can serve as a grid resource capable of affecting grid operations for energy and capacity. This will require high participation rates. OPUC Staff's white paper also requests quick evolution between Testbed work, research, and territory-wide application. PGE is aligned with the vision of both high participation and quick application of learnings.

PGE initially defined "at scale" participation as 25% of residential customers. This was informed by PGE's DR potential study,[36] concluded that the maximum technical potential for residential DR was 25% participation. PGE presented an initial strategy to the DRRC to achieve this 25% participation target through education and outreach. This scenario relied on the voluntary participation of Testbed customers and anticipated $1 million in outreach and education costs.

When the DRRC asked PGE to conduct an exercise to scale costs for 70% and 90% participation, PGE found that recruitment costs rose exponentially (to approximately $3 million and $4 million, respectively). These costs led PGE and a subset of the DRRC to reassess project strategy at the RMI E-Lab Accelerator event.

PGE presented the resulting revamped strategy to the DRRC at their June meeting, as detailed in Appendix D . This strategy targeted 66% participation (the share of residential customers for which PGE has email contact information). The strategy lowered marketing and recruitment costs. PGE's proposed Testbed investment ($5.9 million) is inclusive of all incremental costs and reflects both portfolio level enablement costs and variable DR operating costs (which increase with participation targets).

Testbed goals include both participation rates and MW adoption. To achieve the desired 66% participation rate, PGE proposes an opt-out PTR (discussed in more detail in Section 3.1.2 . To achieve the MW adoption for flexible load identified in PGE's Decarbonization Study requires a larger load impact than can be delivered via optional participation and event-based products such as PTR. PGE proposes to achieve this larger load impact via DLC options, which also offer firmer capacity and greater availability than PTR. PGE proposes to use a "platform approach" (detailed in Section 3.1.1), which migrates PTR participants to the higher-valued DLC options while retaining the 66% participation rate. In addition, DLC delivers DR through automation, which PGE has found to be imperceptible to most customers. For example, the CTA 2045 Pilot showed that PGE could call multiple events per day, sometimes several per hour, without the customer noticing.

During the duration of the Testbed pilot, PGE plans to evaluate communication strategies and incentive designs to migrate participants to opt-in DR offerings. The aggressive scenario migrates 25% of eligible single-family households to thermostat and 25% to water heater DR (a total of approximately 6,500 households); the moderate

[36] Which was submitted with PGE's 2016 IRP and is also referred to as the "Brattle Group Study".

scenario migrates half as many households. Targets vary by household type, given the varying fit of household type to DR pilot.[37] A refined customer value proposition should inform PGE's work throughout the service territory.

3.1.1 Platform Approach

To achieve the Testbed goals, PGE proposes to use a "platform approach", defined as leveraging PGE's platform of current DR offerings, specifically the established customer relationships necessary for "at scale" participation. By using these pilots to establish the relationship with customers, PGE can leverage their operations and familiarity, which mitigates potential barriers to adoption, administration, and operation. Additionally, the current PGE DR offerings are cost effective and, thereby, help PGE control Testbed costs. The platform approach allows flexibility to incorporate new DR offerings. Once the relationship is established, PGE can work with the customers on other new opportunities such as PGE's SFR DR Water Heater Pilot, new rate designs, and DR-enabled appliances.[38] The platform approach maximizes successful customer engagement, which is necessary to achieve PGE's participation goal. To achieve this, PGE plans to implement an opt-out PTR as an engagement tool, which is discussed further in Section 3.1.2. Opt-out PTR will drive participation and capitalize on the communication opportunity to put forward several value propositions to customers. Primary among these value propositions are why the customer should participate and how they can do so in the least intrusive and easiest manner. DLC options are an ideal solution in that they provide customer incentives with less action on the part of the customer. They generally require a customer's attention only at initiation, with subsequent events managed through customer devices.

In addition to easing adoption within the Testbed, PGE's current DR offerings have also informed the development strategy for the Testbed itself. Most notably, Flex Pricing has influenced PGE's understanding of a path to high participation levels that are independent of standard marketing and recruitment efforts. Flex Pricing and its evaluation, performed by Cadmus and provided as Appendix F, have helped PGE and stakeholders understand the benefits and drawbacks of a default opt-out pricing option (e.g. impacts to the PGE brand and lower individual and aggregate load reduction). PGE expects this understanding will help develop a mitigation strategy to facilitate the extension of opt-out PTR to the broader service territory. It is important to note that the Cadmus evaluation concluded that customers *do* respond to opt-out PTR and *are not* harmed when they are unable to respond. Thus, opt-out PTR represents a non-punitive approach to customer engagement.

PGE's current DLC offerings have evolved their approach to customer engagement. For example, PGE's DLCT pilot was originally designed as a "bring your own" pilot. This Pilot granted insights that allowed PGE to move more decisively due to positive customer engagement, the reliability of the technology, and partnership with smart thermostat providers. These insights helped PGE determine that smart thermostats should be a primary DLC offering to Testbed participants. PGE's MFR DR Water Heater Pilot has also had successful deployment. The Testbed approach to DLC was additionally informed by PGE's CTA 2045 Water Heater Pilot. PGE feels comfortable offering both water heater pilots to Testbed participants. Both pilots have shown that most enrollees never notice

[37] Eligibility for various DR pilots includes AC or electric heat, low voltage thermostat, and electric water heater. These characteristics vary by household type.

[38] Detailed information on these new opportunities can be found in Appendix B .

the frequency at which the water heater is dispatched, and very few ever report not having hot water to serve their needs.

The successes of the water heater pilots are informing development of our EV charging pilot, as the same program manager responsible for the success of PGE's water heater pilots will also be constructing our EV charger pilot. During development of PGE's MFR DR Water Heater Pilot, PGE engaged Enbala to provide a DR energy management and device integration system. PGE plans to leverage the Enbala software platform to integrate the various devices that will fertilize the Testbed. We expect that the Enbala system will allow us to manage and aggregate device response. PGE plans to identify (and potentially cultivate) new DR use cases as multiple types of devices are brought online in the Enbala ecosystem.

Alternatively to the "platform approach" that PGE has proposed, PGE could identify a potential Testbed site or choose a set of customers and use the site or customer group to test new DR offerings. However, PGE felt this approach had several drawbacks:

1. It is not recommended to conduct, all at once, an experiment to answer questions regarding technology performance, product packaging, and marketing. It would be difficult for PGE to determine causes of any limitations to success, approach, or product and leave us with no conclusions about the ability to achieve market saturation.
2. If programs were tested in sequence, recruitment would be driven solely by marketing.
3. Synergistic aspects about the programs and dependent program strategy would not be tested.
4. The approach would be expensive as each program would need to reestablish participation; thus, re-engagement efforts would redouble for each new development.
5. Since each program would be new, it would be more difficult to compare against a base case or a control group.

The platform approach mitigates many of the above shortcomings while accelerating the establishment of a Testbed and allowing for new iterations without redundant marketing efforts and expenditures. Importantly, in establishing a Testbed, this approach limits the "financial exposure on the part of [customers]."[39]

3.1.2 Pilot Details

PGE's strategy to acquire this participation involves moving all residential customers in the Testbed to a default opt-out PTR, which was tested in Flex Pricing. In an opt-out program, customers are automatically enrolled, but can choose not to participate (i.e. "opt out") at any time. From the results of the Cadmus evaluation, PGE hypothesized that using an opt-out PTR would benefit the Testbed strategy to reach high levels of participation. PTR is an incentive-driven, non-firm, DR offering that rewards customers with a check for participating in DR events. Those who do not respond to an event notification are held harmless. The energy bill for those not participating should remain as if they were on a non-DR incentive rate schedule. Because participants are held harmless if they do not respond to an event signal, PGE believes implementing PTR as an opt-out pricing option does not those unable to participate due to historical and systemic barriers.

There are several reasons for deploying an opt-out PTR. First, PGE is using an opt-out approach as a recruitment tool. This also becomes a communication and engagement opportunity. Secondly, having an opt-out PTR allows

[39] Supra Note 18.

PGE to understand the costs and benefits of accelerating non-firm DR (PTR and time-of-use, or TOU, pricing) through an opt-out mechanism. However, opt-out PTR is not without drawbacks. The most significant of which is that customer satisfaction rates for opt-out PTR in Flex Pricing was lower than opt-in PTRs and TOU, peak and off-peak, rates. PGE strives for a positive customer experience. Opt-out rates strain the customer experience. For purposes of accelerating PGE's understanding and development of DR, PGE is willing to deploy opt-out PTR in a limited fashion. PGE plans to report to the Commission and the DRRC on insights in making the opt-out experience better.

The opt-out PTR strategy establishes the recruitment, communication, and engagement channel, therefore allowing us to continue the customer value proposition and customer journey to develop more flexible loads through the DLCT pilot. This pilot leverages EE savings and incentives offered through the Energy Trust to move customers to a offering that automates their response to DR events. As part of the DLCT Pilot, the "Bring Your Own Thermostat" offers an enrollment incentive and seasonal participation incentives. In addition, the DLCT Pilot also has a direct install option which offers the customer a smart thermostat for free or at reduced cost in exchange for DR event participation.

PGE plans to have the MFR DR Water Heater Pilot–and when ready, the Single-Family Water Heater Pilot, described in Appendix B.3–offer this migration to automated DR. PGE's MFR DR Water Heater Pilot offers incentives to building owners to allow PGE to control a fleet of electric water heaters. PGE plans to structure the SFR DR Water Heater Pilot similarly to this pilot, with incentives offered for event participation. We believe that a key success factor of the SFR DR Water Heater Pilot–as has been found with the DLCT Pilot–will be coordination with the Energy Trust.

3.1.3 Strategy to Establish the Customer Relationship and Participation

The risk-mitigation strategy PGE plans to use to establish the Testbed is to leverage current cost-effective DR pilots. PGE has seen success from current DR offerings such as smart thermostats, smart water heaters, and large commercial and industrial DR. These pilots are established, studied, and approved by the Commission; they are familiar to PGE's customers, deployment partners, and contractors. By leveraging current DR offerings to establish the necessary relationship with customers in the Testbed, PGE limits not only the adverse impact to these customers, but also the costs associated with wholly-new programmatic endeavors.

While there are still DR opportunities with clothes dryers and refrigerators, these home appliances have not yet demonstrated the connectivity and grid-accessible flexibility necessary to support a DR offering. As a result, space heating / cooling and water conditioning remain the best target for residential DR (and not coincidentally, the two largest loads). PGE expects EVs to become a similarly-large residential load. The first phase of the residential Testbed plan will focus on these loads.

Despite separate timelines and dockets, PGE will attempt to coordinate with other related pilots and programs to extract additional benefits from the Testbed. In the case of the Residential Storage Pilot, PGE will explore how we might target offerings within the Testbed to better understand how residential storage could interact within that ecosystem. PGE is currently identifying customers in the Testbed who would see the greatest value from having an on-site storage system.

By establishing "at scale" customer participation within the Testbed via an opt-out PTR pilot, PGE expects to increase the feasibility of achieving the degree of customer participation needed for Testbed learnings to A) be representative of PGE's customer base, and B) create the learning needed for later, broader deployment of these technologies. For this to be successful, we believe that it is important for us to communicate and educate participants, so they understand the customer value proposition of participating. Without such outreach, the Testbed may fail to meet the desired 66% participation target and miss the opportunity to extract the necessary learnings to accelerate the broader development of DR.

PGE believes that an equally-important component of the PGE Testbed establishment approach is to use of embedded personnel to engage the community at each Testbed site. The plan is to have these personnel engage with key community members, including those who may not have been otherwise identified through traditional research, marketing, and outreach channels. These personnel are expected to bring back engagement lessons from the field and be a first point of contact for community members. This approach was used with great success in the 1980 Hood River Project. The community action staff personnel approach was recommended by members of the DRRC. The Energy Trust is also beginning a similar strategy to reach underserved communities. PGE is employing this strategy to learn as much as possible about the individual and community engagement. PGE is confident that such an approach will result in lessons and approaches that we might not have been able to identify through traditional outreach, research, and marketing channels.

3.1.4 Future Testbed Offerings

Through work with the DRRC and members participating in the RMI E-Lab Accelerator event, PGE has identified several new pilots that it plans to create because of–and through–the Testbed. PGE expects that many of the new measures will require coordination with the Energy Trust and NEEA. Pilots that PGE anticipates developing in the Testbed during the two-and-a-half-year project period include:

- SFR water heaters (new and retrofits);[40]
- MFR thermostats for electric resistance;
- Direct install thermostat pilot;[41]
- PGE plans to work with the City of Hillsboro, Earth Advantage, the Energy Trust, and NEEA on a SFR new construction EE / renewable energy / DR bundle;
- PGE will also seek to offer, with Commission approval, a residential storage pilot[42] and several Level 2 smart charging pilots for residential, multifamily, fleet, and business customers[43]

Detail on current DR offerings can be found in Appendix A; detail on future offerings can be found in Appendix B.

3.2 Coordination with External Stakeholders

PGE has a long history of coordinating with external stakeholders in the region. A recent example is the CTA 2045 Water Heater Pilot that PGE coordinated upon with NEEA and BPA. This was a pilot to develop a water heater

[40] This would expand on efforts already being pilot with BPA/NEEA and offered to customers through Schedule 3.
[41] See UM 1708, 2018 Deferral Reauthorization and Appendix A.1.1.
[42] See UM 1856, PGE Exhibit 101.
[43] See UM 1811, Order 18054, Stipulation Adoption, February 16, 2018.

market transformation plan that is expected to be shared with the region by the end of 2019. PGE is also privileged to sit on the Energy Trust's Conservation Advisory Committee and Renewable Advisory Committee. While PGE does not presently have a seat on the NEEA board, we do attend NEEA board meetings as permitted, and have advocated to the NEEA leadership and Board for coordination on DR efforts.[44]

With this history in mind, OPUC Staff recently requested that PGE develop the DRAG forum to facilitate and extend coordination between these parties. The DRAG held its inaugural meeting on October 25, 2018. PGE expects coordination with the Energy Trust and NEEA to result in customer savings and comprehensive offerings that deliver more efficient customer touchpoints. While coordination of EE and DR offerings is expected to take some time to align and fine-tune, PGE believes that the Testbed is an ideal opportunity to identify those development opportunities.

PGE, the Energy Trust, and NEEA have made specific efforts to coordinate where the benefit of DR and EE intersect–whether within the broader market, at the customer site or engagement touchpoint, or with a technology manufacturer. The partners have identified three such programmatic intersections thus far. Most substantial among these is our coordination on incentive offerings for smart thermostats. We have extended the conversation regarding smart thermostats from an EE measure to their additive DR savings or load shifting. Water heaters represent a second intersection of DR and EE. PGE and the Energy Trust are coordinating on a DR-enabled water heater measure to dovetail our activities and incentives. We recognize that heat-pump water heaters provide significant EE benefits and can also provide a range of energy services including DR load shedding, load shifting, and capacity replacement value. A third intersection is the Energy Trust's engagement in PGE's IRP planning efforts, which has preliminarily identified additional demand-side resource procurement potential.

3.2.1.1 Coordinating Market Transformation

PGE recognizes that market transformation is one of the more powerful and cost-effective tools the region has at its disposal to accelerate the adoption of grid-beneficial customer technologies. Aside from having the Energy Trust and NEEA advise the Testbed project through their participation in the DRRC, PGE also intends to explore market transformation activity from–and within–the Testbed.

As stated earlier, PGE is partnering with Energy Trust, NEEA, BPA, and other regional utilities, which is offered to residential customers as PGE's CTA 2045 Water Heater Pilot. As part of this effort, PGE, NEEA, and BPA are coordinating on a proposal for a regional market transformation funding project. The proposal is to fund market transformation efforts to incorporate CTA 2045 into the manufacture of new water heaters. Thus, as home water heater stock turns over during the next 15 years, we expect to see the natural development of a highly-flexible load capable of providing peak DR and grid balancing services.

To further the CTA 2045 work, PGE and PNNL are co-developing a DOE proposal for funding to explore the implications of these highly-responsive devices. In this proposal, PGE seeks funding to populate a feeder with CTA

[44] It is important to caveat that NEEA's DR coordination may be impacted by their funding restrictions and ongoing strategic planning. As a result, it is not yet clear the degree to which NEEA can explicitly conduct DR work in coordination / conjunction with, or on behalf of PGE and the region.

2045-enabled water heaters. A concentration of these devices on one feeder within the Testbed will allow PGE to learn how best to use new integrated grid capabilities and how these resources provide grid-balancing services.

In addition to CTA 2045, PGE expects to seek assistance and guidance from NEEA around market transformation efforts that can be supported by the Testbed. Currently, NEEA has limited availability for such work, but we plan to continue to engage NEEA and its board on funding DR work. In particular, we expect to work with Jeff Harris and others to identify what market transformation insights and activities the Testbed can inform or carry through.

3.2.1.2 Coordinating Flexible Load

PGE, NEEA, and the Energy Trust began coordinating flexible load efforts following the RMI E-Lab Accelerator event. PGE sees the Energy Trust and NEEA as key to developing a flexible load resource for the following reasons:

- PGE, NEEA, NWPC, and BPA are coordinating on a regional market transformation plan for DR-enabled water heaters through the continuation of PGE's CTA 2045 Water Heater Pilot. Market transformation is an important strategy for development of smart water heaters. Many of the heat pump water heaters now entering the market carry some level of grid enablement. PGE, NEEA, NWPCC, and BPA are working on a regional business plan. The plan is to move the heat pump water heater market and manufacturers to a common communication / control interface for smart (i.e. grid-enabled) water heaters that can provide highly-dynamic energy services.
- PGE is working with the Energy Trust to coordinate smart thermostat incentives and uptake. By coordinating DSM program and product efforts, the Energy Trust, NEEA, and PGE can acquire both DR and EE more rapidly and cost effectively. Another benefit of this partnership is coordination of customer contact, with fewer contacts and more coordinated options offered with any initial contact.
- There are a select number of important measures which may not be cost-effective only if both EE and DR benefits are combined. Examples that we are aware of and are actively coordinating with the Energy Trust on include: direct install thermostats (in residential and commercial buildings), direct install heat pump water heaters, and smart line voltage thermostats.

3.3 Site Selection: Substation-based

3.3.1 Methodology for Site Selection and Customer Samples

PGE proposes a specific geographical approach to Testbed development for several reasons. First, by establishing the Testbed based around certain substations, PGE can learn physical system and operational learnings of having high penetrations of DSM on the distribution system. Second, by using substations to define the boundaries of the communities and customers that would make up the Testbed, PGE would not be subject to the potential inherent or direct bias of choosing customers best suited to help PGE meet participation goals. Lastly, the three substations were chosen in coordination with current and near-term distribution investments that enable the technology embedded within the Testbed to be used for distribution use cases.

PGE identified the three-substation approach by looking for the best way to capture the most benefits for customers. Members of the DRRC have asked why PGE didn't identify pockets of customers within the system that would otherwise present a more perfect representational subset of PGE customers. PGE explored this alternative approach but found (and the DRRC agreed) that siting the Testbed physically across the three substations allowed the Company to develop a representative subset of customers. Having a representational subset of customers better assure that the lessons learned will be applicable.

PGE believes that siting the Testbed across the three substations best positions the company learn about the implications, and value of using DR and DER as a grid resource. Learnings are centered on voltage and frequency regulation and how energy services from these resources are extracted from the physical location to assist the bulk grid. The proposed substations are among the first to receive upgrades to enhance communication, visibility, and automation, and are best positioned to aid our learnings about how to work with DR and DER as a resource. With the capability to communicate, visualize, and operationalize these resources, PGE expects to better understand the locational value and locational challenges of leveraging these resources for the grid and customers. Situating the Testbed across three substations creates a model system, an early learning center for operating these resources.[59]

PGE proposes–with the support of the DRRC– the following strategy and structure. PGE identified three substations which create a representational subset of the PGE service territory:

1. The Roseway substation in Hillsboro offers the opportunity to address new commercial and residential construction as part of the South Hillsboro development. It also allows PGE to coordinate with the Energy Trust and test offerings with home builders and buyers for make-ready smart homes; therefore, offers an important market transformation strategy formation opportunity. Additionally, as the City of Hillsboro works to develop new infrastructure and relationships with new businesses, PGE can assist with new DSM offerings.
2. Island substation, in Milwaukie, is a mixed-use substation with a high concentration of MFRs, several pockets of low income housing, a traditional “Main Street” downtown commercial business area, and several industrial customers. This substation may be the most challenging, but potentially offers the most customer engagement learnings to PGE.
3. The Delaware substation in North Portland offers the opportunity to understand DER development at a community scale. This substation hosts the University of Portland (UoP) campus, which is currently exploring solar energy plants and energy storage systems. It is our understanding that UoP will be making additional investments in co-located energy storage, which is of interest as a higher-capacity DER connected to an advanced substation. Additionally, this substation has a high concentration of single-family homes across several important customer types.

Roseway, Island, and Delaware substations were chosen from a larger set, for which PGE examined the customer type and physical local distribution system capabilities. Two PGE departments contributed data sets: Customer Analytics provided customer persona profile data by sector and Transmission and Distribution (T&D) provided residential subsector data. The data provided by Customer Analytics was overlaid with studies from T&D that identified promising substations for the development of a highly active demand-side resource set.

[59] These upgrades also reduced capacity constraints on these substations, so the opportunities for deferring further investment in substation capacity will be limited. However, what we learn about the impact of DR on substation loads is transferrable to other more constrained substations.

Criteria for substation project inclusion focused on one or more of the following:

1. High growth substations;
2. What information could potentially be gathered to inform transmission congestion on the South of Allston transmission pathway;
3. Information gathering for insight into relief of distribution capacity limitations under contingency;
4. Opportunity to research end-of-life equipment deferral value proposition; and
5. Ability to enable and/or improve microgrid capabilities and system resiliency.

The T&D team then limited the list of potential sites to those with advanced communication, automation, and visualization capabilities. This weeded out several substations, as many have outdated communication systems that could not support a DR or DER build out. The criteria that the Testbed substations have the proper Supervisory Control and Data Acquisition (SCADA) capabilities initially limited the number of substations available to a project like the Testbed.

Criteria for substation project inclusion also focused on customer information. PGE wanted the substations to embody a representational subset of customers so that learnings could be made available and applied to the service territory if the Testbed demonstrates success. Having a representative subset meant that PGE could trust the information received from the Testbed investment. For this subset to be representational, it was imperative to have several residential subgroups, including low income and mobile homes.[60]

PGE also considered the amenability of municipal partners to the project as it was critical that host cities be willing and supportive. Not only would this support Testbed success, but it might also help lower the costs associated with marketing, outreach, and administration. To better understand customers' needs (e.g. billing and offerings), PGE developed a residential market segmentation framework. The framework includes all customers, thus is representative of the population. The distribution of Testbed customers across the segments is very close to the distribution of all residential, indicating that the three substations mirror the population well. The selected Testbed sites have a good representation of:

1. Dwelling types (i.e. MFR, SFR, and mobile / manufactured homes);
2. Low-, medium-, and high-income households; and
3. Gas *and* electric heating of water and space.

Having a good mix of these characteristics is expected to help the team understand total system potential and customer propensity to engage in DR.

3.3.2 Informing the Distribution System

PGE plans to build and operate a smarter, more flexible, and resilient grid to improve operations and enable seamless integration of all energy resources. We expect that the efficient integration of devices and information will require innovation and development of new grid capabilities. PGE is committed to providing customers with

[60] Island has 4% mobile homes; all residential across the service territory has 5% Low income is 24% for all residential; and 23% for the Testbed.

a platform to interconnect and leverage these technologies, which should both benefit the communities it serves and support the transition to a clean energy future.

One component of building this grid requires better integration of customer resources (namely DER and flexible loads) into grid planning and operations. In addition to providing benefits to supplement the overall resource portfolio (i.e. bulk energy and ancillary services), these resources are anticipated to provide locational benefits to the T&D system. These benefits may include value streams such as:

- Distribution voltage management;
- Distribution reliability and energy quality; and
- Distribution capacity and loss reduction.

To optimally build the grid of the future, PGE is advancing the following capabilities:

- Evaluation and valuation of the potential for DERs and flexible loads to contribute toward T&D locational value; and
- Operation of a more dynamic system while maintaining high reliability and power quality.

The Testbed provides an opportunity to explore this more dynamic system so that appropriate learnings can be gained and applied to the broader T&D operation.

Additionally, the Testbed can contribute to PGE’s vision for the distribution system by implementing DR technology and the evolving grid infrastructure. The Testbed may inform PGE to the effectiveness of distribution load curtailment during peak or off-peak periods and the reliability of DR regarding reducing the strain of high demand on the system (i.e. distribution capacity and loss reduction). Based on these results, the Testbed may influence PGE decision-making regarding capital projects to mitigate capacity constraints and reduce reliance on traditional generation sources.

PGE expects the Testbed to help evaluate and quantify several distribution and locational values. The distribution voltage management value stream can be calculated based on the potential for DR to offset investments otherwise needed to support conservation voltage reduction (CVR). The distribution resiliency value stream can be calculated based on the potential for DR to offset distribution reliability and resiliency-based investments. In relation to distribution system capacity and system losses, PGE may be able to forecast what change in distribution system losses may be available given the presence and availability of a flexible load portfolio to offset system demand during a system peak event. The Testbed should also help PGE understand the effects and benefits of DR in relation to hosting capacity and, as DR and other DERs on the grid continue to evolve, ultimately establish a process for review hosting capacity on a regular basis.

The Testbed is also expected to inform PGE about the behavior of customers participating in a DR offering and how that could lead to predicting future behavior and distribution system loading. Customer behavior can be unpredictable–they could choose to opt-out of a portion of an event or even opt-out of an event altogether. Therefore, an expected benefit of the Testbed will be gaining insight about the behavior of customers participating in a DR offering and how that could lead to predicting future behavior and distribution system loading, particularly during extreme weather conditions. Gaining an understanding of DR behavior is expected to allow for more accurate planning and forecast of the distribution system needs. Ultimately, the Testbed should enhance our understanding of how to optimize operation of the distribution system, with DR and other embedded DERs, as well as what impacts a DR offering may have on supporting bulk grid operations. The Testbed could also inform PGE's distribution resource planning (DRP) efforts, by providing information to help integrate DERs and flexible loads into the system planning process.

PGE expects that the future grid will require greater visibility into system voltage and power values at a more granular level and require greater adaptability to changing customer demands. This may include a higher penetration of new DER and flexible load. With the implementation of necessary technologies and communications to enhance situational awareness and operational control, the presence of DERs and flexible loads will have the potential to contribute additional value to the T&D system.

The technology needed to support DR, as well as other new technologies to build smarter energy infrastructure, could be validated within the Testbed. Communication of devices within the Testbed will be important, including the protective devices at the substation, equipment on the distribution system, and two-way communication at the customer meter. Communication and visibility into these devices is expected to allow for integration into a Distribution Management System (DMS). The DMS in turn is expected to integrate and streamline data, allowing more efficient operation of the distribution system and integration of smart grid technologies.

The following provides more detail regarding the three chosen substations:

- Delaware Substation, in North Portland, is planned and funded for reconstruction by the end of 2019. The substation upgrade is slated to include the addition of SCADA. SCADA capability provides real-time visibility to feeder loading, bettering inform operators and engineers on the impact of DR offerings. The historical loading data, that SCADA capability provides, is expected to help prove the success of the Testbed.

- Planned reconstruction of the Roseway Substation, located in the Hillsboro area, is expected to be completed in 2020. Like Delaware Substation, the Roseway Substation upgrade will include additional SCADA capabilities and is expected to yield the same benefits in providing visibility to the impact of a DR offering. PGE plans for Roseway Substation service to include the South Hillsboro Land Development Project (SoHi) community, which has become a point of interest for introducing smart grid applications. We believe that Roseway Substation has a greater likelihood of pairing DR with higher concentrations of distributed solar, storage, and EVs, due to developer interest in the SoHi area.

  PGE plans for substation upgrades at Delaware and Roseway Substations to include advanced protective relays, expected to facilitate reliable integration of higher levels of DER on the feeders. The substation switchgear is planned in line with PGE's latest design standards including voltage monitoring on the load-side of the feeder breaker (which we believe will be necessary to support transfer-trip protection for large DER). Plans are for transformers to include advanced voltage control, enabling additional inputs for improved voltage profile management along the feeder, which is important for enabling CVR.

- The Island Substation, located in Milwaukie, has no current plans to upgrade, but the breakers and equipment are currently outfitted with SCADA capabilities that are capable of providing real-time and historical loading data expected to prove the success of the Testbed. The substation's location facilitates a strong collaboration with the City of Milwaukie and their redevelopment efforts in the downtown and waterfront areas.

The Testbed is meant to create an opportunity for PGE to explore a more complete integration of data from the Advanced Metering Infrastructure (AMI) into PGE's operations for greater visibility into system voltage and loads at a more granular level. PGE expects that the Testbed will also create an opportunity for us to explore changes in our operations by integrating these areas into a DMS and associated Distributed Energy Resource Management System for optimized dispatch and control of devices and resources to support a more flexible T&D system.

3.3.3 Residential Customer Insights

These substations provide a wide breadth of segments seen in the residential market. However, they do not simply approximate the general population in terms of composition; they are intended to capture a broad diversity of customer type. Our plan is to ensure that we observe issues that arise in a wide range of applications. PGE is confident that the sites chosen for the Testbed will generate learnings from working with 20,000 customers that can be applied to all residential customers in the service territory. Table 2 provides a distribution of residential customers in the three Testbed sites.

Table 2 Distribution of Residential Customers Across Testbed Sites

Testbed	Count of Residential Accounts	Percent of Residential Total	Sum of Residential Annual kWh	Percent of Residential Total
Delaware	6,938	36%	5,4974,528	32%
Island	7,995	41%	78,510,188	45%
Roseway	4,398	23%	40,954,696	23%
Total	**19,331**	**100%**	**1,74,439,412**	**100%**

The following section describes highlights from the customer analytics we did on the three substations, showing that they (individually or as a whole) are adequately representative of the service territory, and calling out where they differ.

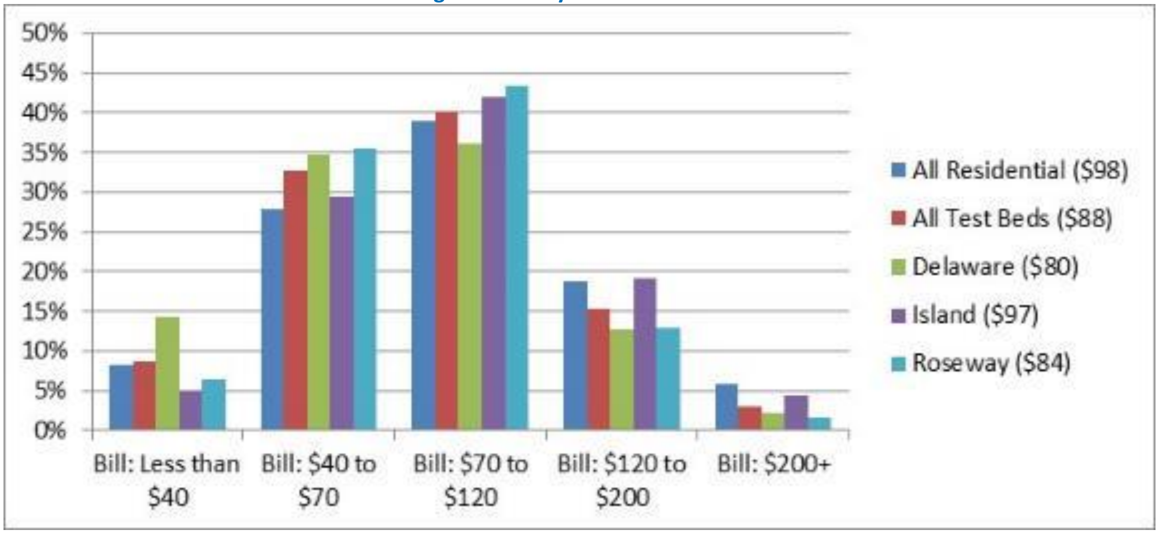
3.3.3.1 Urban-centric

Rural residential customers are underrepresented in the Testbed. Only Roseway has material agricultural load. While this is a shortcoming of the Testbed's sample composition, rural customers are particularly challenging for a project where customer representation, system operations, cost, and applicable learnings are valued above the need to have all customer types participating. The substation sites have nearly the same percentage of Suburban customers (58%) as All Residential (59%), and a higher percentage of Urban customers (37% versus 26% for All Residential).

3.3.3.2 Average PGE Bill Amount

Testbed participants' distribution of monthly bill amounts is close to All Residential. They are less likely to have high PGE bills (over $200 per month) and are more likely to have bills in the $70-120 (medium) range. Delaware represents customers with low bills, which correlates with their propensity to have smaller homes and non-electric heat.

Chart 1 Average Bill Size by Substation vs. All Residential

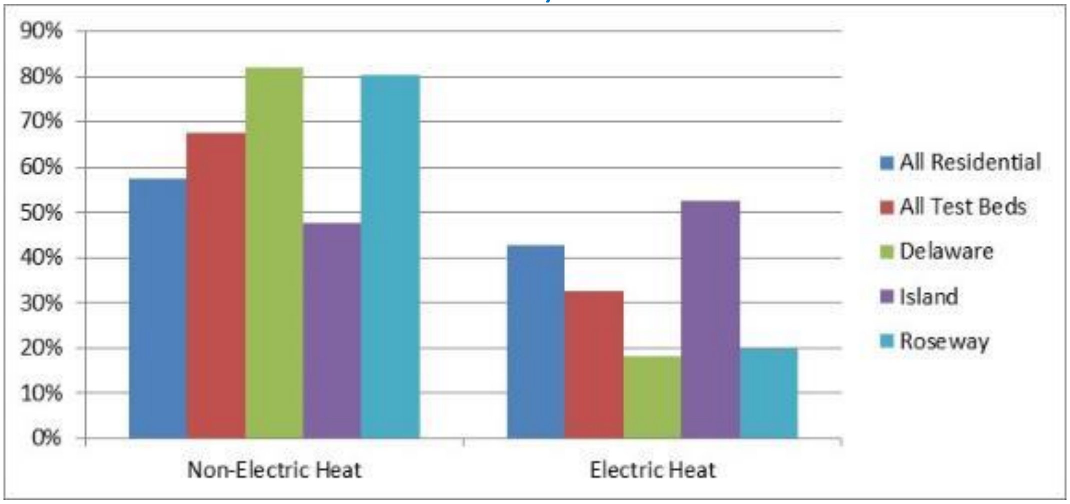


3.3.3.3 Home Heat Source[61]

The Testbed, as a whole, has slightly more non-electric heated homes than All Residential. Delaware and Roseway substations have more non-electric heated homes; however, when combined with Island substation (which has a high percentage of electric heat homes and comprises 41% of the total Testbed population), the overall mix is representative. PGE expects that the fact that many homes in Roseway and Delaware are gas-heated will make recruitment for heating, ventilation, and heating, ventilation, and air conditioning (HVAC)-focused DR strategies challenging, but no more than the average customer across the service territory.

[61] It should be noted that PGE data on heating fuel type can be unreliable as it is based on reported fuel type at time of construction and can change with renovations/improvements.

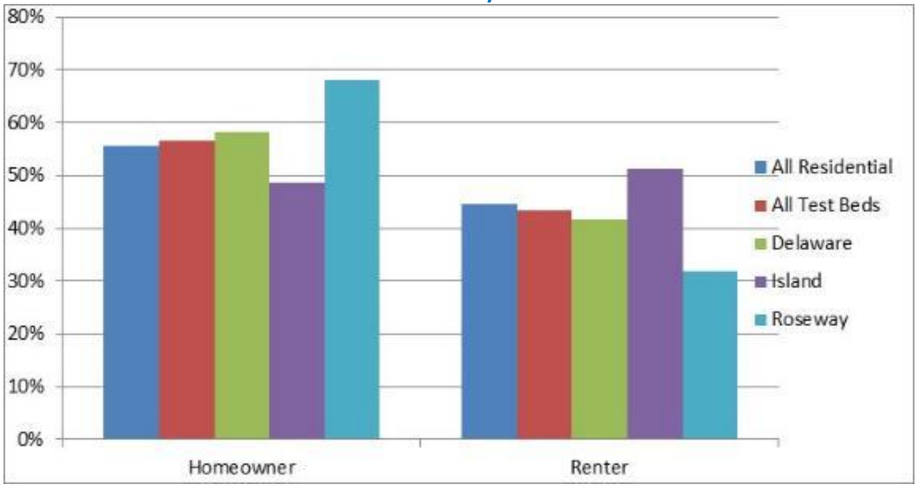
Chart 2 Electric Heated Homes by Substation vs. All Residential



3.3.3.4 Homeowner versus Renter

Renting and the split incentive problem[62] for PGE customers to invest in demand-side resources and strategies, such as EE and DR, is a well-documented issue. Again, across the three substations PGE has a representative subset of homeowners versus renters.

Chart 3 Homeowners and Renters by Substation vs. All Residential



3.3.3.5 Energy Tracker Use and Product Enrollments

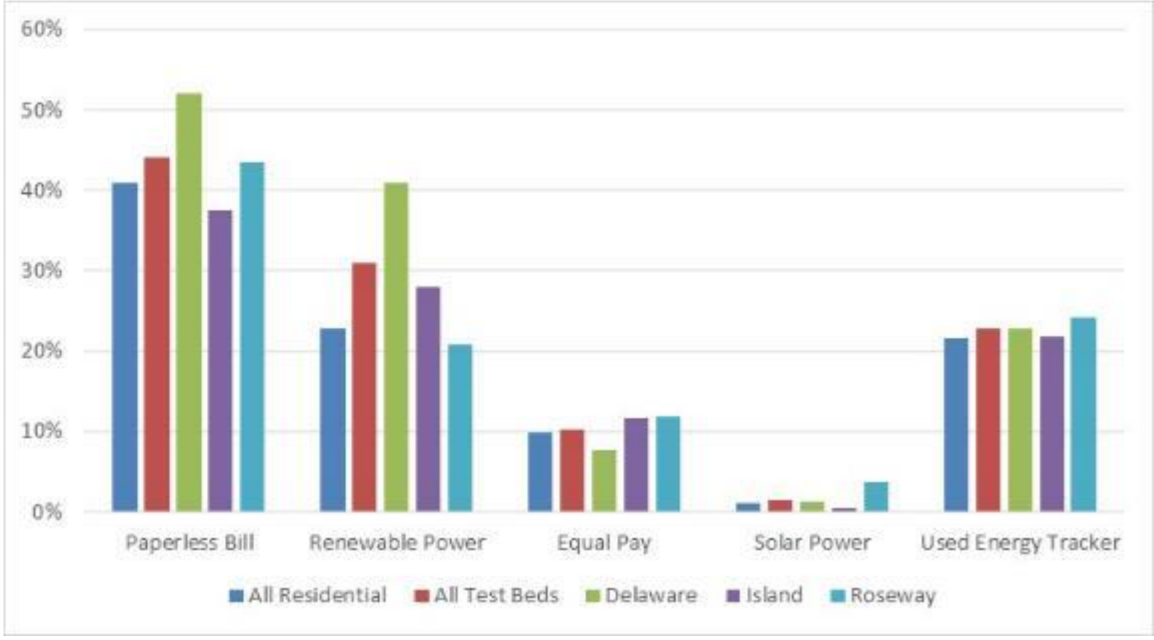
Energy Tracker is PGE's online tool for accessing energy usage and getting tips for improving EE in the home. Research shows that 23% of Testbed customers have used this tool, virtually identical to the 22% across All Residential.

Testbed customers are slightly more likely than All Residential customers to enroll in Paperless Billing, the Equal Payment program, Solar Energy, and Renewable Energy. Customers served by the Delaware substation have much

[62] The "split incentive problem" is that DSM measures often require capital investment from the property owner, while the benefits are accrued to the tenant.

higher-than-average enrollment rates in Paperless and Renewable. PGE looks forward to learning whether higher-than-average engagement in these programs translates in higher DR participation.

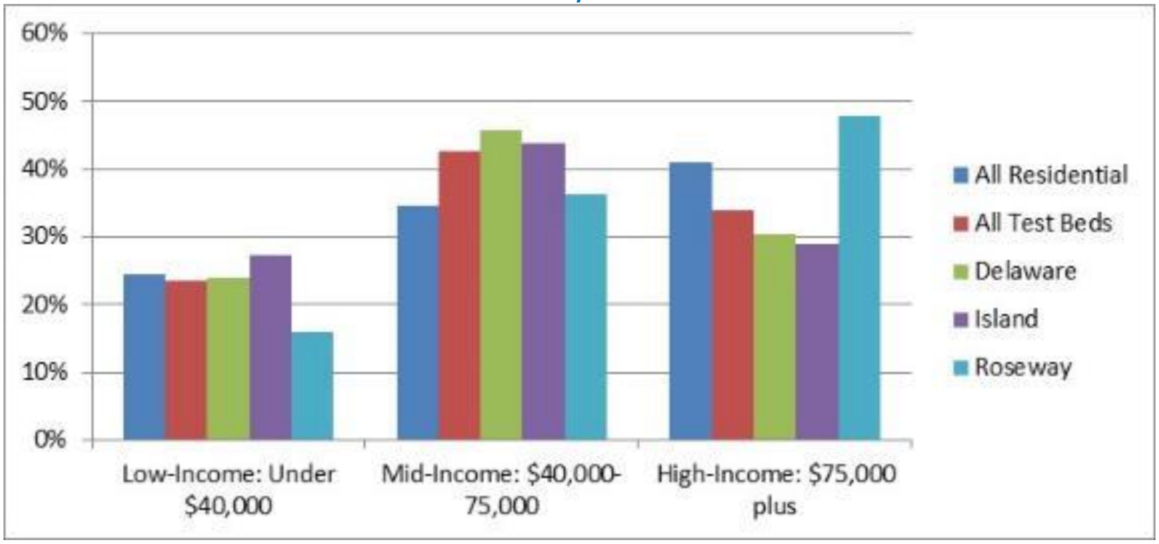
Chart 4 Program Participation by Substation vs. All Residential



3.3.3.6 Estimated Household Income

Overall, the Testbed represents low income customers very well. It has slightly more mid-income and fewer high-income than All Residential, but Roseway has a higher-than-average income distribution, which enables us to test the correlation between the high-income group and pilot participation.[63]

Chart 5 Income Distribution by Substation vs. All Residential



[63] Note that the income data informing this analysis is purchased and is skewed toward higher income earners overall; so, while useful for comparative analysis, it doesn't adequately reflect the percentage of the population that is low income.

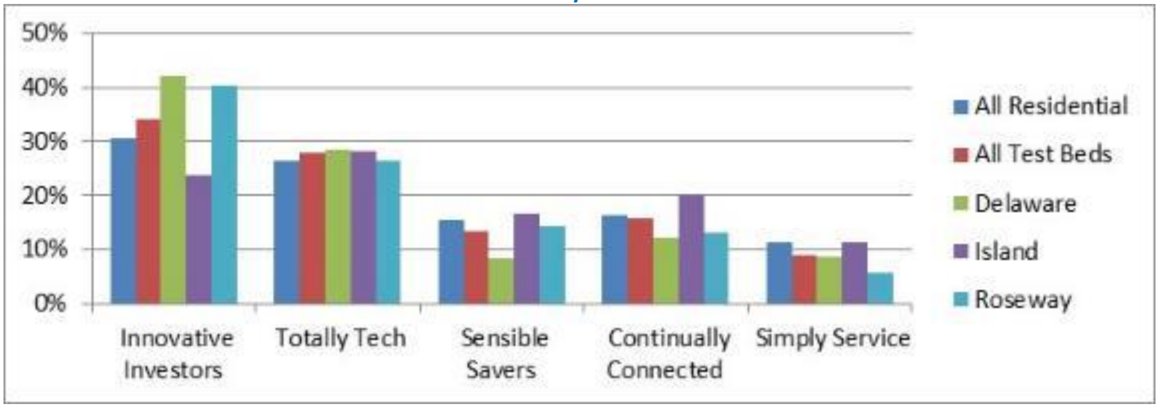
3.3.3.7 Market Segments

PGE has created a residential segmentation framework that consists of five segments that can be defined by "customer personas":

- ***Innovative Investor*** customers are more affluent and often participate in renewable programs.
- ***Totally Tech*** customers are more likely to engage with PGE through electronic means and are often early adopters of new technologies.
- ***Sensible* Saver** customers have lower income but live within their means and have good PGE credit scores. They are often willing to invest to save money in the long run.
- ***Continually Connected*** customers have PGE payment issues and contact PGE's Customer Service frequently to manage those issues.
- ***Simply Service*** customers tend to be younger, renters who move often, and have low PGE bills.

While the individual substations have a mix of distinctive segment distributions, overall the Testbed is very close to All Residential.

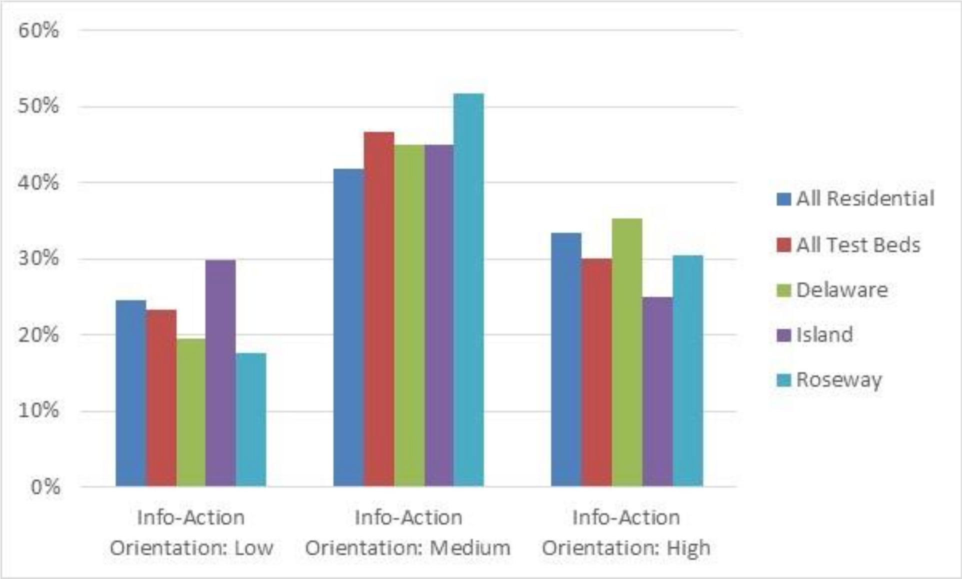
Chart 6 Customer Personas by Substation vs. All Residential



3.3.3.8 Information-Action Orientation

PGE has data that details whether customers are likely to consume information before participating in programs or make purchases. This attribute is relevant to DR offerings because understanding how DR works and why customers participate is expected to inform enrollment and participation plans. As shown in Chart 7 below, overall the Testbed participants are relatively close to the All Residential. PGE expects to be able to extrapolate from learnings and facilitate the desired broader deployment of these technologies.

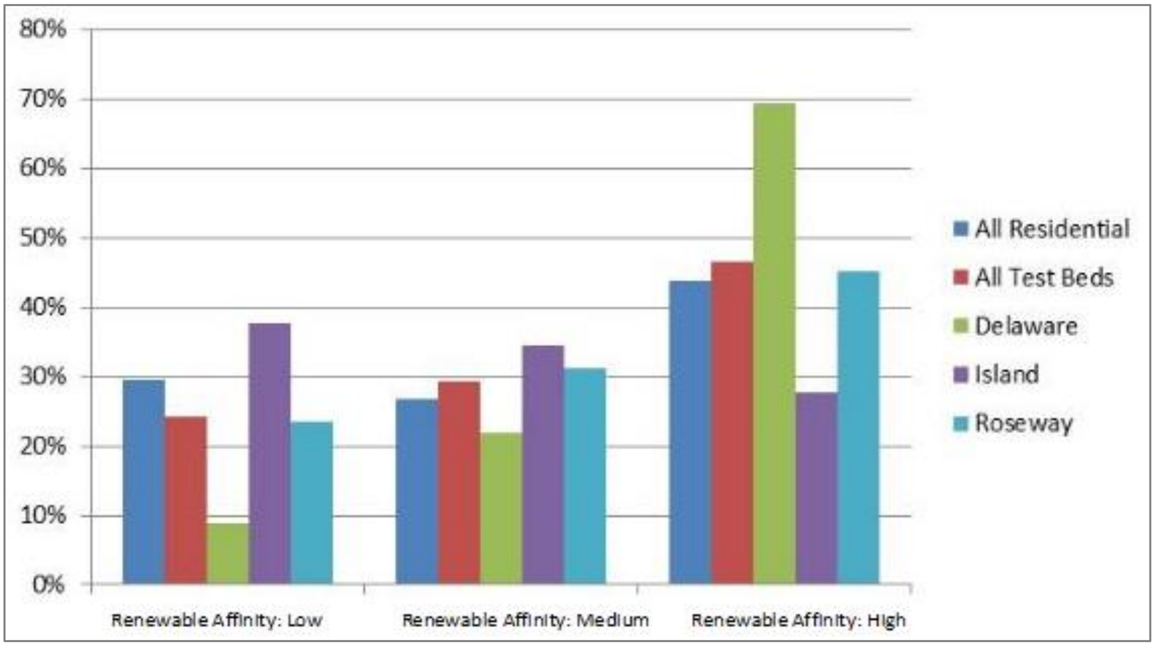
Chart 7 Info-Action Orientation by Substation vs. All Residential



3.3.3.9 Renewable Affinity

PGE has data that tells whether a customer has high, medium, or low Renewable Affinity (e.g. "caring for the environmental impact of products or behaviors"). Since DR has renewable benefits, this attribute may be indicative of customers' propensity to participate. Overall, Testbed participants have close-to-average Renewable Affinity (and PGE's All Residential scores are very high relative to national scores). As seen in Chart 8 below, customers supplied by the Delaware substation are particularly high (as they were on Paperless and renewable enrollments)—they are expected to be a good test of whether higher Renewable Affinity is correlated with higher DR participation.

Chart 8 Renewable Affinity by Substation vs. All Residential



Overall, while there are differences between the *individual* substations and the All Residential population, the combined set of all Testbed participants and their homes are representative of the All Residential population–they are similar in many more ways than they are different. PGE has excluded many attributes with similar findings between the Testbed and All Residential to keep this overview succinct (e.g. PGE found very small differences in payment and credit-related attributes).

3.3.4 Business Customer Insights

Table 3 Businesses and Meters by Substation

Testbed Site	Count of Distinct Businesses	Percent of Testbed Distinct Businesses	Count of Business Meters	Percent of Testbed Business Meters
Delaware	447	34%	750	29%
Island	651	50%	1,256	49%
Roseway	263	20%	556	22%
Total	**1,304**	**100%**	**2,562**	**100%**

Table 4 Business Annual KWh by Substation

Testbed Site	Sum of Business Annual kWh	Percent of Testbed Business kWh
Delaware	34,997,125	21%
Island	76,942,465	46%
Roseway	55,980,596	33%
Total	**167,920,186**	**100%**

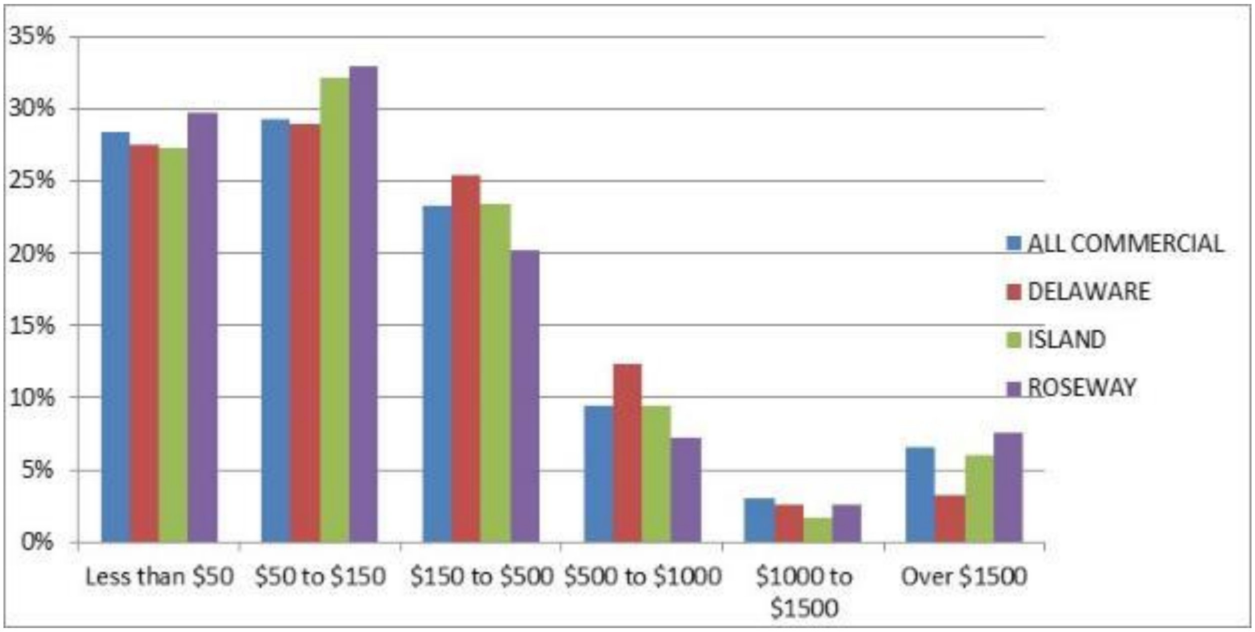
Even though the kWh per meter is much higher for Business customers than Residential, about half the kWh usage in the Testbed comes from Business customers.

The following section describes highlights from the business customer analytics we did on the 3 substations. While is it much harder to get a sample that represents the All Commercial PGE market when it is based on geography, the Testbed has a relatively well-rounded set of business customers.

3.3.4.1 Rate Code and Bill Amount

The Business Testbed customers have a close-to-average distribution across bill codes–89% are on PGE's Tariff Schedule 32 (small non-residential service) compared to 84% of All Business. The Bill Amounts distribution, shown below in Figure Chart 9, is also close to the All PGE Business distribution.

Chart 9 Distribution of Bill Amounts



Business Segments

PGE's business segmentation framework is based on Standard Industrial Code (SIC) groupings. Chart 10 and Chart 11 show how business types in the Testbed sites compare to those in the All Business population.

Chart 10 Business Types in Testbed vs. PGE Service Area

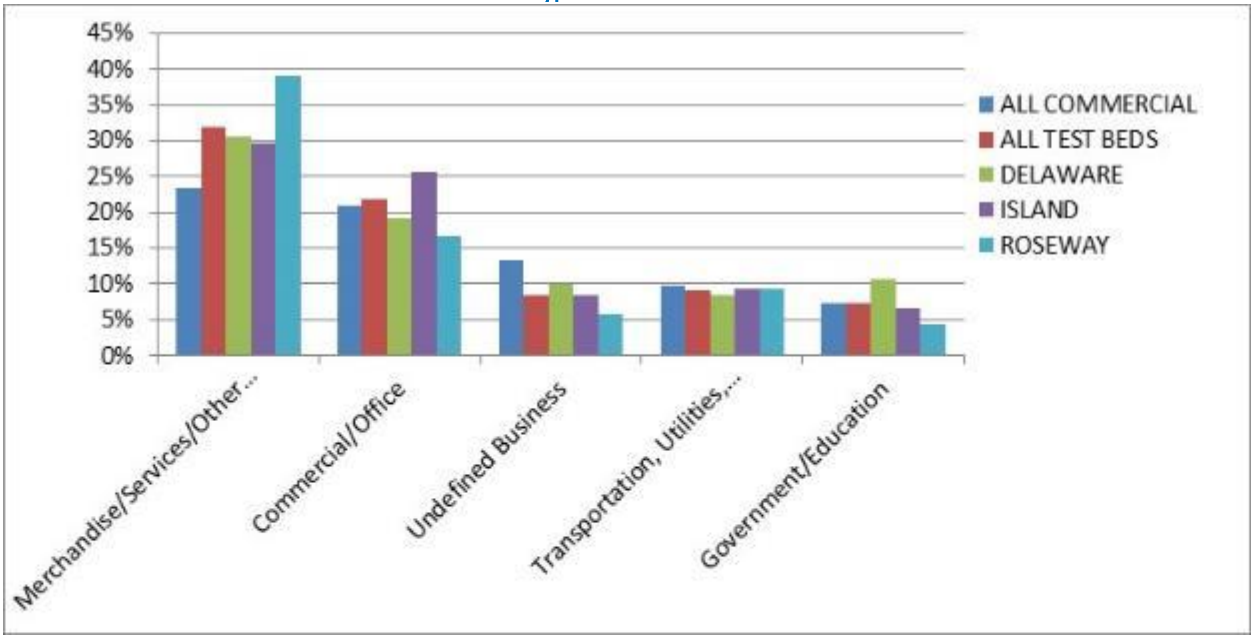
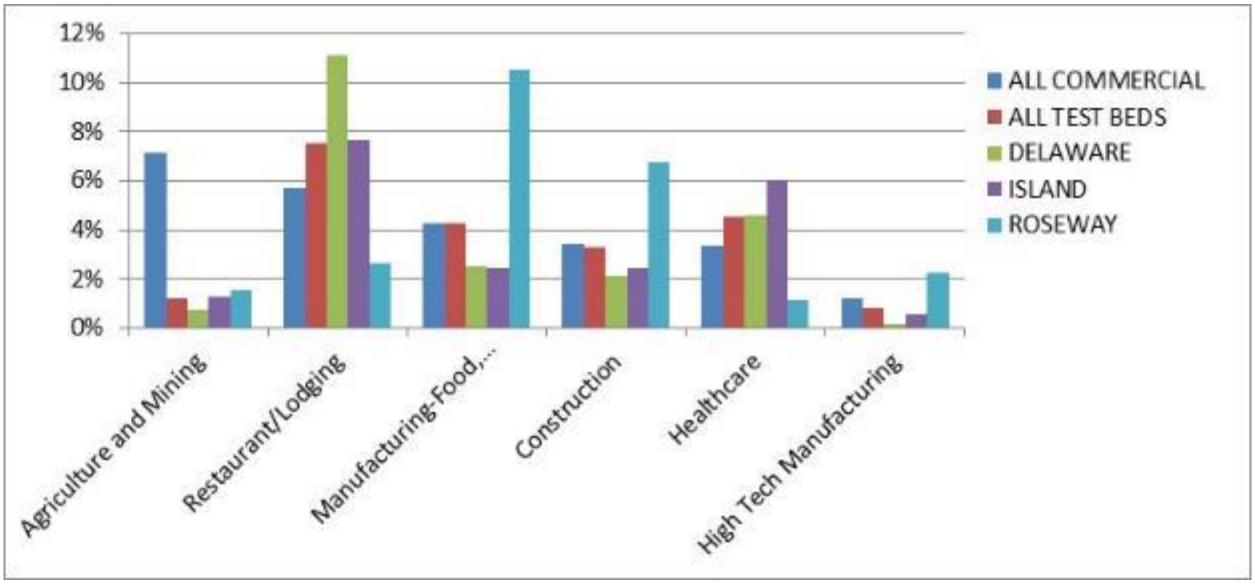


Chart 11 Business Types in Testbed vs. PGE Service Area (continued)



3.3.4.2 Product Enrollments

Testbed business participants are close to the All Business average for enrollments in Paperless Billing and Renewable Energy–and those served by the Delaware substation are particularly high (as we saw with Residential customers). PGE expects to learn whether the higher current participation translates to higher DR participation.

3.3.4.3 Summary

It is more difficult to get a representative sample of business customers than residential participants (especially when the sample is based on the substations serving them) because there are fewer business participants and businesses differ more than residential customers. Still, the Testbed Business customers are not overly dissimilar to All Business customers served by PGE. PGE is confident that we will be able to extrapolate from business learnings to the general business population.

3.4 Pilot Design

As stated earlier, the Testbed targets a 66% residential participation rate across four residential offerings, and a 25-40% commercial participation rate.

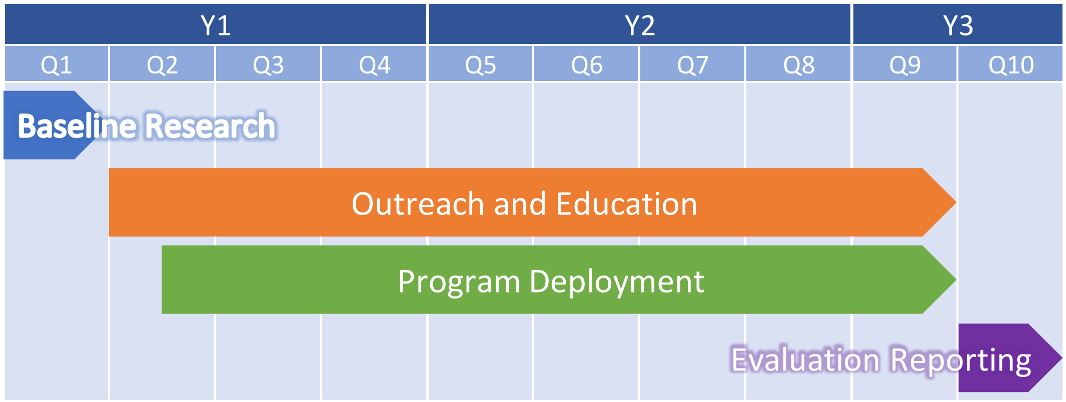
High residential participation is driven by assigning all residential customers for whom PGE has email contact to the PTR pilot. This is an opt-out PTR for a voluntary response pilot, in which participants receive rebates for reducing energy usage during 10-20 DR events annually. PGE plans to migrate PTR participants to one of two DLC pilots over a two-year period, as these automated pilots offer greater load reduction and value to the grid. The aggressive scenario anticipates that within the Phase I timeframe, 25% of PTR participants migrate to a thermostat offering (either bring your own, or direct install) and an additional 25% migrate to a water heater DR offering. The pilot also targets five percent enrollment in TOU pricing. Total enrollment targets over 13,000 households.[64] In the moderate scenario, migration to DLC offerings is half as great, or 12.5% migration into each program.

PGE plans to recruit and have commercial and large nonresidential customers (Schedule 32 and 38)[65] participate through our Energy Partner program. The PGE Testbed team, including our program administrator, CLEAResult, have researched the C&I customers at each of the Testbed sites. The C&I approach outlined in this application calls for Testbed-specific incremental spending for marketing and incentive dollars. The Team plans to deploy new approaches to acquire C&I customers in the Testbed that would otherwise be difficult to engage through the Energy Partner program. As we develop energy storage pilots we may also approach these customers with energy storage proposals. Additionally, as we develop new fleet and business EV charging pilots, we plan to approach these C&I Testbed customers. The lessons learned by developing new C&I approaches in the Testbed are expected to inform new and adjusted program designs for broader service territory application.

3.4.1: Testbed Timeline

PGE built a timeline for the Testbed that includes work over ten calendar quarters. Program deployment is forecast for two years of activity between the research and evaluation work. PGE plans to conduct research in the first quarter of the 2.5 years of work, and to conduct evaluation in the final quarter of scheduled work. Thus, research work is projected to begin in 2019. The research conducted in the first quarter is meant to inform the program activity and the outreach and education work. We expect research to identify the Testbed customers that are eligible to participate and how they might participate. We also expect research to inform how we message and outreach to different types of customers. Program deployment encompasses the bulk of this application's proposed activities: roll-out of opt-out PTR, migration of customers to DLC pilots and programs, and retention of those customers who did not migrate. The evaluation activity in the last quarter of Phase I Testbed work is expected to help inform PGE, stakeholders, and the Commission of lessons learned around the strategy and activity deployed during the two-year period.

Figure 1 Testbed Timeline



64 PGE assumes no overlap (other than TOU + PTR) as households cannot participate in DLC and PTR simultaneously.
65 PGE's Schedule 32 offers standard service and pricing for small nonresidential customers (not to have exceeded 30 kW). PGE's Schedule 38 offers optional standard service with time of day energy pricing for large nonresidential customers (not to exceed 200 kW). Schedule 38 does not have demand charges.

3.5 Benefits

The PGE Testbed is being undertaken to accelerate the development and understanding of DR as a system resource. To understand the true potential of the resource, the Commission required the Testbed to acquire DR "at scale." While PGE and the DRRC have interpreted the term at scale in several ways, all parties agree that 25% participation is a reasonable quantification of the "at scale" goal. PGE is going beyond this to target 66% Testbed participation via opt-out PTR.

DR is expected to help PGE procure needed and carbon-free capacity and model the building of smarter energy infrastructure. PGE's 2016 IRP, filed in OPUC Docket No. LC 66, identified a 2021 capacity need driven by the closure of PGE's Boardman coal plant. To help fill this gap, PGE is working to acquire at least 77 MW of DR. PGE's recent decarbonization study identifies acquiring significant flexible load (which encompasses DLC DR programs) as a key strategy in integrating renewables while increasing electrification. Flexible load describes all demand-side resources with high availability. The Decarbonization Study anticipates up to 900 MW of flexible load, which is expected to require a new paradigm for grid operations. PGE anticipates that the Testbed will allow insight into this new paradigm through its concentration of flexible load.

We believe that the Testbed will require the industry to improve coordination channels and protocols to deploy DR more broadly. We expect that iterating a pilot offering will require coordination with PGE's other DSM entities such as NEEA and the Energy Trust to identify synergies with present pilot and program offerings. We also expect to coordinate with Transportation Electrification market actors.

PGE also expects that improved coordination within PGE will be required. PGE is reprioritizing substation investment timelines to advance upgrades at the Island substation in Milwaukie. We plan to site new Electric Avenues–multi-vehicle public EV charging sites approved in Docket UM 1811–in two of the Testbed sites. Additionally, if approved by the Commission, PGE plans to bring UM 1856 energy storage efforts into the Testbed.

3.5.1: Immediate Benefits (0-1 year)

3.5.1.1 Coordination of Activity Internal to PGE.

1. **Incentive Coordination.** PGE is currently working with Energy Trust and NEEA to coordinate DR, efficiency, and renewable incentives, as well as measure development to drive DR participation.
2. **PGE Internal Coordination.** PGE is internally coordinating across areas.
    i. Both the Milwaukie and the Hillsboro Testbed sites are sited to have new Electric Avenue deployments.
    ii. PGE is internally coordinating with planned distribution system upgrades. PGE has accelerated the Island Substation's upgrade timeline to facilitate and support Testbed activities. Previously, the Island Substation was lower in the upgrade queue. To support the Testbed, the distribution team accelerated the Island Substation upgrade timeline.
3. **Strategic Alignment.** The Testbed is a strategic initiative supported by the PGE executive team. We believe that this initiative will help determine the shape and scale of DR as part of PGE's future operations.

4. **Community Engagement.** PGE is coordinating with Milwaukie, Portland, and Hillsboro city staff to better understand how to engage each community. These coordination meetings have led PGE to believe that "on-the-ground" community engagement will be necessary for the project to succeed. PGE plans to meet with the Energy Trust to assure that our respective efforts in these communities are coordinated.

3.5.1.2 Insights

5. **Approach insights.** Testbed discussion is helping PGE to identify possible new approaches to participation in our larger commercial and industrial DR program.
6. **Program Development insights.** PGE is developing new residential DR offerings in the Testbed such as SFR water heaters.
7. **Home Builder Outreach insights.** PGE plans to work with new home builders in Hillsboro to enable DR in new homes.

3.5.1.3 Other

8. **Customer Value Proposition.** Development of a customer value proposition for participating in DR programs.
9. **Customer Recruitment and Retention.** PGE expects to improve its understanding of how to recruit and retain PGE customers to participate in DR programs.
10. **Deepen Understanding of DR Potential.** Better understanding of the technical and feasible potential of DR and flexible load including data for IRP planning of DR resource development and potential.
11. **External Funding.** Identify and create space for external funding of pilots and programs within PGE's service territory (see Section 3.5.6:).
12. **Distribution Planning.** Better insight into how to integrate demand-side resources into DRP.

3.5.2: Near Term Benefits (1-2 years)

1. **Customer Value Proposition.** Development of a customer value proposition for participating in DR programs.
2. **Customer Recruitment and Retention.** Understand how to recruit and retain PGE customers to participate in DR programs.
3. **DR Potential.** Better understanding of the technical and achievable potential of DR and flexible load including data for IRP planning of DR resource development and potential.
4. **External Funding.** Identify and create space for external funding of projects and programs within PGE's service territory.
5. **Distribution Planning.** Better insight into DRP.
6. **Leveraging DR through Partnerships.** Understand how best to create partnerships to leverage DER.

3.5.3: Mid-Term and Long-Term Benefits (2-5 years)

1. **DR Resource Potential.** Better insight and understanding into DER resource potential.

2. **Grid Integration.** Understand how to incorporate EE, DR, and DER assets into power grid operations.
3. **Grid Operations.** Understand distribution grid operation implications of high penetration rates of DR, EE, and DER.
4. **Communications and Controls.** Better understanding of the communications, visibility, and controls needed to incorporate high rates of DR and DER.
5. **Data Development.** Better data development for more complex DRP.
6. **External Funding.** Allow for external funding of pilots and programs within the PGE service territory.
7. **Sharing Knowledge in the Region.** Program knowledge that can leveraged by others in the region for resource planning and utilization and program development.
8. **Technology Vetting.** Offers a place for new technology to be vetted and tested in real world conditions before investment commitments are made.

Once Testbed activities have begun, we expect additional benefits to arise including, but not limited to, those uncovered through the following efforts:

1. **Research effort** – PGE expects to learn more about its customers and how they view DR. Furthermore, we anticipate that the Company will learn about others' willingness to partner with an energy company to reduce the energy footprint of the system (e.g. lower the carbon content of energy, control overall energy costs, help lower rates, provide better energy resiliency within their communities).
2. **Education and outreach campaigns** – PGE expects to learn about the customer value proposition of DR and how the customer wants to engage with their energy company, successful incentive structures, the communication approach, and the proper messaging for each type of engaged and non-engaged customer.
3. **Project field work** – PGE expects to learn how to structure offerings to participants that better fit their needs and automate their response to grid needs without inconveniencing the participant (e.g. affecting clothes- or dish-washing, or the heating or cooling the home) or interrupting the participants' electric service.
4. **Program work** – PGE expects to learn how best to coordinate efforts with other DSM providers such as the Energy Trust and NEEA to offer customers comprehensive packages. Additionally, through the program work, PGE expects to learn how to accelerate DR program development and program participation. PGE also expects to better learn about the technical and feasible potential of DR, as well as the system and operational necessities, proclivities, and unique operational attributes of DR. We expect that this will inform grid operations and grant insight to PGE's Power Operations regarding the capability and implication of using DR as a grid resource. We anticipate that many of these benefits will be continued (and possibly be augmented) should the Testbed continue into Phase II, where many new types of resources can be leveraged to help understand how to reach PGE's carbon reduction goal and how to build flexible load.

3.5.4: How the Testbed Saves Customers Money

The Testbed is primarily meant to speed the development of DR. As Staff stated in their second round of comments in PGE's 2016 IRP, historically, PGE development of DR from pilot to program has taken too long.[66] PGE expects that an abbreviated development duration will reduce program cost. We also expect that the Testbed will accelerate our understanding of how to communicate, offer, enroll, and retain customers, and ultimately increase customer participation in DR. It would then be possible for PGE to apply Testbed learnings throughout the service territory. Without the Testbed, learnings would follow individual pilot and program timelines and be specific to the offering, on separate timelines, and possibly not coordinated.

PGE plans to continue its current internal efforts to coordinate Testbed DSM investments to optimize benefits and learnings. Further, PGE has begun to coordinate with the Energy Trust and NEEA on program development, marketing, and coordination of incentive offering. We have undertaken these efforts to advance and accelerate the development of DR and EE where synergies can be identified. By defining a Testbed by its physical energy system (i.e. substation), PGE expects to better learn how to incorporate this dispatchable resource within our system. We expect that distribution system operators and planners will have better data about how to operate and plan for a system with increasingly high penetrations of DSM.

3.5.5: New Program Development within the Testbed

While we plan for Phase I of the Testbed to be focused on existing DR technologies, the PGE DR team is working to develop new programs to reach additional markets with those technologies through the Testbed. These include a SFR water heater offering for both electric resistance and heat pump water heaters. PGE plans to investigate a direct mail offer for new smart thermostats and a new "bring your own" thermostat pilot for commercial customers. Additionally, the DR team expects to coordinate with PGE's Energy Storage and TE teams. We expect that the learnings of opt-out PTR within the Testbed will inform our strategy for migrating customers to automated DR offerings. Additionally, PGE is working with the Energy Trust, NEEA, Earth Advantage, and various home builders in Oregon to create new home strategies to make these homes smart-grid enabled.

3.5.6: Third Party Funding

PGE has indirectly conducted research (through our DRRC member, PNNL) and prepared materials for the U.S. Department of Energy (DOE) review of a proposal for SFR heat pump water heater research. PNNL has counseled PGE that DOE is unlikely to supplement funding for the Testbed, but are generally willing to provide funding for research efforts that could leverage the funding made by customers for the Testbed.

PGE is committed to continuing outreach efforts to various organizations and entities that might be willing to fund research efforts in the Testbed that would benefit PGE customers. PGE is also leveraging Energy Trust funds to finance measures that have both EE or renewable energy and load management benefits.

3.6 Cost Effectiveness

The Testbed leverages current cost-effective DR pilots and amplifies resources dedicated to DR education and program adoption. These amplified resources–marketing, education, outreach, research, and evaluation–drive

[66] Supra Note 29.

cost effectiveness down, but represent the cost of timely learnings. In the absence of the Testbed, these learnings would be cultivated one pilot at a time over a course of several years if not decades.

PGE forecasts that Phase I of the Testbed will cost $5.9 million and provide about six megawatts of capacity. The $2.6 million in development costs, as reported in Table 5, represents the customer investment and the cost to accelerate the development of DR as a non-carbon based peak energy replacement resource. The Testbed is being undertaken so that PGE, the Commission, and our stakeholders can learn together to develop new demand-side resources. PGE expects to work with the DRRC to extract as much value as possible from the investment. The $3.3 million operating costs reflect the cost to offer our present DR pilots "at scale" or at higher participation rates within the Testbed.

Table 5 Testbed Costs by Year

Budget Category	Launch	Year 1 Operations	Year 2 Operations	Total
Development Costs				
Marketing	335,000	335,000	111,000	780,000
Research and Evaluation	130,000	110,000	240,000	480,000
Staffing	148,000	607,000	607,000	1,362,000
Subtotal	613,000	1,052,000	958,000	2,623,000
Operating Costs				
Materials and Equipment	-	1,076,000	1,162,000	2,238,000
Program incentives	-	446,000	558,000	1,004,000
Subtotal	-	1,522,000	1,720,000	3,242,000
Testbed Total Costs	613,000	2,574,000	2,678,000	5,865,000

3.6.1 Marketing Costs

PGE has incorporated a total of $780,000 in marketing, education, and outreach dollars into the budget. The Testbed is meant to find new approaches to induce participation. The marketing and outreach plan anticipates digital advertising, direct mail and email marketing, community events and partnerships, outreach with community leaders, establishment of a neighborhood model home, and local media placements. Lessons learned within the Testbed include how best to approach and package DR and leverage marketing of efficiency and renewable resources to improve the cost effectiveness of existing and future DR programs.

3.6.2 Research and Evaluation Costs

The Testbed is a research project; $480,000 is budgeted for data analytics and evaluation efforts. Findings are expected to inform education and outreach as well as program development. Research and evaluation costs encompass participant surveys and interviews at inception, midway, and conclusion, and encompass A/B testing, data analytics, and reporting.

3.6.3 Staffing Costs

The pilot cost includes four full-time equivalent (FTE) employees, either limited term or contract employees; one for each of the three substation sites and one program manager. City partners have advised the DRRC that a community organizer dedicated to each site will be necessary to attain participation goals and understand the constituent populations. PGE believes that by having a presence at each site, the Testbed is likely to more quickly resolve issues raised by customers. The approach and value of having a personal presence within a project of this size and complexity is supported by similar projects, most notably the seminal 1980 Hood River Conservation Project.[68] Those members of the DRRC familiar with the Hood River Project have voiced support for Testbed project community organizers.

Program manager responsibilities are expected to encompass distribution, metering, research, evaluation, operations, project management, and reporting functions, as well as coordinating with other program groups such as energy storage and EVs.

3.6.4 Operating Costs

Materials and equipment costs are estimated at $2.2 million and include all variable costs such as data aggregation, smart thermostat or water heater purchase and installation, software licensing, equipment maintenance, and commercial equipment installation. Customer incentives for the Testbed effort are estimated at just over $1 million. These estimates reflect the financial design and variable cost estimates for each separate DR pilot included in the Testbed effort. PGE expects operating costs to vary with program adoption.

Fixed costs associated with each DR pilot were omitted from the Testbed budget and cost effectiveness analysis. Examples include program management, vendor implementation costs, and marketing associated with unique DR offerings. Fixed costs have already been represented in the pilots' independent cost effectiveness analyses; the assumption is that Testbed participation will not drive increases in fixed costs.

3.6.5 Cost Benefit Estimates

PGE's cost effectiveness modeling includes four distinct tests and is based on PGE's 'A Proposed Cost-Effectiveness Approach for DR,' submitted to the OPUC in 2016 and based upon California protocols.[69] Cost Benefit ratio estimates for each test are reported below under two Testbed enrollment scenarios. All tests compare the net present value (NPV) of costs and benefits over a 10-year horizon.

Benefits primarily consist of the capacity value associated with each DR pilot within the Testbed beyond that expected from PGE's programs in this area in the absence of the Testbed. This varies with load impact and program availability (greater availability results in greater capacity value). The Testbed analysis uses the 2016 IRP Update value of the avoided capacity proxy resource ($128.96 kW/yr. for a simple-cycle combustion turbine), and de-rates that value separately for each program, to reflect program availability and event notification requirements.

Each of the DR offerings modeled within the Testbed have undergone independent cost effectiveness analyses that supported each pilot's initial filing. Testbed cost effectiveness is significantly lower than any independent DR

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[68] See BPA Library for reports on the Hood River Project.

[69] See PGE UM 1708 compliance filing April 28, 2016 (https://apps.puc.state.or.us/edockets/docket.asp?DocketID=19228). For further details on California methodology, see http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=11574.

offering due to its amplified resources dedicated to DR education and adoption. These additional resources–marketing, education, outreach, research, and evaluation–drive cost effectiveness down, but represent the cost of timely learnings. In the absence of the Testbed, these learnings would be cultivated one pilot at a time over a course of several years if not decades.

The aggressive enrollment scenario produces an estimated 0.58 cost benefit result on the TRC. This test is intended to encompass the perspective of all parties (utilities + participants). Results fall to 0.48 in the moderate enrollment scenario due to the lower load impact across which to spread fixed cost.

Table 6 Benefit: Cost Estimates by Enrollment Scenario

	Aggressive Scenario	Moderate Scenario	Costs Included	Benefits Included
Total Resource Cost Test: *'all parties' perspective*	0.58	0.48	Administrative + soft costs	Avoided costs of electricity + environmental
Program Administrator Test: *energy company perspective*	0.43	0.36	Administrative + incentives paid	Avoided costs of electricity
Rate Impact Measure Test: *customer perspective*	0.43	0.35	Administrative + incentives paid + sales revenue lost	Avoided costs of electricity
Participant Cost Test: *participant perspective*	3.16	2.90	Soft costs	Incentives paid
Annualized MW load impact	**6.17**	**4.88**		

Cost effectiveness falls to under 0.50 in the Program Administrator and Rate Impact Measure tests. These results are typically below the TRC test. Results are generally highest for the Participant Cost test.

As a quantitative measure, cost effectiveness does not fully capture the most important benefit of accelerating DR program development, particularly the pilot phase. If the Testbed can identify pathways to increase DR program participation (e.g. that framing DR as a community resource resonates with customers; or new channels and / or smart assistants can be key to participation), these insights can be applied to the entire portfolio, thus reducing portfolio costs. In this sense, the Testbed is analogous to the first phase of market transformation programs, which are assessed for cost-effectiveness based on long-term costs and benefits. Given the number of uncertainties about the Testbed outcome, it is difficult to develop such long run quantitative analysis. However, given the scale of the Testbed versus the potential resource, it is safe to say that the benefits of making DR scale-up feasible are extremely large.

Table 7 Testbed Costs – Aggressive Enrollment Scenario

Total Resource Cost Test: 'All Parties' perspective

Cost/Benefit Category	Costs	Benefit
Administrative costs	$5,897,000	
Avoided costs of supplying electricity		$4,083,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		$28,000
Incentives paid		
Revenue loss from reduced sales		
Transaction costs to participant	$446,000	
Value of service lost	$708,000	
	$7,051,000	$4,111,000
Benefit Cost Ratio		**0.58**

Program Administrator Cost Test

Cost/Benefit Category	Cost	Benefit
Administrative costs	$5,897,000	
Avoided costs of supplying electricity		$4,083,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		
Incentives paid	$3,364,000	
Revenue loss from reduced sales		
Transaction costs to participant		
Value of service lost		
	$9,261,000	$4,083,000
Benefit Cost Ratio		**0.44**

Rate Impact Measure Test

Cost/Benefit Category	Cost	Benefit
Administrative costs	$5,897,000	
Avoided costs of supplying electricity		$4,083,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		
Incentives paid	$3,364,000	
Revenue loss from reduced sales	$281,000	
Transaction costs to participant		
Value of service lost		
	$9,542,000	$4,083,000
Benefit Cost Ratio		**0.43**

Participant Cost Test

Cost/Benefit Category	Costs	Benefit
Administrative costs		
Avoided costs of supplying electricity		
Bill Reductions		$281,000
Capital costs to utility		
Environmental benefits		
Incentives paid		$3,364,000
Revenue loss from reduced sales		
Transaction costs to participant	$446,000	
Value of service lost	$708,000	
	$1,154,000	$3,645,000
Benefit Cost Ratio		**3.16**

Table 8 Testbed Costs – Moderate Enrollment Scenario

Total Resource Cost Test: 'All Parties' perspective

Cost/Benefit Category	Costs	Benefit
Administrative costs	$4,882,000	
Avoided costs of supplying electricity		$2,889,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		$20,000
Incentives paid		
Revenue loss from reduced sales		
Transaction costs to participant	$463,000	
Value of service lost	$689,000	
	$6,034,000	$2,909,000
Benefit Cost Ratio		**0.48**

Program Administrator Cost Test

Cost/Benefit Category	Cost	Benefit
Administrative costs	$4,882,000	
Avoided costs of supplying electricity		$2,889,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		
Incentives paid	$3,138,000	
Revenue loss from reduced sales		
Transaction costs to participant		
Value of service lost		
	$8,020,000	$2,889,000
Benefit Cost Ratio		**0.36**

Rate Impact Measure Test

Cost/Benefit Category	Cost	Benefit
Administrative costs	$4,882,000	
Avoided costs of supplying electricity		$2,889,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		
Incentives paid	$3,138,000	
Revenue loss from reduced sales	$201,000	
Transaction costs to participant		
Value of service lost		
	$8,221,000	$2,889,000
Benefit Cost Ratio		**0.35**

Participant Cost Test

Cost/Benefit Category	Costs	Benefit
Administrative costs		
Avoided costs of supplying electricity		
Bill Reductions		$201,000
Capital costs to utility		
Environmental benefits		
Incentives paid		$3,138,000
Revenue loss from reduced sales		
Transaction costs to participant	$463,000	
Value of service lost	$689,000	
	$1,152,000	$3,339,000
Benefit Cost Ratio		**2.90**

The DRRC has agreed that the aggressive scenario is best suited to deliver the targeted participation levels and comports with OPUC direction:

- The Commission's stated goal for the Testbed: "The purpose behind Staff's proposal of the DR Testbed is to rapidly accelerate the development of viable DR programs and demonstrate its ability to function as a resource."[70]
- The Commission's direction regarding DR in general: "Given the analyses produced in this proceeding and PGE's stated need for capacity in the short term, Staff recommends the Commission require PGE to meet 77 MW (winter) and 69 MW (summer) DR megawatts as a floor, with a reach goal of meeting PGE's own DR High Case of 162 MW (summer) and 191 MW (winter)."[71]

Cost effectiveness measures are further discussed in Appendix E.

[70] Supra Note 29.
[71] Ibid.

3.7 Customer Education, Outreach, Recruitment and Retention

The overall marketing strategy is to find the customer value proposition and communicate the value of DR in many cases alongside efficiency or renewable values from the associated equipment. This messaging, once successfully identified, can be honed and transferred to the broader service territory. PGE's DR focus groups[72] have shown that customers do not understand, nor are particularly interested in, participating in DR offerings. However, this study also demonstrates that messaging and how PGE educates customers about DR shapes their understanding of its value and thus their willingness to participate.

The Testbed will target 66% participation, a level currently unpredicted in any service territory. As a comparison, PGE's long running voluntary renewable energy program has 21% participation, while the Paperless Billing program has 37%.

There are several other factors that make the endeavor additionally challenging. Firstly, PGE is only asking for approximately two years of in-field activity. This is a compressed timeline for an unprecedented and far-reaching undertaking. Secondly, the Testbed sites–distributed across three substations–are a cross section of PGE's service territory. This means that to approach a 66% participation and retention rate, PGE will need to communicate the customer value proposition to customers that traditionally would not engage with PGE on matters extending past regular billing. These customers pose new challenges on the PGE program-side, as well as to research & marketing, education, and outreach activities. However, for the Testbed to reach high levels of participation and to understand the true potential of DR and flexible load as a replacement resource, these hard-to-reach customers need to participate. Thus, PGE is budgeting approximately $780,000 to develop an outreach strategy to inform cost-effective program development. We expect this outreach strategy will include messaging around the customer value proposition for various customers within the PGE Testbed, the goal being to apply learnings to the service territory broadly for years to come. PGE plans to build the outreach strategy based on the lessons from DR marketing in other regions with considerably more experience, but test their findings against Oregon's culture and environment, and against the need to extend beyond "early adopters" to more reticent markets.

To reach a 66% participation rate in the Testbed and develop flexible load, PGE believes that we must ramp up engagement, and thus, plans to automatically enroll qualifying Testbed participants in PGE's opt-out PTR pilot. There are only a few utilities in the country that have deployed this strategy.[73] We expect that clear and compelling communication of the customer value proposition will be extremely important to retain opt-out PTR customers, as well as migrate them to automated response pilots (such as the DLCT pilot or one of the water heater pilots). Therefore, the first step in customer engagement is planned around awareness and education of the following:

- **DR Concepts:** Educating customers about DR needs to be tactfully undertaken. Even the term "DR" is energy company-centric. The lexicon relied on by system operators needs to be redeveloped for communicating the value proposition to the customer. Additionally, most customers do not think much about, or understand, how energy is generated and transmitted and take electric service for granted. PGE's plan is to focus its education and outreach on the concept

[72] "Demand Response Customer Focus Groups", Opinion Dynamics Corporation, Dec 2017.

[73] Currently Baltimore Gas and Electric has an opt-out PTR program. California is currently working toward an opt-out time-of-use rate for residential customers across the state.

of DR and how it fits within an energy ecosystem that includes other DSM options, as well as how this new resource can help control costs and address climate change.

- **Effect Upon the Customer Bill:** DR–whether as a pricing mechanism or an incentive offering–can reduce customers' overall energy costs. TOU pricing can also reduce the customer's monthly bill, but requires knowledge and consistent daily behavioral changes. Incentives for DLC, such as a smart thermostat offering or a smart water heater offering, can assist customers with their overall energy costs by providing an incentive for participation or the technology required for participation. Hybrid offerings, such as PTR, familiarize the customer with the concept of beneficial behavioral change for a series of DR events. PTR offerings operate by providing the customers an incentive for responding to DR events while holding those harmless who cannot, or choose not, to respond to an event. This is a similar argument, but not identical to those employed for efficiency and renewable resources. We anticipate that some care will be needed to harmonize the messages without blurring the distinctions.
- **Beneficial Effect on Future Customer Rates:** Part of the customer value proposition to be communicated is that DR is a customer-controlled resource that has the capability of offsetting larger, long-term investments in new fossil fuel generation. By offsetting these investments, the individual customers are helping to keep rates from rising to meet a limited number of hours of high energy needs that would otherwise need to be met by investments in fast-ramping resources (traditionally single cycle gas plants with long investment terms).
- **Environmental Implications:** Using DR instead of fossil fuel-fired generation to address energy needs can help with capacity gaps. PGE's plan is to present the customer and the community with the environmental benefits of DR. Offsetting investments in fossil fuel presents its own implicit environmental value proposition. However, as presented in this proposal, DR is one of the many customer resources on the horizon. We believe that–in addition to established efficiency and renewable options enabled by advances in IT and grid operations–the distribution system can now be leveraged as a resource to meet customers energy needs, grid service's needs, and as part of a tool set to lower the carbon content of the electric system. Supported by PGE's Decarbonization Study, PGE expects to need up to 900 MW of customer-sited resources. DR is the first of these resources. In Phase I of the Testbed, PGE plans to develop a new type of service paradigm where customers are part of the system, lending value to the whole, and where the energy company gives value for services provided by the customer.
- **Community Effort:** Enabling the customer and the energy company to utilize DR can be a community effort with broader and immediate implications. In related customer messaging, PGE plans to present a community benefit beyond assisting with customer bills and putting downward pressure on energy rates. PGE plans to site the Testbed across three substations; each substation being a community within a city and serving several types of sub-communities. Many customers consider community-level messaging and action a significant incentive. PGE's plan is for messaging to these customers to promote the community value of DR to empower and enable the customer to control energy costs and address environmental considerations (also applicable to DERs). PGE also expects to leverage investments by customers who can afford early adoption of technologies (e.g. roof-top solar, energy storage, or EVs) to assist the community. PGE believes

that residential customers' investments in DER can help spur additional renewables, help mitigate rate increases, and provide both locally-sourced energy services during normal grid operations and resiliency services during emergencies.

3.7.1 Approach

PTR is the preferred offering for automatic enrollment with residential customers because it has the highest customer satisfaction ratings when compared to the other twelve pricing approaches tested in Flex Pricing. The pilot enrolled 16,000 customers for a saturation rate of 70% among those eligible without intensive community based, multi-technology approach proposed in the Testbed. Learnings have informed PGE's current development of PTR and soon-to-be filed pilots for several other cost effective non-firm DR pilots.

The primary reasons for PTR's high customer satisfaction are that customers saw monetary benefit for their efforts and that occasional behavior changes on specific days present less of an obstacle to participation than day in, day out changes.

After initial DR education and awareness, PGE plans to communicate information about PTR and encourage customers to stay with PTR or move to a DLC offering. DLC offerings capture larger DR loads and are automated, which presents fewer hurdles to event participation. Therefore, we believe that transitioning customers to DLC will be key to prove the resource capability of DR.

For PGE to achieve the high customer participation and satisfaction necessary for the Testbed to be a success, PGE must take the following steps:

1. The first step of any successful marketing campaign is market research. PGE needs to understand who its customers are and identify early adopters. Information on demographics, buying behavior, and the motivations to the geographic locations of the Testbed are important. We believe that it will also be important to look at information that's already available to use (secondary research). PGE plans to conduct a meta study of other energy company efforts to develop DR in conjunction with our Testbed and other service territory research efforts. PGE can extract information and learnings regarding messaging and approach from the successes or mistakes of other utilities and review best practices in other industries for successful opt-out programs. As stated earlier, PGE understands the need to rebrand DR and communicate the concept with approachable, customer-centric language. We expect that this will require us to rename the Testbed and possibly the concept of DR itself.
2. Once PGE concludes the initial research portion in the first quarter of Testbed activity, PGE expects to have better information, data, and understanding of our customers. With this research information in hand, PGE plans to flesh out a communication strategy and channels for reaching the target market. Through the communication outreach efforts, PGE plans to inform each Testbed participant enrolled in PTR that they have several options: (1) continue with PTR, (2) move to an automated response through enabling technology, such as a smart water heater or thermostat, or (3) opt-out of Testbed activities.
3. Given, the low awareness of DR in our region and the many different types of customers across the three Testbed sites, PGE expects that it will be important to utilize several marketing channels to reach as much of our target audience as possible. PGE plans to utilize channels such as TV, radio, and digital advertising that reach a large audience all at once. Since it can take an individual five to seven times

before they understand or recognize a product offering, PGE must utilize a suite of marketing channels. PGE plans a tiered marketing approach where:

a. General awareness of DR is first created, and the customer is familiarized with terminology, e.g., "peak times", "shifting energy" (or other terms), the need to participate as a community. The idea here is that by understanding the terminology and reasoning for DR, the customer is more satisfied in participating and excited to transition from PTR to the smart thermostat pilot.
b. Normally, a general awareness campaign would take 6-12 months. However, we expect the general awareness campaign timeline will be compressed. PGE plans to develop a detailed timeline after we have the results of its research efforts. We plan to internally develop potential strategies and approaches for a general awareness campaign and share these with the DRRC before they are deployed. PGE plans to deploy a general awareness and communication campaign around PTR opt-out, messaging on why we need customers to participate, and the value to those who do participate. PGE expects that part of the deployment will leverage the community aspect of the pilot. We expect this will be done in part through communication and utilization of key community leaders such as neighborhood associations or environmental groups. We expect that utilizing this type of in-person communication will help foster the trust necessary to move the needle on customer participation, and that this will complement the broad channel approach outlined above.
c. At the time that PGE notifies customers that they are part of the Testbed and are enrolled in PTR, PGE plans to explain how PTR operates and their opportunities to participate in automated DR, stay with PTR, or opt-out altogether.

4. PGE expects that it will be important to streamline the customer experience and fix weak spots where we risk losing customers. To do this, PGE plans to map out the enrollment process through an Awareness, Interest, Desire, and Action (AIDA) model. Before launch, PGE plans to categorize customers by their AIDA stage, which will help us determine the level of communication needed across these groups, as well as several critical points for confusion and / or customer drop-off.

AWARENESS

- **Audience Perspective:** Hasn't heard of product offer or isn't interested yet.
- **Objectives:**
    - Cultivate customer awareness and education of DR.
    - Spread the word, reach as many people as possible.
    - Ensure that customers within the geographic target(s) are hearing about DR multiple times within the first three months of awareness campaign.
- **Communication Channels**: Advertising (TV, radio, print, digital), public relations, web, direct marketing (email, mail), newsletter, customer service representatives.
- **Estimated audience size**[75] of ~90%, or 18,000 participants

[75] Audience size is an estimation of how many customers will see or hear advertising on the communications channel(s) selected.

INTEREST

- **Audience Perspective:** Has heard of concept and might be considering offer.
- **Objectives**: Trust is extremely important here as some DR pilots have shown customer skepticism and concerns around privacy.
- Build a connection and trust that is inspired by interesting content.
- **Communication Channels**: Website, video, social media ads, in community offices, events (e.g. fairs, festivals, farmers markets), influencers (e.g. leaders, activists, neighborhood associations, piggybacking on established PGE and Energy Trust contacts and communications campaign), model homes, search engine marketing, and customer service representatives.
- **Estimated audience size:** ~60%, or 12,000 to 13,000 participants

DESIRE

- **Audience Perspective:** Weighing options for enrollment and participation in additional offerings (beyond PTR).
- **Objectives**: Offer proof to win over customers on the brink of decision making. Showcase the best solution for them. PGE can do this by making sure the customer experience is seamless and easy, otherwise PGE could lose an interested customer forever. In our experience, most individuals do not make a second attempt at enrollment if they were confused by the options or how to participate the first time they tried.
- **Communication Channels**: Website, email, social media, in community office, customer service representatives, door to door.
- Estimated audience size: ~30%, or 6,000 participants

ACTION/ADVOCACY

- **Audience Perspective:** active participation and engagement (not just happening to them but they are aware)
- **Objectives**: Keep the customer engaged and satisfied. We expected that high customer satisfaction will lead to participation in additional offerings or advocacy of offerings to friends. The goal is to move the customer to a DLC option in the second year of participation.
- **Communication Channels**: In phone app or dashboard, website, email, social media, word of mouth, earned media
- **Estimated audience size:** ~5-10%, or 1,000 to 2,000 participants (this is a high estimate for best case scenario. Average customer advocacy is typically in the 2-5% range).

3.7.2 Participation Options

PGE plans to offer customers several options to participate in the Testbed. One of the tasks of marketing is to help guide them to their best option. In our experience, presenting customers with product options, increases their engagement and satisfaction with the product. However, too many choices will lead to decision paralysis, which means the right balance of options must be presented. At the kick-off of the Testbed timeline, PGE plans to enroll qualifying customers (approximately 66%) in the PTR pilot. PGE is using 66% target because this is the proportion of customers for which PGE has email addresses (needed for PTR notifications and/or alerts). Our plan is for these customers to have an option to opt-out or switch to a DLC option right away. By the end of year two, PGE expects to have the following rough breakout based on home type, as seen below.

Table 9 Moderate Scenario Enrollment within Testbed by Home Type[76]

Home Type	Thermostat BYOT	Thermostat Direct Install	Water Heaters	PTR OO	TOU	Total
Single Family	1,073	268	536	7,564	472	9,442
Multi Family	52	13	1,234	2,131	172	3,430
Mobile Home	-	75	38	138	-	251
Total	**1,125**	**356**	**1,808**	**9,833**	**644**	**13,123**

Table 10 Aggressive Scenario Enrollment within Testbed by Home Type[77]

Home Type	Thermostat BYOT	Thermostat Direct Install	Water Heaters	PTR OO	TOU	Total
Single Family	2,146	536	1,073	5,687	472	9,442
Multi Family	104	26	2,469	832	172	3,430
Mobile Home		150	75	25		251
Total	**2,250**	**713**	**3,617**	**6,543**	**644**	**13,123**

3.7.3 Community Engagement

This project is in three specific communities and so there is an advantage in creating a community environment with respect to this work. PGE wants customers to understand the value of being a part of this project and the contribution they are making. For this aspect, PGE *and our municipal partners* believe it will be important to have a presence in each Testbed community so customers can ask questions and interact with each other. In addition to attending high visibility community events, such as farmers markets, neighborhood associations, churches, and fairs / festivals, PGE plans to host several open house events for customers to learn and ask questions prior to and after roll out.

We believe that customers will need an easy-to-use web-based platform to feel like part of the community and stay engaged with the offering. Furthermore, we believe that the best way to deliver this is via an application that customers can download on their smartphones. Our plan is for this tool to track customer participation in DR offerings and provide points or rewards for doing so. In our experience, acquiring new customers is 5 to 25 times

[76] Table assumptions:

1. TOU participants are a subset of PTR participants (enroll in both offerings).
2. No more than 66% of the total population can participate across all DR offerings.
3. Table does not reflect annual 3% opt-out rate from PTR (customers that will not be captured elsewhere).
4. Mobile home customers are the best candidate for Smart Thermostat Direct Install or PTR given their heating type.

more expensive than retaining existing ones. Therefore, we believe that it makes sense to keep existing customers satisfied and engaged in the Testbed. Without this type of engagement and reward system, we are concerned that the offering could see high drop rates or resistance in moving to DLC pilots. The price of this tool is not included in the budget because it varies significantly and would require an Request for Proposal process.

The following are the benefits and features of application engagement:

1. Re-enforces the value of DR by visualizing participation, progress, and impact;
2. Friendly competition between neighbors or neighborhoods that shows how they stack up against their peers or what they've achieved, e.g. "You've shifted eight megawatts as a community";
3. Makes the process fun and exciting by using gamification;
4. Can be used for referrals (including referral incentives); and
5. Can allow social media posts of progress to create additional awareness (e.g., tell their friends the impact they've had).

3.7.4 Examples of successful rewards programs

The Strava application provides customer details on run performance and compares results against other runs.

The Waze application provides real-time construction, accidents, and other updates for best rates. It also rewards users for their contribution to road information.

The Forest app helps you stay focused and off your phone by accumulating "tree points", which they use towards planting real actual trees on your behalf.

Figure 2 Marketing Timeline

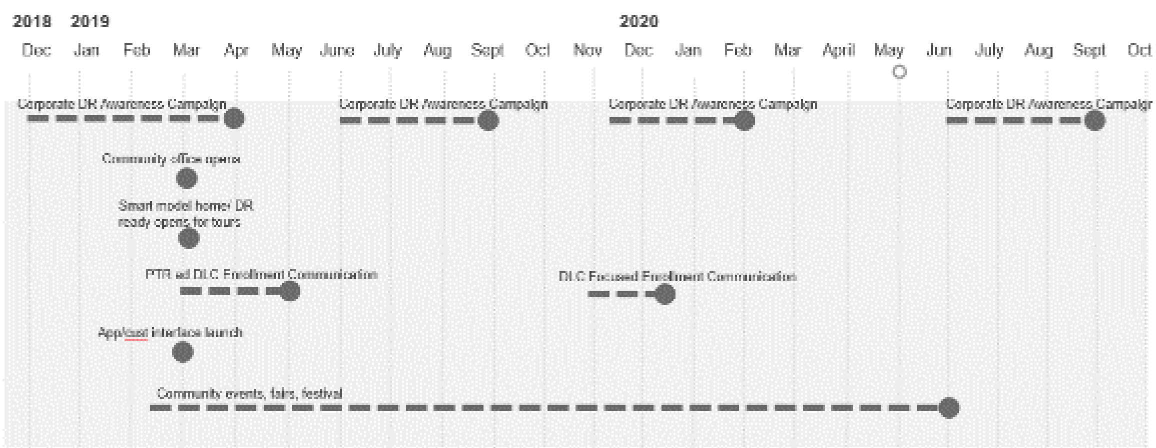


Table 11 Marketing Budget

Marketing Tactic	Cost
Digital advertising	$ 270,000
Search engine marketing	
Digital advertising/social advertising	
Direct mail/Email marketing	$ 80,000
Targeted direct mail and email combo sent to each neighborhood	
Community events/partnerships	$ 100,000
Tabling and sponsorships at fair/festivals	
Working with businesses on gamification of outreach	
Work with business customers to engage their customers	
Influencer marketing	$ 150,000
Identify influential/ community leaders in each neighborhood, get them on board to talk about offerings through social media or at events, community forums, etc.	
Model homes - in each neighborhood	$ 10,000
PGE employee or influencer home enrolled in all DR offerings - utilized to showcase, take pictures of home, create profile of home, and utilize in case studies, social media and for tours.	
TV, radio, print	$ 60,000
Local or community/neighborhood papers, local radio (OBP, NPR)	
This is for TV placement only and does not account for production costs	$ 110,000
Customer retention (year 2020)	
Total	$ 780,000

3.8 Market Research and Evaluation

3.8.1 Summary

The principal purpose of the Testbed project is to enable PGE to gather information about DR in a high-adoption scenario, and thus, improve territory-wide offerings and planning for the future. The purpose of the evaluation is to measure the effectiveness of the offering against the objectives, areas for continuous improvements, and impacts on the system.

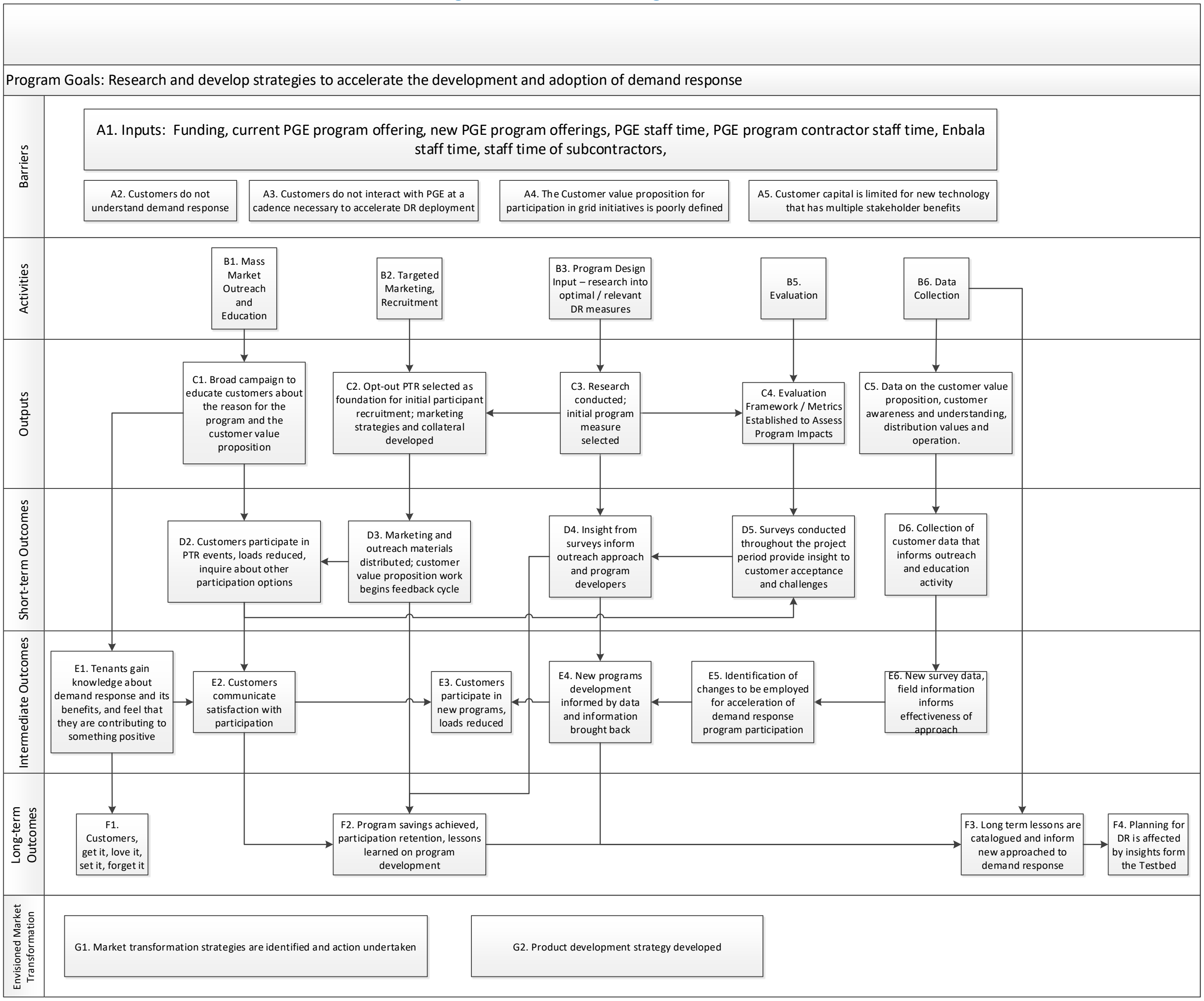
Table 12, below, identifies some of the key objectives of the DR sites and potential measures that would accompany them. This is not meant to be an exhaustive list.

Table 12 Key Testbed Objectives and Potential Metrics

Objective of the Offering	Process to Measure	Potential Metrics
Identify, develop, and communicate the customer value proposition of DR to PGE's customers.	Customer Surveys	Awareness, consideration, evaluation, and attitudes in pre and post conditions
Work with customers to establish and retain a high level of customer participation in DR offerings.	Customer Surveys, Customer Interviews, Data Analytics	Participation level, Dropout rate, Load reductions, etc.
Learn how to recruit and retain customers' participation and translate these learnings for development of cost-effective strategies to be applied to service territory offerings.	A / B testing on messaging and process; extrapolation to PGE territory	Cost per recruit, Drop outs, business and residential customer profiles/segments
Collect information on DR potential that can inform resource potential studies in achieve maximum technical potential.	Customer Surveys, Interviews, onsite visits, DR impact analysis	Additional controllable equipment observed, or self-reported, actual demand reduced by participants
Create new offerings that can quickly translate to broad deployment program offerings.	Monitor evolution of offerings and introduction of new programs	# of new programs, customer adoption, and retention.
Coordinate on new program development with other demand-side measure providers such as the Energy Trust and NEEA.	Monitor NEEA, the Energy Trust, and other initiatives in the Testbed, customer surveys, and customer usage	Program interactions on adoption, retention, and DR Response.
Study and understand the system operational implications of high levels of DR and gain insight into how high levels of flexible load–necessary to meet PGE's carbon reduction goals–is expected to have upon the system.	Customers usage impact analysis	Measure impacts against system and sub-station peaks, selected wholesale market criteria, DR interactions.

Figure 3, below, is a draft logic model developed by PGE. As part of the evaluation, PGE plans to work with an Evaluation firm to develop a complete logic model with additional measures.

Figure 3 PGE Testbed Logic Model



PGE's plan is to undertake four major market research and evaluation activities, described in Table 13 below, to achieve the above objectives:

Table 13 Market Research and Evaluation Activities

Activity	Major Pieces of Knowledge Gained
Customer Surveys (Residential / Small Business)	• Baseline awareness and consideration of DR • Customer appeal of new marketing messages and offers • Assessment of importance of neighbor-to-neighbor message spreading • Customer satisfaction with DR participation • Additional DR opportunities • Inclination to participate in other offerings (PGE/others)
Large/Medium Business Customer & Stakeholder Interviews	• Feedback on Testbed business & government DR activities • Motivations and/or barriers affecting enrollment • Assessment of PGE relationship-building with local government & other key local opinion leaders • Customer equipment survey/additional DR opportunities • Documentation of PGE activities, successes, and challenges • Inclination to participate in other offerings (PGE/others)
Ongoing Analysis of Marketing	• Setup and analysis of A/B Testing • Quantification and documentation of which messages are more effective
Additionality and Impact Analysis & Extrapolation to PGE territory	• Extent to which participation in territory-wide DR offerings is greater due to Testbed marketing & PTR • Comparison of Testbed demographics and business composition, local government, and other factors to entire PGE territory • Extrapolation of how much DR could be achieved territory-wide if applicable Testbed initiatives were extended • Comparison of adoption and impact to general PGE service area.

3.8.2 Customer Surveys

PGE expects that the market research component of the Testbed will:

1. Provide information on customer awareness of DR offerings;
2. Provide an understanding of customer preference or interest for DR concepts;
3. Gauge customer willingness to participate in DR offerings, including their reaction to proposed messaging;
4. Measure changes in the above over the course of the evaluation period; and

5. Measure customer satisfaction and trends over the course of the evaluation.

PGE's approach to customer surveys is to field a series of quantitative surveys aimed at residential and business customers over the course of the offering. Our plan is to deliver surveys via either web and / or phone instruments to maximize the number of respondents for various groups. We expect this quantitative approach to provide the evaluation team with a cost-effective method to acquire the data they need to determine if the Testbed activities have had an impact on the measures identified above.

PGE plans to conduct survey research in three phases:

1. The first survey to be conducted at the beginning of Testbed activities and be used as a baseline.
2. The second survey to be conducted at the end of the first year of Testbed activities and be compared against the baseline to determine the efficacy of the offering.
3. The third survey to be launched at the end of year two and provide a second point for the team to measure the impact of the Testbed activities. Our plan is for the first and last surveys to cover the Testbed area as well as PGE's entire territory, the latter being necessary to perform additionality analysis.

Planned survey topics include:

1. Current technology present in the home / small business;
2. Willingness to adopt new technology;
3. Willingness to support the grid and community;
4. Awareness and comprehension of DR;
5. Value proposition testing; and
6. Message testing

3.8.3 Interviews of Large / Medium Business Customers, Stakeholders

A more customized information gathering approach is recommended for key organizational actors in the Testbed. This would primarily entail structured, in-depth interviews with local governments, larger / medium businesses, implementation contractors, PGE staff, and other stakeholders. This approach can provide a detailed, nuanced picture of each organization's attitudes towards DR and–for participants–their experience with the offerings.

PGE expects these interviews will provide an objective perspective on key stakeholders' understanding of DR, and their willingness to participate and act as "evangelists" for DR. They may also uncover barriers or opportunities for PGE's DR initiatives that would otherwise have remained hidden.

3.8.4 Ongoing Analysis of Marketing

Some types of online marketing provide an unparalleled opportunity to test whether a message is resulting in action; they can deliver these insights because clicks and enrollments can be tied back to specific ads or webpages. PGE's plan is to employ A/B testing to compare responses to different messages. PGE expects to deliver an A/B test message to a target group and to compare the elicited response with another randomly-assigned group's response to a different message. PGE's plan is to document that the results and lessons learned from particular A/B tests.

3.8.5 Additionality Analysis / Extrapolation to PGE Territory

Apart from the lessons learned regarding the pilot and program designs and marketing of the trials in the Testbed, the project is also expected to yield useful data for PGE's long-term planning and forecasting. Specifically, the Testbed should provide more certainty about the amount of cost-effective technical potential that is realistically achievable, and how quickly it can be acquired.

We believe that the Testbed will give important real-world feedback on PGE's 2016 DR Potential study, which estimated:

- PGE's technical potential (the amount of DR technologically feasible in PGE's service territory);
- Cost-effective technical potential;
- Achievable potential (the portion of the cost-effective technical potential that offerings could reasonably access); and
- Interactions between offerings

The Testbed provides a real-world test case to inform forecasting. We expect that this will allow us to more accurately forecast DR achievement, thereby potentially reduce overall costs to customers from investment in more expensive resources.

To gain the most value from this information, we plan to perform analysis to extrapolate the Testbed approach, or a variation thereon, to the broader PGE system. The question to be answered is, "If the project and outreach and education approach in the Testbed were extrapolated to PGE service territory as a whole, how much DR would be achieved?" The proposed approach has three parts:

1. Quantitative and qualitative comparisons of Testbed demographics, firmographics, local governments, and DR awareness to PGE service territory as a whole.
2. A quantitative estimate of the extent to which PGE's marketing and PTR in the Testbed increased enrollment in PGE-wide DR offers. Our plan is for this section to also include documentation of enrollment in Testbed-specific offers.
3. A quantitative combination of the first two parts to estimate DR achievement if similar activities to the Testbed were applied to PGE's service territory as a whole. This analysis leverages PGE's 2016 DR potential study, the 2018 DER / Flexible Load forecast, as well as evaluations of PGE's territory-wide DR programs.

3.8.6 Potential Changes Based on Market Research and Evaluation

PGE is committed to translate market research into appropriate action. We envision making some or all of the following types of changes to our DR offerings in response to information gained in the Testbed:

- Changes to marketing messaging for specific offerings;

- Changes to overall DR awareness messaging;
- New or different DR offers;
- Edited short and/or long-term DR forecast and potential studies; and
- New approaches to partnership with local governments and other stakeholders.

Table 14 Estimated Market Research and Evaluation Timeline and Budget

Activities	Budget
Set-up, surveys, Initial Interviews, & Interim reporting	$270,000
Ongoing A/B Testing	$35,000
Final Surveys, Interviews, Impact and Extrapolation, and final report	$175,000
Total	**$480,000**

3.8.7 Deliverables

Yearly reports on Testbed for performance, impact, and process improvements areas measuring against the objectives. On-going information on process improvements and learnings from the Testbeds.

3.9 Equity

Equity of service is an important pillar of PGE's business practice in recognition of historic and systemic barriers that limit fairness and equality in outcomes for underserved customers. PGE has incorporated principles of equity learned in the SB 978 process within the structure of the Testbed strategy. In addition, PGE plans to continue to address equity considerations and concerns from stakeholders, especially those from community-based and environmental justice organizations, to ensure their voices are represented throughout the administration of the project. The Testbed is designed to reach customers and have them be able to fully participate, regardless of socioeconomic class, ability to pay, or language spoken. PGE plans for outreach and education materials to use a multilingual strategy, as we are aware that many of the PGE's customers speak a home language other than English.

3.9.1 Opt-Out PTR

The strategy of using opt-out PTR is an equitable, non-punitive approach to establishing participation in the Testbed; it holds the customer harmless for not participating but otherwise rewards the customer's response to an event notice. This default approach, applied to all residential customers in the Testbed, is and inclusive and informed by an environmental justice principle of preventing harm (i.e., to non-participating customers). PTR is structured to hold the customer harmless if they are unable to respond to a DR event call but are rewarded for participating in events. To further ease any burden of responding to events, PGE plans to use its DLCT pilot to offer a no-charge smart thermostat to those interested in automating their response. Smart thermostats not only enable the customer to respond to DR event calls, they are also an EE measure, prompted by the Energy Trust, for both electric- and gas- heated homes. So, customers may also lower their monthly bills through EE and also receive incentives for responding to PTR called events. Lastly, any customer may opt-out of Testbed activity and the PTR pilot by calling PGE's Customer Service.

3.9.2 Staffing

As noted above in explaining project costs, PGE is proposing to hire one FTE for each substation site (three in total) for the two-and-a-half-year period of the Testbed Project Phase I. PGE believes–and has been counseled by the cities involved–that a community organizer-like presence within each site is necessary to attain participation and understand the customers taking service within each Testbed site. PGE believes that by having a personal presence at each site, the Testbed is likely to reap many different benefits and quickly resolve customer issues. The approach and value of having a personal presence within a project of this size and complexity is not new. The seminal 1980 Hood River Conservation Project similarly utilized this approach. In fact, evaluations of the project credited the personal presence within the project for being able to keep the project on track and effectively and efficiently administered. Within the Hood River Project, these individuals were credited with community outreach, contract workmanship resolution, and identification of emerging issues. PGE expects that similar personal support personnel within each site will assist in the effective administration of the project and outreach to the various Testbed communities. PGE has explored this approach with the DRRC. City partners and those members of the DRRC familiar with the work in the Hood River Project were supportive of the idea.

In addition, PGE requests funding to hire one program manager (contractor or limited term) responsible for daily administration, coordination of substation FTE, coordination of PGE Distribution and Power Operations, as well as other pilots and programs such as energy storage and EVs.

3.10 Two-Phase Concept

In Staff's final comments filed in PGE's 2016 IRP proceeding on May 12, 2017, Staff issued a white paper which informed Order 17-386 whereby the Commission required PGE to establish a DR Testbed by July 1, 2019.[78] The Commission further opined that the time between Order 17-386 and PGE's next IRP will, "be a critical opportunity for PGE to more aggressively develop DR as a resource to address it capacity needs." The Commission direction to establish a Testbed is an opportunity to develop a capacity and a resource, with the assistance of the Commission. PGE is working to establish a Testbed by July 1, 2019. PGE expects to wrap-up research efforts within the Testbed prior to July 1, 2019. PGE plans a target launch of programmatic activity by July 1, 2019. PGE's plan is to leverage research to inform the education and outreach plan in time for programmatic deployment of Phase I.

The PGE Testbed project is proposed in two phases for several reasons. Firstly, PGE realizes that the Commission has given some latitude to conduct research and development work. The Commission should have the opportunity to thoroughly evaluate PGE's efforts and be allowed an opportunity to either continue, halt, or hasten the effort based on said evaluation.

The second reason to proceed with a phased approach is that PGE expects Phase I will require two-and-a-half years to demonstrate that an opportunity to scale and accelerate DR exists with the PGE customer base. Much of the first two years is about establishing the right kind of customer relationship. PGE believe that this will be critical

[78] Public Utility Commission of Oregon, Docket LC 66 Final Staff Comments, Appendix A (May 12, 2017)

as the resource (unlike supply-side generation) is customer-based and requires a level of customer engagement for which there is no precedent. Success can then be evaluated by the retention rate of these customers and their participation rate in DR offerings and events. We also expect participation rates to affect both overall megawatt savings and our understanding of cost effectiveness. PGE expects attendant benefits of the Testbed will include coordination with other DSM service providers, new offerings, new strategies for customer recruitment, participation and outreach, more data on how best to develop DR, and better information about the technical and achievable potential of DR and other demand-side resources whose success is dependent on customer engagement and involvement.

PGE originally conceived and presented to the DRRC the idea that the Testbed would have two phases. The first phase, a two-and-a-half-year endeavor to establish the Testbed encompasses this filing. PGE also conceived and discussed the development of Phase II to explore new offerings, assuming Phase I received funding and the activities were deemed worthy to continue.

To be explicit–PGE is not asking for approval of Phase II here. However, PGE felt it best to share with the Commission what we believe Phase II activity would look like.

3.11 Program Compatibility / Incompatibility

PGE plans to place Testbed customers on opt-out PTR and offer those customers the choice to migrate to a TOU and / or other DLC options. The following paragraphs, and Figure 4 Compatibility, outline the compatibility of PTR, TOU, and DLC options:

- It *is* feasible for customers to be enrolled in multiple DLC options because PGE can discern which load control device was responsible for responding to an event dispatch.
- It *is* feasible for customers on TOU rates to be enrolled in one or more DLC options. This is because TOU rates are a daily occurrence and are generally persistent while DLC options are temporal, event-driven, and discernable when analyzing customer metering data conjunction with device data reporting.
- It *is* feasible for customers to be enrolled in both PTR and TOU. Customers may be enrolled in PTR and TOU as the former is event-driven while the latter is a daily / persistent behavioral change. This dual enrollment in PTR and TOU follows the logic, practices, and findings of Flex Pricing as well as Cadmus's evaluation findings thereon.
- It *is not currently* feasible for customers to be enrolled in both PTR and DLC options because PGE cannot currently ensure that customers are not paid twice for the same response or capacity. PGE plans to explore A) whether customers can differentiate, and B) whether the energy company can verify that customers responding to a PTR pilot can additionally respond through a DLC option. Where customers on both offerings can demonstrate additional load shifting from the DLC option, PGE plans to explore how to create an offering. This offering could pay customers for verified additional load drop attributable to additional activity beyond the automated response through a DLC technology such as a smart thermostat or smart water heater.

Figure 4 Compatibility of Offerings

	PTR	TOU	DLC 1	DLC 2	DLC 3
PTR		✓	✗	✗	✗
TOU			✓	✓	✓
DLC 1				✓	✓

Section 4 Proposed Phases

4.1 Phase I: Demand Response Research via Current Pilots

Phase I of the Testbed is expected to run approximately two-and-a-half years. With this application, PGE requests $5.6M. PGE will present its learnings to the Commission at the close of Phase I and request approval for Phase II activity, if deemed beneficial. PGE's plan is for Phase I to deliver on the following goals:

1. Identify, develop, and communicate the customer value proposition of DR to PGE's customers;
2. Work with customers to establish and retain a high level of customer participation in DR programs;
3. Learn how to recruit and retain customers program participation and translate these learnings for development of cost-effective strategies to be applied to service territory program offerings;
4. Collect information on DR potential that can inform resource potential studies;
5. Create new program offerings that can quickly translate to broad deployment program offerings;
6. Coordinate on new program development with other demand-side measure providers such as the Energy Trust and NEEA; and
7. Study and understand the implications that high levels of flexible load has on system operations.

PGE believes that these goals are significant and will be challenging to meet within the timeline for Phase I.

4.1.1 Coordination with Other PGE Offerings

PGE plans to coordinate rollout of the Testbed with other programmatic efforts that either have a DR component or may have interactive effects. Energy storage and transportation electrification are examples of the coordination of the Testbed with distribution-sited programmatic efforts.

Coordination of the Testbed with transportation electrification takes several forms. PGE has already sited two new Electric Avenue charging stations within the Testbed.[79] We also plan to foster smart charging participation within the Testbed by coordinating our rollout of residential and commercial EV charging pilots therein.

PGE expects the coordination of energy storage within the Testbed will be multifaceted. Home-sited energy storage has been identified as an important resource in a distributed grid. For their part, Staff and the Commission have determined that energy storage is defined by its use cases.[80] Currently, the most viable use case for home energy storage is as a capacity / DR resource. This is because residentially-sited energy storage can immediately respond to DR events and do so with extraordinary accuracy. PGE could wait until Phase II to incorporate behind-

[79] Details on Electric Avenue sites and activity can be found in Appendix B.5.
[80] OPUC Docket No. UM 1751, https://apps.puc.state.or.us/edockets/docket.asp?DocketID=19733.

the-meter energy storage into the Testbed. But we felt that as the opportunity comes at no additional incremental cost, it was prudent to capitalize on the coordination opportunity and gain these insights without the further delay that a subsequent phase of conceptualization, proposal, and possible approval would entail. PGE expects to coordinate the rollout of the residential energy storage program within the Testbed to understand the interactive effects of siting energy storage units within the home. In part, PGE would like to know more about customers' reactions to having multiple DR-capable resources in the home. PGE would also like to understand how to optimize the home to participate in DR events when an energy storage is present.

PGE expects that having pilots such as energy storage, smart thermostats, smart water heaters, and EVs within the Testbed will inform us about the interactive effects of multiple DR offerings and the operational impacts within the home and local grid. PGE's goal is to optimize these resources for maximum grid effect while maintaining customer comfort and needs. Table 15 below lays out the planned deployment of DR offerings in the Testbed.

Table 15 Schedule of Deployments into the Testbed

Measure	Project	New / Existing Program	Target Market	Timing of Testbed Deployment					Comments
					Q1	Q2	Q3	Q4	
Water Heater Multifamily		Existing		Q1	●●●				
Water Heater Single Family (New Construction)		New		Late Q2		●			Pilot basis
Water heater Single Family (Existing Residences)		New		Late Q2		●			Pilot extension of MF water heater
Connected Thermostat	NEST, Whisker Labs, Bring Your Own Thermostat	Existing		Q1	●●●				
	Direct Install	Existing	Free to electric heat or heat pump customers. A/C customers offer at $150	Q1	●●●				
	Direct Ship	New		Q2 / Q3		●●●	●●●		Free to qualifying customers, electric forced air, or heatpump or A/C
Opt-Out PTR	Flex	New	All qualifying residenital customers	Q2		●●●			
TOU			Opt-in						
Behavioral DR			Opt-in						
Business and Government DR (BGDR)	Energy Partner	Existing			●●●				
	AutoDR	New	All current and new BGDR customers	Q2		●●●			Increased incentive for new more dynamic availability
	Peak Demand Management	New Strategy for enhancing BGDR		Q2 / Q3		●●●	●●●		
	BTM Batteries	New		Q4				●●●	Pilot basis
Residential Energy Storage		New	Qualifying residenital customers, open to all	Q2				●●●	Coordinated Testbed roll out

PGE has identified the following Testbed enrollment targets:

Table 16 Aggressive Enrollment Targets (Residential)

	(Direct Load Control Programs)			(Voluntary)	*(no events)*	
Meter Type	Thermostat: RHR	Thermostat: Direct Install	Water Heaters	Peak Time Rebate	*Time of Use**	Total
SFR	2,146	536	1,073	5,687	*472*	9,442
MFR	104	26	2,469	832	*172*	3,430
Mobile Home		150	75	25	-	251
Total	2,250	713	3,617	6,534	*644*	13,123

Table 17 Moderate Enrollment Targets

	(Direct Load Control Programs)			(Voluntary)	*(no events)*	
Meter Type	Thermostat: RHR	Thermostat: Direct Install	Water Heaters	Peak Time Rebate	*Time of Use**	Total
SFR	1,073	268	536	7,564	*472*	9,442
MFR	52	13	1,234	2,131	*172*	3,430
Mobile Home	-	75	38	138	-	251
Total	1,125	356	1,808	9,833	*644*	13,123

**TOU participants are a subset of PTR participants. They are excluded from the total column.*

A target of 577 business participants across the three geographies was established by CLEAResult, the administrator of PGE's commercial DR offering. This equates to 25% of both small- and medium-sized businesses located within the Testbed, and 40% of large businesses. Table 18 below provides detail on the commercial participation targets.

Table 18 Commercial Participation Targets

Business Size	Customers within Testbed	Existing Program Participation Target	Testbed Target Rate	Incremental Testbed Rate	Target Participation: Testbed Effort
Small	2,105	0.3%	25%	24.7%	520
Med	225	1.1%	25%	23.9%	54
Large	17	22.7%	40%	17.3%	3
Total	2,347	13	589		577

4.1.2 Security

Each DR program vendor that interacts with PGE customer data must pass our rigorous IT security certification. PGE's main concern is always to keep Personal Identifiable Information (PII) safe and secure. All of PGE's Demand Response Management Systems (DRMS') are required to segregate PII from the underlying monitor / control / dispatch system. As a result, any security breach of the DRMS would not expose customers' PII to third parties.

4.1.3 Limitations of the Testbed Activity

Phase I of the Testbed is focused primarily on identifying the customer value proposition of DR and validating strategies to increase program and event participation. The strategies at present include but are not limited to:

- Using an opt-out program to increase engagement and participation;
- Using this opt-out approach to establish engagement opportunities with the customer to communicate the value proposition of DR. Using the opt-out approach to migrate customers to more valuable DLC options;
- Identifying the successful value propositions for increased participation on a DLC option; and
- Working with EE providers regarding coordination of DR program development and delivery.

There are many additional expectations and possible benefits of operating the Testbed which may include effects of "at-scale" DR operations on the distribution grid and the capture of data to inform distribution system value of DR. Additional expectations include guidance to PGE on the development of a smart grid strategy and possible new approaches to new construction program strategy and delivery. While these and other additional goals are part of the Testbed, they can add to the funding burden and the work load burden of the DRRC and limited PGE staff. PGE plans to seek internal and external coordination to deliver as many research benefits and long-term guidance as possible. Additional Phases or funding may be necessary to include many of the foreseeable benefits of conducting a research effort such as the Testbed.

4.2 Phase II: Potential to Extend into New Program Offerings

PGE believes that Phase II of the Testbed would continue to advance our efforts to accelerate the development of DR and expand efforts from DR and current DSM program offerings into DER development and advanced control schemes and operation of all DSM resources. PGE foresees that the distribution system will house various new resources that will be leveraged to provide the grid with capacity and energy services, as well as providing communities and individual customers with energy and resiliency services. To prepare for this smart grid and service paradigm, PGE envisions continuing the development of the Testbed such that we accelerate the current state of DER development to learn about how to best prepare, extract benefits, and how to approach a system where nearly one quarter of grid resources and services come from DERs. PGE expects Phase II may include research some of the following:

- Advanced dynamic pricing;
- Transactive control;
- Distribution system operator models;
- Distribution system planning approaches and modeling not already explored through data collection from Phase I of the Testbed; and
- Home or customer energy management systems.

Appendices

Appendix A PGE's Current Residential Demand Response Offerings

A.1 Direct Load Control Thermostat (DLCT) Pilot

A.1.1 Pilot Description

The DLCT Pilot aims to enroll and operate connected residential thermostats to control heating and cooling load and build DR capacity. To participate in the program, PGE customers must operate either a ducted heat pump, electric forced-air furnace, or central air conditioner. The pillars of the pilot rest on three delivery channels:

1. **Bring Your Own Thermostat.** Customers may enroll online in PGE's DR program by A) purchasing a new qualifying thermostat, or B) using an existing qualifying thermostat attached to a qualifying HVAC system. Customers receive a $25 enrollment incentive and $25 for each DR season that they participate in at a 50% of the DR hours called within a season. Customers are permitted to opt-out of any or all events.
2. **Residential Thermostat Direct Installation.** Customers with a qualifying HVAC-system can participate by obtaining a connected thermostat, getting it installed, provisioned, and enrolled into PGE's DR platform. This channel is currently focused on ducted heat pumps and electric forced air furnaces due to the high DR capacity value. Customers with central air conditioners are charged an incremental cost of $150. Participating customers coming through this channel are excluded from receiving PGE enrollment incentives, seasonal participation incentives, as well as thermostat incentives by the Energy Trust.
3. **Residential Thermostat Direct Ship.** PGE's roadmap for residential thermostat includes an expansion for 2019. This channel would allow PGE customers to go online and order a thermostat free or at a reduced charge. In return, customers are required to self-install and enroll into PGE's DR program. Participating customers coming through this channel are excluded from receiving PGE enrollment and seasonal incentives. This channel is currently not yet active or approved–it is scheduled to be available in the summer 2019 season.

The pilot aims having a total of 20,000 residential thermostats by 12/31/2019.

A.1.1.1 Primary Goals

- Determine and verify customer acceptance of the above delivery channels.
- Build a minimum of 20 MW summer capacity and two megawatts winter capacity.
- Successfully operationalize and maintain or increase customer satisfaction for all three delivery channels.
- Dispatch and control enrolled thermostats and obtain DR capacity at or above planning estimates.
- Minimize customer drop-outs from *the pilot* (not event-based overrides) to increase customer retention.

A.1.1.2 Market Opportunity

- This program's primary targets are PGE customers with and without existing connected qualifying thermostats that live in SFRs with ducted heat pumps, electric forced air furnaces, or central air conditioners.
- The total number of eligible households is about 298,000 units. This number is continuously improving due to increasing installations of central air conditioners. The achievable potential is **149,000** units, which represents **82.5 MW**.

A.1.2 How Will Connected Thermostats Work Within the Testbed?

- PGE plans to operate all existing channels of the thermostat program within the Testbed.
- PGE plans to augment existing outreach via targeted recruitment at community events, door-to-door outreach, targeted mailings, and a generally-increased presence in the community.

A.1.2.1 What learnings can be extracted from the Testbed to advance the development of the DLCT Pilot?

- The Testbed aims to identify ways to increase/accelerate adoption of the pilot within PGE's service territory:
    - Unique sales techniques
    - Unique outreach marketing
- Bundling opportunities with other offerings (TOU, water heaters)

A.1.2.2 What questions can the Testbed help the DLCT Pilot answer?

- How does PGE expand the program from mainstream target customers to other customer groups?
- How does PGE accelerate the growth of the program?

A.2 Multifamily Residential Demand Response Water Heater (MFR DR Water Heater) Pilot

A.2.1 Pilot Description

The Pilot aims to enable and operate electric water heaters for DR purposes in MFR housing. It is structured in phases, moving from pilot to program within two to three years. PGE plans for the program to enable 4,000-8,000 smart electric water heaters and provide two to four megawatts by 12/31/2019. The project serves as backbone to provide water heater solutions in new and existing construction markets for single family housing, as well as in owner-occupied MFR housing as early as Q2/2020.

A.2.1.1 Primary Goals

- Successfully operationalize and field deploy retrofit devices that allow for successfully controlling existing water heaters in PGE's DR platform. Operationalize and field deploy DR-enabled new water heaters that can be controlled via PGE's DR platform.

- Operationalize communications technology that provides uptime of 90+% for the PGE water heater fleet.
- Reduce costs for hardware, installation, maintenance, and operations down to cost-effective levels while scaling up the program during the pilot period.
- Test, modify, and proof business model with MFR property owners and their agents (MFR property managers).
- Successful dispatch of PGE water heater fleet in DR events with an average capacity of 1KW per water heater during the DR event period.
- Expansion of operation of PGE water heater fleet from DR to daily load shifting by 10/01/2019. Demonstration of load following capability before 12/31/2019.

A.2.1.2 Market Opportunity

- This project targets the large scale / non-owner occupied MFR market: 25 units/site.
- The total number of eligible apartments in large scale MFR housing is 100,000 units. The achievable potential is **50,000 units** corresponding to **25 MW by 2027**.

A.2.2 How will PGE's MFR DR Water Heater Pilot work in the Testbed?

- PGE plans for the general approach of the program to remain intact, with the exception of additional targeted research on the ownership and management of existing MFR housing stock in the Testbed. PGE plans to follow this up with more intensified outreach to building owners / managers.
- PGE's MFR DR Water Heater Pilot may augment incentive levels such as providing one-time enrollment incentives to get one or more initial buildings within a property manager's housing portfolio enrolled and DR-enabled. In our experience, the initial decision to participate with the first building is the highest barrier to entry.
- The pilot may provide additional marketing collateral to property managers / owners to allow them to self-identify their participating community in the Pilot (a good environmental steward).

A.2.2.1 What learnings can be extracted from the Testbed to advance the development of PGE's MFR Water Heater offerings?

- The Testbed allows for the identification of mechanisms that allow for increased / accelerated adoption within PGE's service territory:
  - Unique sales techniques
  - Unique outreach marketing
  - Testing of alternative incentive / benefit structure to overcome skepticism

A.2.2.2 What questions can the Testbed help answer regarding future MFR Water Heater offerings?

- How does PGE expand the pilot from a mainstream target customer to other customer groups?
- How does PGE accelerate the growth of the pilot?
- What other value streams might owners / managers or tenants benefit from that have not yet been identified or could be more effectively communicated?

A.3 Non-Residential Demand Response

PGE is piloting a non-residential DR program designed to reduce peak demand requirements during specific time windows in the winter and summer seasons by incenting customers to reduce their energy consumption during those times. PGE expects the primary source of this reduced demand (load) will be from large customers, with an option for small and medium customers to participate as well. The 2018 target is 14 MW of DR, increasing to 20 MW in 2019, and ultimately to 27 MW by January 1, 2021.

PGE's non-residential DR program was launched in December of 2017, and was directly administered by PGE, with support from:

- CLEAResult for program implementer
- Enbala for technology integration via their Virtual Power Plant (VPP) software platform. PGE took a more active approach than the prior "turnkey" DR program administered by EnerNOC, as PGE found that third party aggregation fell far short of load goals.

The new arrangement offers the flexibility to offer a variety of products and potentially adjust them in the future. The secondary reason for PGE to work directly with customers is portfolio resiliency. With the loss of EnerNOC in 2017, PGE had to execute new contracts and deploy new technology to current participants. This presented customer retention risk. Directly administering the program should avoid such adverse operational risks should a third party exit the program. PGE administration of the program also allows for better bundling and / or cross-marketing of the program with other offerings such as EE, renewables, storage, and dispatchable standby generation.

Delivering an impactful business DR program and the associated flexible load is key to A) delivering upon PGE's IRP commitment, B) supporting Oregon's 50% renewables by 2040 (SB1547) target, and C) enabling PGE to achieve aggressive carbon reduction goals (carbon emissions reduced by 80% below 1990 levels). The program is expected to help us learn how to drive program adoption, optimize the DR software platform, and leverage the program value over time–evolving from solely a capacity resource to other use cases such as load following and renewable firming. Including business DR in the Testbed provides an opportunity to accelerate learnings, as well as test and optimize new use cases in a high penetration / limited geography before expanding to the full-service territory.

PGE's previous business DR program was initiated in 2013 and administered by EnerNOC. This prior iteration fell short of its 24 MW DR target, and by the end of 2016 had achieved only 10.6 MW. The volume gaps were attributed primarily to EnerNOC's approach to program design (inflexible and oriented solely to large customers) and their sales process, which lacked on-site account management. Their model delivered results in other geographies but was not adjusted to meet the needs of PGE's customer base. PGE's redesigned program offers customers flexible participation options during events, greater remuneration, options for both large and small-to-medium sized customers, and a "higher touch" sales approach.

In the prior program, customers had to enroll for 40 hours of event time per season and be on call from 7 am to 10 pm in the winter and noon to 10 pm in the summer. In the current program, customers can select from 20, 40, or 60 hours of events per season and customize their participation schedule by selecting one or more event windows such as 7-11 am (winter), and 11 am to 4 pm, 4-8 pm, 8-10 pm (summer and winter). Compensation is also more favorable: the same selections as the prior program now earns 22% more, and the maximum hour / maximum window option pays 76% more.

The EnerNOC program lacked participation options for small-to-medium size businesses. PGE's updated program offers a smart thermostat free of charge; this unit controls heating and cooling during DR events and pays customers $60 per season if they participate in a minimum of 50% of event hours. Larger Commercial and Industrial customers also benefit from this option, as many have office buildings on site.

Another gap addressed by the revamped business DR program is the addition of dedicated sales representatives and engineering staff (provided by CLEAResult) who can work on site with customers. EnerNOC predominantly serviced accounts over the phone and via email and were unable to build the customer insight and trust essential to success. Unlike residential DR programs which leverage a "mass market" approach, business customers require individualized, ongoing focus to ensure their operations are not disrupted by DR events (e.g. nominations may require adjustments, questions may arise as to how to optimize participation during events).

A final limitation of the EnerNOC program was their DR Management System (DRMS) which was acceptable for the prior pilot but lacked the technical capability to meet future requirements. The tool only supported an "all call" approach, which notified all participants during a multi-hour event. Compare this to Enbala's more sophisticated VPP, which can call devices based on constraints such as location (e.g. around a feeder), or customer sited set points (maximum and minimum pump set points). The Enbala VPP software used with PGE's new program provides the flexibility to meet these future needs.

Customer feedback on the redesigned program has been positive. Customers appreciate the flexible program design and dedicated / responsive sales and engineering staff as improvements. PGE is proud that PGE were able to transition the great majority of customers to the new program. When combined with additional customers that PGE has signed up for the program, and PGE is on track to exceed its 2018 target of 14 MW. A comprehensive Measurement and Verification evaluation of event performance and customer satisfaction is expected in third quarter 2019.

A.3.1 Incremental Testbed Activities

The non-residential DR program's inclusion in the Testbed is expected to entail bolstering several program design elements to accelerate the program's ability to refine and optimize its delivery activities. Specifically, PGE plans for the program's Testbed activities to include enhanced incentives, targeted marketing, and dedicated sales / outreach. We expect these efforts will be incremental to the program's "business as usual" operations, meaning that they leverage existing program activities. Furthermore, we expect these incremental efforts to be invaluable in defining optimal program delivery strategies and tactics, identifying customer segment-specific ceilings for program participation, and facilitating acceleration of significant load reduction capacity within the DR portfolio.

Examples of potential incremental program activities evaluated in the Testbed include:

- Incentives
    - Offering enhanced incentives at a to-be-determined level

    - If possible, testing multiple enhanced incentive levels is desirable due to ability to determine "incentive elasticity"
- Marketing
    - A/B testing of the same messaging delivered through different delivery mechanisms
    - A/B testing of customer segment-specific messaging
- Sales / outreach
    - Testbed-dedicated sales / outreach staff
- Product design
    - Bundling of program offerings (e.g. DR with behind-the-meter energy storage and / or EV charging stations)
    - New tariff designs that provide majority of monetary benefit to customers upfront
    - Tiered incentive levels tailored to the DR approach (e.g. manual, automated, or advanced)

PGE intends to leverage non-residential DR program activities in the Testbed to drive improved program performance on a territory-wide basis. To enable this, the program expects to have informed answers to the following questions at the end of Testbed activities:

- By customer size and segment:
    - What incentive levels are most cost-effective at driving program participation?
    - Which product bundle and marketing messages are most compelling?
    - What is the maximum expected conversion rate given various incentive / marketing / sales / outreach configurations?
    - Are marketing, sales / outreach, or incentives most impactful in driving program participation?
- Which customer segments are extremely *unlikely* to participate (regardless of incentive level) due to operational challenges not conducive to DR participation?
- Is sales / outreach or targeted marketing more effective at converting small-to-medium sized customers?
- Do customers have a higher propensity to participate if businesses located near them are also participating?

PGE expects that evaluating the non-residential DR program's learnings via its Testbed activities will improve our ability to fine-tune DR offerings in both the small-to-medium business (SMB) and large commercial and industrial spaces. The proposed budget for delivering the incremental Testbed activities is presented below.

Table 19 Proposed Budget for Incremental Testbed Activities

Program Design Element	Amount	Comments
Marketing	$90,000	Testbed-focused marketing campaign for SMB and large customers
Sales/Outreach	$50,000	Bolstered sales team focused on large customers in Testbeds; testing of sales team focused on SMBs, which are not program's Business as Usual (BAU) activities
Provisioning	$250,288	Engineering funding for DR-enablement incremental to program's BAU activities
Equipment	$478,246	Equipment funding for DR-enablement incremental to program's BAU activities
Incentives	$142,810	Incentives incremental to program's BAU activities
Project Management	$70,000	In support of incremental Testbed activities
Total	$1,081,343	

A.4 Residential Pricing Pilot (Flex Pricing)

A.4.1 Background

In 2018, PGE completed a two-year Residential Pricing Pilot in which a combination of opt-in and opt-out TOU, PTR incentives, and Behavioral DR scenarios were tested. In all, some 14,000 customers were enrolled in control or treatment groups. In June 2018, Cadmus completed its evaluation, confirming that PGE can cost-effectively obtain customer demand savings through pricing and behavior-based DR programs to manage system peak demand while maintaining a positive customer experience.

Based on Cadmus recommendations for increasing demand savings and customer satisfaction, PGE is working to develop a broader offering with OPUC Staff and stakeholders that we believe will achieve high customer satisfaction and support PGE's floor goal of 77 MW of DR by end-of-year 2020. PGE plans to propose these offering as part of its "Residential Pricing Program." The offerings may include an opt-in TOU / PTR Hybrid option and an opt-in PTR option as outlined below. PGE plans to introduce the program to residential customers in Spring 2019.

1. Opt-in TOU / PTR Hybrid:
    a. TOU**:** Customers can save on their daily energy costs by shifting usage to off-peak times when rates are lower.
    b. PTR**:** Customers receive notifications asking them to shift energy use during peak-time events (16- 20 events per year). As a reward, they receive an on-bill credit based on actual vs. the usage expected had they not shifted.
2. Opt-in PTR:
    a. Customers are not on TOU pricing but have chosen to participate in the PTR incentive offering. They receive notifications asking them to shift energy use during peak-time events (16- 20 events per year). As a reward, they receive an on-bill credit based on actual vs. the usage expected had they not shifted.

A.4.2 Benefits of Testbed-to-Program Design

PGE expects the Testbed will allow us to evaluate the following for the Residential Pricing Pilot:

- Customer reception to an opt-out PTR program as part of a broader engagement initiative;
- Measure performance of those residential customers who are enrolled;
- Test communication strategies to ensure ongoing participation and retention; and
- Refine program offerings and incentive levels to support high levels of customer satisfaction

If an opt-out strategy proves successful within the Testbed, PGE may explore an opt-out PTR offering with targeted customers or geographic areas. Large-scale participation in programs of this nature provides the opportunity for significant DR load shift, an alternative to additional fossil fuel-based energy plants, as well as supporting PGE's DR goals.

Additionally, the Testbed provides an opportunity for PGE to learn if PTR incentives serve as a "gateway" to other DLC options by fostering behavioral changes that encourage adoption of additional DR offerings.

A.4.3 Why Customers Will Accept the Offering

PGE believes that its customers will accept the Residential Pricing Program offering for the following reasons:

- PTR incentives offer a no-risk opportunity for residential customers to participate in DR offerings by shifting energy use during high-demand times.
- PTR scenarios achieved the highest load shift and levels of customer satisfaction of the twelve scenarios tested during the pilot.
- PTR incentives offer low-income customers opportunities to reduce their monthly bills and have proven highly-successful with economically challenged populations[81].

A.4.4 Broader Impact of the Program for Customers

The Residential Pricing Program helps customers save money on their monthly bills and provides an alternative to building additional fuel-based energy plants, thus putting downward pressure on rates for all.

A.4.5 Long-term Customer Impacts

- The program could support customer adoption of smart-devices such as thermostats and water heaters; these would enable a more automated / consistent load shift, savings, and maintain a high level of customer satisfaction.
- Shifting energy use during peak times helps customer save money and helps the energy company keep rates lower.

[81] In Entergy New Orleans 2014 PTR study of low-income customers, not only did two-thirds of customers save energy with PTR, but 96% of PTR participants said they would like to be part of the program on a permanent basis.

Appendix B Detail on New Residential Offerings in the Testbed

B.1 Single Family Water Heater Testbed Pilot

B.1.1 Description

This pilot uses technology (hardware, software, and a DR platform) currently being deployed in PGE's MFR DR Water Heater Pilot. The Testbed extends these deployments into water heaters in single family housing. This pilot may use different communications technology (4G LTE instead of Wi-Fi) to ensure connectivity with the enabled water heaters. PGE plans to recruit customers into the pilot by receiving a recruitment incentive, an annual participation incentive, and / or possibly a discounted DR response enabled water heater. This pilot may target existing homes as well as new construction single family homes.

B.1.2 Why is the Testbed the best place to pilot Single Family Water Heaters?

- Enabling water heaters for DR purposes in single family settings has not historically been cost-effective for two primary reasons:
    1. Lack of economies of scale with regards to installation labor. Contractors must spend time travelling between installation sites having to set-up specific installation windows with specific customers. The installation costs run at least double that of the MFR market.
    2. Prohibitive cost to enable the water heater with communications devices independent of the customer's own Wi-Fi (necessary due to the disconnects due to router reboots, energy outages, etc.) A cellular 4G LTE solution remains significantly more expensive than the Wi-Fi solution PGE deployed for PGE's MFR DR Water Heater Pilot. The latter is not feasible for single family homes due to their increased geographic dispersion.
    3. The ongoing costs for cellular data have (until recently) been too expensive to operate individual water heaters
- Since the start of PGE's MFR DR Water Heater Pilot, costs for 4G LTE modules–as well as the related data plans–have dropped significantly. It is prudent to assume that costs will continue to drop in the next 3 years, which puts a full Single-Family Water Heater DR program within striking distance of cost-effectiveness. It therefore makes sense to test out a program delivery structure, an incentive structure, and program operations in a defined geographic setting such as the Testbed.
- The incremental cost to extend PGE's MFR DR Water Heater Pilot into a single-family setting is relatively low.
- The Energy Trust and PGE are interested in collaborating to enable heat pump water heaters for DR. There is an opportunity to combine incentives to lower the cost to upgrade from an electric resistant water heater to a heat pump water heater.
- Some existing heat pump water heaters are nearly capable of supporting a simplified DR-roll out. These "plug and play" units would not require a licensed / bonded / insured contractor. This basic "plug-and-play" solution (supported by CTA 2045) may allow for cost effective deployment of DR on water heaters in single family settings.

B.1.3 Benefits the Testbed Conveys to the Single-Family Water Heater Pilot

- The Testbed allows for the accelerated enablement of heat pump water heaters into PGE's DR portfolio.
- The Testbed allows for PGE and the Energy Trust to explore a joint incentive structure for heat pump water heaters supporting this key technology.
- Heat pump water heaters require a different DR control structure. Having heat pump water heaters enrolled and in the control infrastructure allows for the DR platform to adequately deploy and control the water heaters.
- PGE's MFR DR Water Heater Pilot provides incentives to property owners and managers. The residential incentive is comparatively low. The Testbed allows PGE to explore alternative approaches to provide benefits to participants to determine those that customers value most and most effective in recruitment and retention of households.
- The Testbed is expected to shorten the delivery period needed to plan, obtain approval for, and deploy a full-scale pilot across PGE's service territory by a minimum of 12 months.

B.1.4 Prospective Strategy for Rollout of the Single-Family Water Heater Pilot

- PGE may use the same delivery infrastructure that is currently used for PGE's MFR DR Water Heater Pilot. The main difference is that for Single Family recruitment to be successful, we expect it will need to include mass marketing channels, direct mail, emails, and door-to-door sales campaigns.
- If new construction properties are available, PGE may engage with builders, developers, and architects to install water heater technology in homes prior to customer move-in.

B.1.5 Why PGE Expect Customers to Adopt the Single-Family Water Heater Offer

- Customers surveys and focus groups consistently convey that customers want to participate in clean and advanced energy programs that provide an environmental benefit.
- Customers have expressed that their willingness to participate if up-front costs are either non-existent or relatively low. PGE plans to provide this program at no cost to participating customers. We plan to cover the costs of the equipment, installation, and operation. If customers participate by purchasing a new qualifying water heater, PGE plans to cover the incremental costs between a regular water heater and the qualifying tank.
- Customers may receive a one-time enrollment incentive as well as an annual performance / participation incentive.

B.1.6 Customer Benefits of the Single-Family Water Heater Pilot / Long-Term Benefits of Extending the Pilot to a Program

- The goal of the pilot is to identify a path to a cost-effective program for single family water heaters. A significant proportion of water heaters within the single-family housing market are electric resistant. Unlocking this market allows for increased growth in DR capacity, as well as the delivery of EE savings (when deployed with heat pump water heaters).

- The target market for single family housing with electric water heating is estimated to encompass 148K households, with an achievable potential of 74,000 households that represents 37 MW (assuming a capacity of 0.5 KW per water heater).
- Successfully establishing both the Single-Family Water Heater program and the CTA2045 standard may allow for water heaters to be DR-enabled by code by 2025.

B.2 Multifamily Residential Thermostats

B.2.1 Description

The Pilot aims at enabling and operating electric baseboard/wall heaters for DR purposes in multifamily housing. The Pilot would replace existing low-tech and inaccurate line voltage thermostats with Wi-Fi-enabled digital thermostats. Property managers benefit by receiving an annual incentive and possibly a sign-up incentive.

Tenants benefit from much improved comfort level due to much increased accuracy of temperature settings. EE savings may be possible, depending on the thermostat, possible occupancy sensors, and the availability of seasonal savings programs provided by the manufacturer or DR-platform provider. Assuming a displacement strategy the Pilot may remove just in the main living area and/or replace multiple thermostats within an apartment. The Wi-Fi enabled digital thermostats would be connected to a localized router via Wi-Fi. The router would connect the thermostats via 4G LTE and cloud services to a PGE operated DR platform. This Pilot can leverage existing communications technology (routers) that are already in place serving PGE’s MFR DR Water Heater Pilot. Recruited properties may also benefit from getting DR-enabled for PGE’s MFR DR Water Heater Pilot and MFR Thermostat Pilot at the same time. This creates the opportunity to create more DR-capacity with the same customer and lower installation costs overall.

B.2.2 What benefits could the Testbed bring to this Pilot design?

- Line-voltage thermostats are not very common nor deeply tested in MFR baseboard housing today.
- The Testbed allows for the testing of line-voltage thermostats in real-life settings. Real-life installations and the operating of such assets in a DR-platform are invaluable. It provides information that would allow PGE to make decisions regarding the timeline, technological viability, and cost-effectiveness of a full-scale Pilot and possible program roll-out across the service territory.
- There are approximately 300,000 MFR properties with electric resistant baseboard heat that could benefit from the data, information, and analyzing resulting from a Pilot deployed in the Testbed.

B.2.3 How Will the Testbed Accelerate this Pilot?

The Testbed allows for a lower threshold for obtaining early information for development of a full-scale DR pilot. Given the relatively unknown space for DR-enabled line-voltage thermostats, it’s nearly impossible to develop a full program without early R&D focused inputs that allow for the construction of assumptions required to justify a larger rollout.

B.2.4 Potential Strategy to Deploy the Multifamily Thermostat Program in the Testbed?

- The Pilot would be rolled out in the same fashion that is used for the PGE's MFR DR Water Heater Pilot. The focus is on reaching out to property managers and owners operating MFR housing apartment in Testbed locations.
- This Pilot would be offered as bundle with PGE's MFR DR Water Heater Pilot. It may also be offered as stand-alone if property owners or manager have objections or concerns to sign-up for both at the same time.
- The pilot would aim to enable between 50-1,000 apartments with line-voltage Wi-Fi-connected thermostats. The total number depends on the ability to recruit apartment, the number of tested line-voltage thermostats, the availability to integrate specific vendors into a DR-platform, and targets need to allow for statistically significant evaluation results.

B.2.5 Why PGE Expect Customers to Accept the Offering

- Early indicators from PGE's MFR DR Water Heater Pilot indicate that property managers and owners have interest in opening new revenue/profit streams, participate in environmentally friendly programs, and see upgrades to their apartments and systems. This Pilot offers upgraded thermostats, which should create increased tenant comfort, and may lower apartment turnover in later periods.
- Low income housing benefits significantly from additional income streams. A lot of projects that are on the brink of penciling out can move forward if additional income can be generated from participating in a DR-Pilot.
- Tenants are not making the decisions related to technology and building systems. PGE expects tenants to benefit from increased comfort and possibly energy savings if the chosen thermostats come with occupancy sensors and/or can be coupled with a seasonal savings program. These programs are early in development and deployment even in single-family low voltage thermostat settings.

B.2.6 What is the broader impact of the Pilot for all customers?

The pilot offers an opportunity to create additional DR capacity with a target market of up to 300K households should the Testbed lead for an opportunity to create a full-scale Pilot of this approach.

B.2.7 What are the long-term customer impacts?

- Customers get to pro-actively participate in the energy grid of the future.
- MFR customers that usually are sidelined due to the intricacies of the owner/tenant relationship are included in DR programs.
- PGE may be able to increase its planning estimate for DR-capacity, which would provide a positive impact on the IRP.
- Lower pressure on increasing residential rates

B.3 Single-Family Construction Demand Response Pilot

B.3.1 Description

This pilot aims at enabling single family new construction homes with all viable DR technologies during construction and / or the early occupation of the home by the new owners.

- This pilot may rely on:
  1. Pre-enrollment of end-user devices at the time of installation and allowing customers to opt-out of components of the pilot.
  2. Post-occupancy enrollment of new occupants / customers into components of the DR pilot based on residence within a DR-enabled home.
  3. Participating households may or may not receive ongoing incentives for participation in the pilot. Whether incentives will be ongoing depends on the cost effectiveness of A) the individual DR components, and B) the overall bundle of technologies installed in a home. Some technologies also provide EE and / or comfort benefits to the PGE customer.

The Single Family New Construction bundle may include connected thermostats, connected water heaters, and / or connected EV-charging stations. To maximize the DR capacity and customer value, homeowners may be subject to opt-out or opt-in TOU pricing and / or PTR.

PGE may promote the following building systems or components to build dual-season DR capacity, provide EE benefits, and reduce greenhouse gas emissions:

- Ducted heat pumps
- Ductless mini-splits
- Heat pump water heaters
- EV-charging make ready/EV-charger pre-installed

PGE plans to engage developers, builders, verifiers, contractors, and architects during the planning and execution of new single-family housing projects. We expect the pilot to mitigate adoption hurdles for these components by providing upstream incentives, education on DR / EE benefits, and conveying the energy benefits to the Energy Performance Score (EPS).

B.3.2 Why the Testbed is an Ideal Location for this Pilot

The Testbed is expected to be an ideal opportunity to explore one or more approaches to integrating new technologies within single family homes within a contained environment. The Testbed facilitates “quick” learnings regarding the new construction housing market and allows for successes, failures, and swift adoption of new tactics and strategies that would be difficult to replicate in a full-scale program.

B.3.3 Benefits the Testbed Conveys as PGE Build the Program

The Testbed allows for early feedback on different sales approaches with the market, incentive levels, sales drivers, and possible adoption hurdles. It also allows for testing of technologies, communications, and control strategies. The goal in operating the pilot within the Testbed is to inform the type of construction bundle(s) that allow for successful rollout to the broader new single-family housing market.

B.3.4 Potential Strategy for the Rollout of the Pilot

Potential strategies for the rollout of the Single-Family Construction DR and Electrification pilot may include:

- Working with developers, builders, architects, verifiers, and contractors.
- Determining how to best cover the gap in costs related in existing technology to DR-enabled / EE-technologies as well as non-monetary benefits. Goal here being to create demand and thereby transform the market
- Testing opt-in and opt-out designs.
- Collaborating with entities already active within this market.

B.3.5 Why PGE Expects Customers to Adopt the Offer

PGE believes that customers will adopt the Single-Family Construction DR and Electrification offer due to the following:

- The pilot should result in little-to-no additional cost to the builder / developer building the new homes.
- The product is expected to be perceived as higher-end / sophisticated, to provide an improved EPS, to be "smarter" than non-enabled new homes, and to generally provide more comfort to the homeowners.

B.3.6 Customer Benefit / Long-Term Benefit

- A successful new construction bundle offers an opportunity to influence hundreds of homes at a time when builders / developers are switching from conventional home technologies to advanced DR-enabled technologies.
- DR assets installed during new construction maximize the longevity of the asset and offer lower installation costs.
- The Testbed may allow for an accelerated deployment of a full-scale pilot or program.

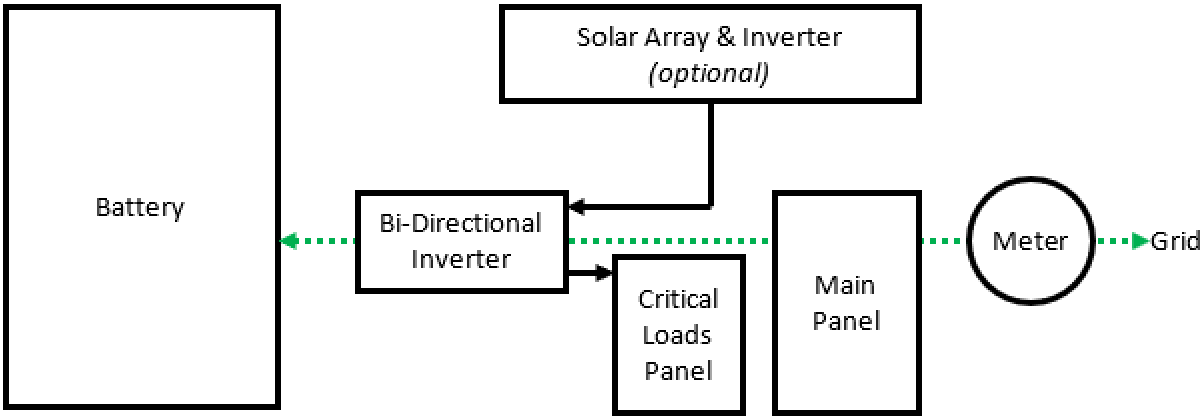
B.4 Integrating the Residential Energy Pilot into the Testbed

B.4.1 Pilot Description

PGE proposed, in UM 1856, to implement a residential energy storage pilot program by installing Battery Inverter Systems (BIS) at customers' homes. Individually, the BIS would provide enhanced power reliability capabilities to program participants by offering back-up power during grid outage events. As an aggregated fleet, the BIS would provide capacity, energy and ancillary services, and transmission deferral services to PGE.

During normal operating conditions, the BIS would operate in parallel to the electrical distribution grid, as shown below. This arrangement would allow the BIS to charge and discharge as needed to provide grid services and / or serve site loads.

Figure 5 Battery Inverter System (BIS) in Normal Operating Mode

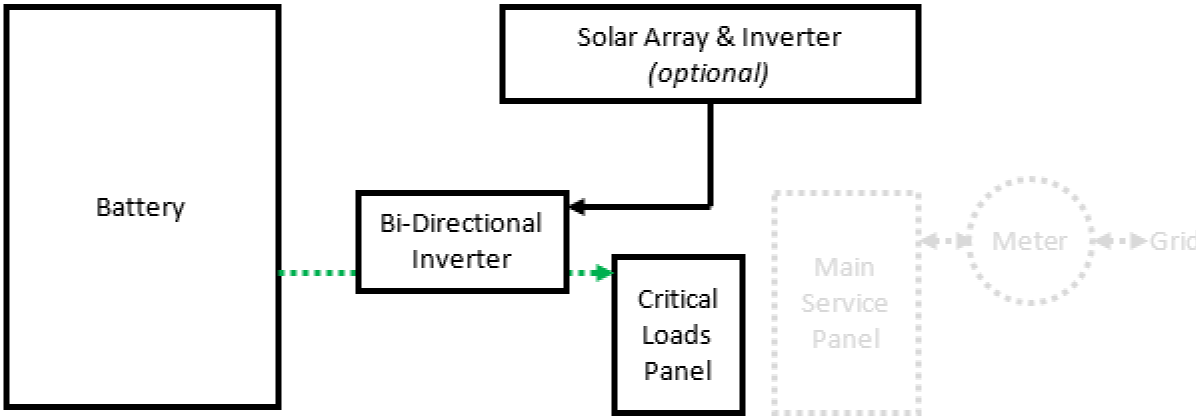


Smart grid services could include, but are not limited to:

- **System Capacity Services (Capacity)***:* The BIS discharges in response to a system-wide peak demand period. The unit may be charged from on-site photovoltaics (PVs) or grid power.
  - *Frequency:* Four to eight times per year, including winter and summer seasons.
  - *Duration:* Approximately three hours.
- **Premises Peak Shaving (Capacity)***:* The BIS discharges during daily household peaks. The unit may be charged from on-site PV or grid power.
  - *Frequency:* Daily, up to 365 days per year.
  - *Duration:* Approximately three hours.
- **Energy Company Economic Dispatch (Energy)***:* The BIS charges during times of low rate periods and discharges during times of high rate. The unit may be charged from on-site PV or grid power.
  - *Frequency:* Daily, up to 365 days per year.
  - *Duration:* No event time limit.
- **Ancillary Services***:* The BIS unit charges and discharges according to commands for frequency regulation, spinning reserve, or load following services.
  - *Frequency:* Sub-minute.
  - *Duration:* No event time limit.

During an outage event, the BIS would island itself from the grid and provide back-up energy to the whole home or a subset of household loads isolated by the critical loads panel, as shown in the figure below. Back-up energy duration would depend on system size, energy storage state of charge, and site loads. No grid services are available to PGE in this mode of operation.

Figure 6 Battery inverter system (BIS) in Outage Mode



PGE proposes to pilot both customer and PGE-owned assets, allowing customers to choose the option that works best for them. Under both options, PGE plans to use the energy storage systems for grid services during normal operations. PGE expects the storage device to energize some loads at the customers' premise during an outage. Details for each ownership model are provided below:

- **PGE Ownership:** The customer pays PGE for the service of added reliability — PGE anticipate the customer cost under this model to be about $50 per month. PGE is responsible for BIS installation, commissioning, operation, maintenance, and end-of-life.[82] PGE controls the asset during normal operation to provide grid services. During outage events, the BIS provides energy reliability services to the customer. If the customer wishes to leave the pilot program before the program end date, the customer may purchase the energy storage system from PGE or pay an early termination fee.

Customers may be presented with three end-of-life options at the end of asset's life:

1. Purchase the energy storage system from PGE for a nominal fee and stay in the program until device failure;
2. Purchase the energy storage system from PGE for a nominal fee and opt out of the program; or
3. Have the energy storage system removed at no cost.

- **Customer Ownership:** The customer independently finances, utilizes on-bill financing, or purchases a PGE-approved BIS directly from a third party. The customer is responsible for arranging BIS installation, commissioning, operation, maintenance, and end-of-life with the vendor as applicable. PGE provides the customer with a monthly on-bill credit of approximately $55 for grid services and the customer agrees to provide PGE direct control of the asset during normal operation. During outage events, the BIS provides energy reliability services to the customer. The customer may leave the pilot program at any time. With an estimated monthly financed cost of about $90, the net cost to the customer would be approximately $35 per month under a low energy storage cost scenario.

[82] PGE anticipates contracting with OEM for maintenance services as a component of the product warranty.

Monthly net cost increases to over $110 under a high cost scenario, indicating the large variability in market pricing.

B.4.2 Why Integrate with the Testbed?

PGE plans to co-locate residential energy storage systems and residential participants' properties within the Testbed to pilot additional use cases and accelerate program learnings and participation. PGE plans to expand the potential benefits of residential energy storage into new and novel use cases such as coupling energy storage system dispatch to feeder-level EV charging, hot water heating, air conditioning, or heating loads. Current energy storage system use cases are focused on power capacity and energy market dynamics. PGE expects the Testbed to enable additional visibility into customer loads and provide the data necessary to pilot new use cases.

PGE expects that leveraging and coordinating the Residential Energy Pilot with the Testbed's research, outreach, and education efforts will further–and perhaps accelerate–learnings PGE would expect from the broader PGE residential energy storage pilot offer to the PGE service territory.

The Testbed also offers a discrete physical system boundary which–when properly established and fertilized with various DSM assets–is expected to reach a level of DSM concentration that could become visible / impactful to the local distribution system. The opportunity to see how residential energy storage in concert with other DSM measures might affect PGE's Distribution and Power Operations, which is expected to be an important benefit of having residential energy storage operate within the Testbed; use cases would not only be identified but operationalized for grid and local distribution operations. PGE expects this to provide important learnings about the integration of various DSM measures and perhaps even insight into DER placement, operations, management, costs, benefits, interconnection, and communication requirements.

B.4.3 Customer Interest in Residential Energy Storage

PGE proposes to locate energy storage at residential sites because of customer interest in enhanced energy reliability. PGE commissioned a study of residential customer interest in February 2016 and found that 63% of customers found it to be highly important to never experience an outage. PGE also found that 34% of customers without backup energy have already considered a reliability solution.[83]

Customer interest in residential energy storage has also been demonstrated by demand for non-grid integrated products. Tesla reported that their Tesla Powerwall 1 residential energy storage product received 38,000 pre-orders after introduction.[84] PGE's interconnection team has reported twenty-eight non-grid-integrated storage devices installed in the last twelve months, with more expected to complete by the end of 2018. PGE also expects product offerings to advance and rates to fall in the near term. Bloomberg New Energy Finance projects behind-the-meter residential energy storage costs to decline by 38% between 2017 and 2020[85].

[83] *Tesla announces 38,000 pre-orders for Tesla Powerwall home battery.* The Verge, 2015. https://www.theverge.com/2015/5/6/8561931/tesla-38000-powerwall-preorders-announced.
[84] Bloomberg New Energy Finance Storage Market Insight. https://www.bnef.com/core/insights/13684.
[85] Conversations with Josh Castonguay, Vice President and Chief Innovation Executive at Green Mountain Power.

Green Mountain Power (GMP), a vertically-integrated energy company serving over 270,000 customers in Vermont, has also seen customer demand for behind-the-meter residential energy storage. Their first program, in which Tesla Powerwall 1 energy storage systems were leased to customers for $37.50 per month, quickly reached the 500-unit program cap and began to accumulate a waiting list of interested customers.[86] Building on this successful program, GMP released a second program where customers can lease a Tesla Powerwall 2 for $15 per month with a program cap of 2,000 units[87]. The Powerwall 2 program launched in August 2017.

B.4.4 Roll-out Strategy

PGE proposes to include residential energy storage as both bundled and stand-alone program offerings within the Testbed. PGE plans to provide customers interested in a suite of DR services with the option to include a residential energy storage system. We expect this strategy to reduce costs otherwise incurred by multiple site visits for the installation of other connected devices.

B.4.5 Customer Benefits of Testbed Integration

PGE expects that all customers will benefit from potential lower pilot program administration costs and the addition of new value streams from residential energy storage systems. Including residential energy storage in planned Testbed outreach and education activities is expected to help lower customer acquisition costs and potentially reduce program resource requirements. Piloting new use cases is expected to help maximize the value of energy storage systems for all customers, potentially lowering program participation costs and increasing the efficiency of the grid.

B.5 Transportation Electrification in the Testbed

As a part of Senate Bill (SB) 1547, the 2016 Oregon Legislature adopted a goal to accelerate TE in Oregon. The legislature determined that "widespread transportation electrification requires that electric companies increase access to the use of energy as a transportation fuel."[88]

On February 16, 2018, the OPUC filed Order 18-054 approving several TE pilots to "help increase the use of [energy] as a transportation fuel."[89] The pilots include:

- A planned expansion of PGE's Electric Avenue charging station program to six new EV charging hubs—with each station expected to include four high-powered quick-charging stations and two Level 2 stations. The pilot aims to increase the visibility and accessibility of energy as a transportation fuel.
- A pilot with Tri-Met whereby PGE plans to own, operate, and maintain charging stations for TriMet's first all-electric bus fleet. The pilot is expected to allow TriMet to leverage grant funds to purchase five all-electric buses and electrify an entire bus route.

[86] GMP – Tesla Powerwall Innovative Pilot Program Rider (filled with Vermont Public Service Board on December 3rd, 2015).
[87] *GMP Launches New Comprehensive Energy Home Solution from Tesla to Lower Costs for Customers.* Green Mountain Power, 2017. (http://www.greenmountainpower.com/press/gmp-launches-new-comprehensive-energy-home-solution-tesla-lower-costs-customers/).
[88] Senate Bill 1547, 78th Oregon Legislative Assembly 2016, Section 20.
[89] Order No. 18-504. https://apps.puc.state.or.us/orders/2018ords/18-054.pdf.

- An education and outreach pilot to increase the awareness of EVs and decrease barriers to adoption of the same. PGE's plan is for this pilot to foster adoption of EVs by residential and business customers.

The OPUC ordered PGE to propose two new offerings within a year of the Order:

- A residential charging offering; and
- A business charging offering (workplace and / or fleet)

PGE has also registered as a credit aggregator for the Oregon Department of Environmental Quality's Low Carbon Fuel Program (LCFS). The LCFS is a law established to reduce the average carbon intensity of Oregon's transportation fuels by 10% over a 10-year period. As a credit aggregator, PGE will be responsible for monetizing credits on behalf of our customers and establishing programs that support adoption of EVs in PGE's service area.

The Testbed creates ample opportunity to build upon our planned support for the state's goal of increasing access to and adoption of electricity as a transportation fuel. The Testbed also allows for testing opportunities to efficiently integrate charging load onto the system (e.g. smart charging, time-variant pricing, etc.). In the near term, PGE see the Testbed as an area to test aggressive EV outreach (e.g. ride and drives, business fleet assessments) and to increase effectiveness and utilization of our Electric Avenue sites. Longer term, PGE see Phase Two of the Testbed as a venue to realize high penetration of connected charging infrastructure via our future residential smart charging and business charging pilots, as well as future LCFSs.

B.5.1 Electric Avenue, Outreach, and Technical Assistance

PGE is currently evaluating two potential Electric Avenue sites within the Testbed:

1. Downtown Milwaukie at SE McLoughlin Blvd and SE Jackson Street (on Island substation); and
2. South Hillsboro at SE Cypress St and SE Tualatin Valley Hwy (on Roseway substation).

We anticipate utilizing pilot funds from Order No. 18-054 to build Electric Avenue sites and to run various outreach initiatives (e.g. ride and drive events). PGE's goal is to increase awareness, consideration, and ultimately adoption of EVs starting within concentrated areas. By focusing infrastructure and outreach efforts in the Testbed early on, PGE hopes to increase EV adoption in those targeted areas to the extent that they are anticipated to be prime candidates for future controlled charging programs.

Figure 7 Proposed Electric Avenue in Downtown Milwaukie

Figure 8 Proposed Electric Avenue in South Hillsboro

As EV original equipment manufacturers (OEMs) develop EVs able to accept higher rates of charge than 50-kW, the charging stations at Electric Avenues may be increased accordingly (up to 350 KW per charger). If upgrades are conducted on the charging stations in the Testbed, PGE may explore opportunities to do feeder-level DR to manage non-coincident peaks and to allow higher-powered charging while reducing the need for additional distribution system upgrades.

B.5.2 Future Offerings

B.5.2.1 Residential and Business Smart Charging

Pursuant to Order No. 18-054, PGE anticipate proposing a residential smart charging pilot to the OPUC later in 2018, with a target launch in 2019. PGE plans for the pilot to reward customers with an incentive for installing a connected home charging station and enrolling in a TOU rate schedule. The pilot may include an option for customers to lease a charger from PGE at a discounted rate.

Concurrently, PGE is also developing a business charging pilot to reduce costs for business customers installing chargers at their business (for fleet, workplace, or public) while encouraging efficient integration into the grid. Though PGE are in the early stages of pilot design, it may include some incentives for planful charging that minimize impacts to the system.

The Testbed presents prime locations to encourage high adoption of residential and business smart chargers as PGE expect our charging stations and outreach efforts to increase EV adoption in the area. Within the Testbed PGE could deploy additional marketing resources to increase adoption of the offerings—we would do this to test how much it costs to greatly-increase participation rates. Because the home charging market is still in its infancy, PGE would aim to achieve near 100% adoption of smart charging technology within the Testbed. PGE expects drivers are likely to adopt because the planned offer will reduce their fueling costs without impacting their ability to use their vehicle.

Rollout of the residential pilot would be targeted to new and existing EV drivers. PGE would collaborate with the Oregon Department of Transportation and utilize our own survey data to target marketing directly to EV drivers. When PGE combine outreach efforts with efforts to increase smart charging, PGE should find not only cost saving synergies, but also strategies that are likely to deliver insight and benefits more broadly.

PGE plans to focus the rollout of the business charging pilot on businesses with fleets of light or medium duty vehicles, as well as sites with 50 or more workplace parking spots.

Co-locating DR-enabled smart chargers with customers participating in the Testbed is expected to yield various synergistic benefits. One such is understanding whole home energy usage patterns when more than one DR technology or strategy is being utilized.

Because an EV charger is a substantial load in homes / facilities–and since EV adoption is expected to rise quickly over the next decade–PGE must learn how to effectively monitor, influence, and control EV charging loads on both a system and local level. We expect the Testbed to enable PGE control of dozens to hundreds of charging stations in a concentrated area; which may allow us to demonstrate:

- load curtailment;
- load shifting;
- load balancing (e.g. ensuring aggregate charging load on a feeder does not exceed a certain setpoint);
- charge throttling;
- charge accelerating (e.g. increasing charge rates to absorb excess renewables; and

- transmission system and distribution system ancillary services.

A successful pilot is expected to demonstrate a concept capable of being scaled to hundreds of thousands of EVs across the service area by the 2030s. Effective customer engagement and charger control at scale is expected to create broad benefits for all customers, including the reduction of costs to A) integrate renewables (e.g. reduce energy costs and the need to curtail renewables), B) integrate with the distribution system, as well as controlling capacity costs.

Appendix C Site Maps

Figure 9 Delaware Substation Feed Configuration

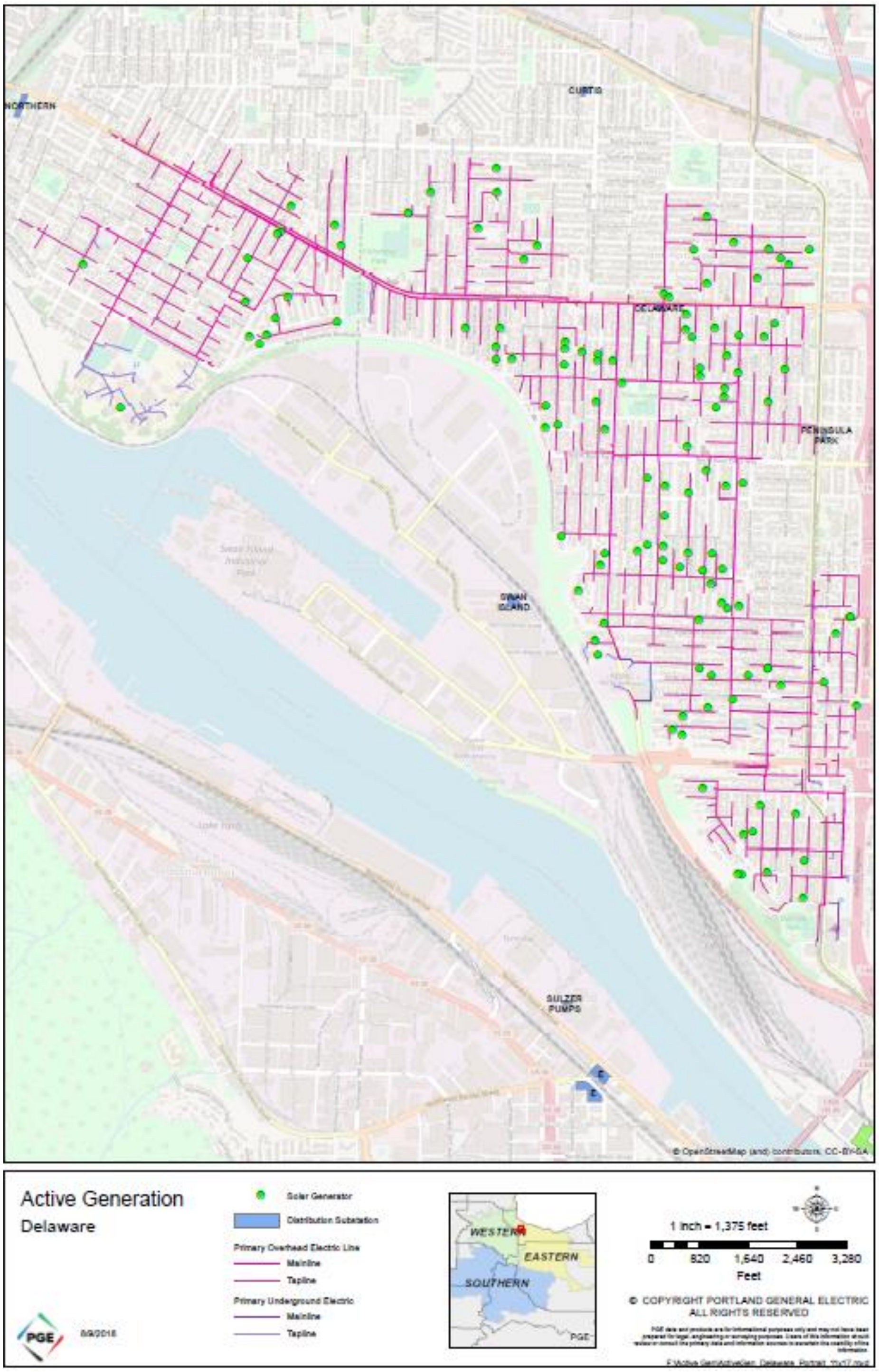


Figure 10 Island Substation Configuration

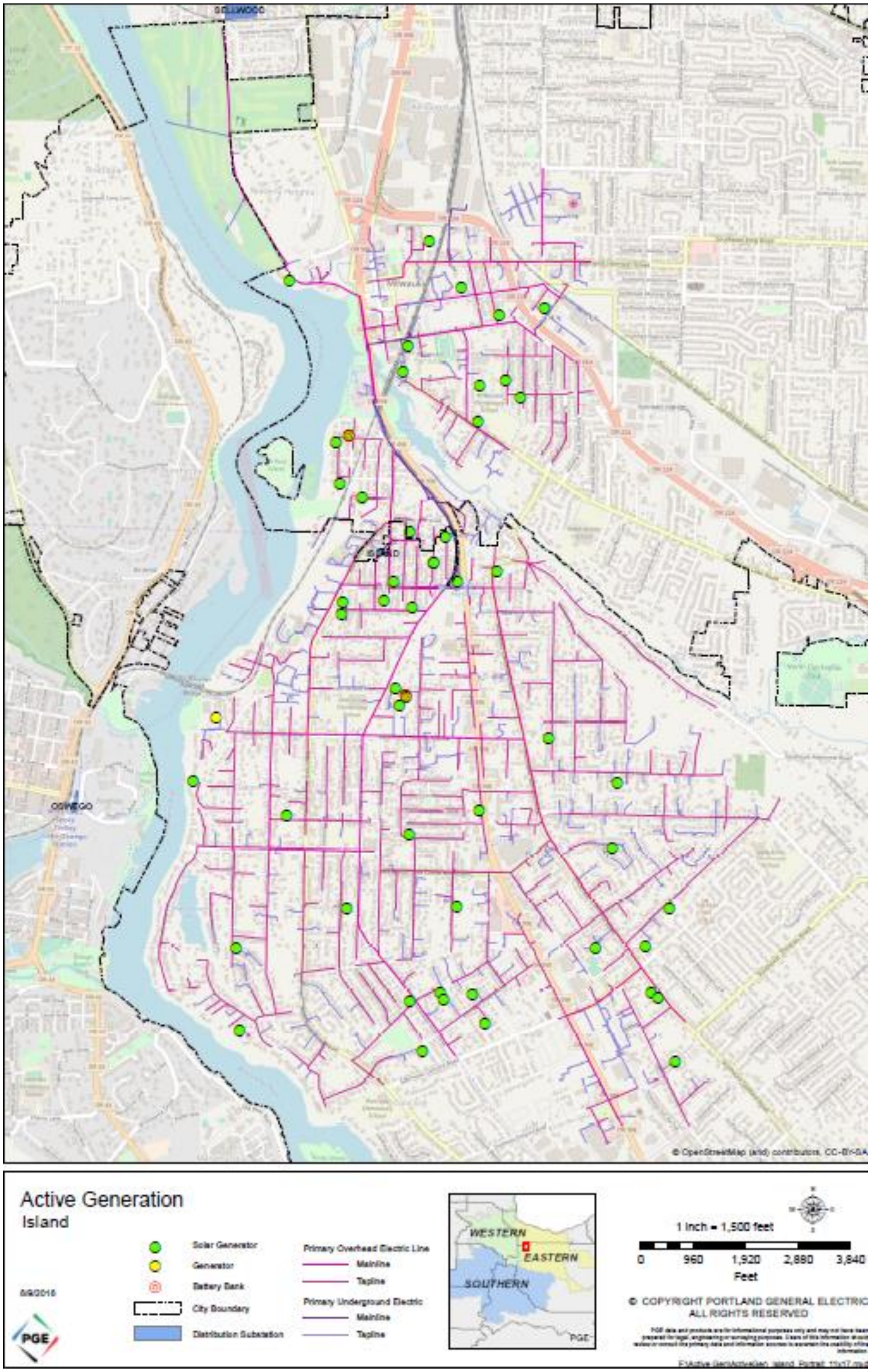
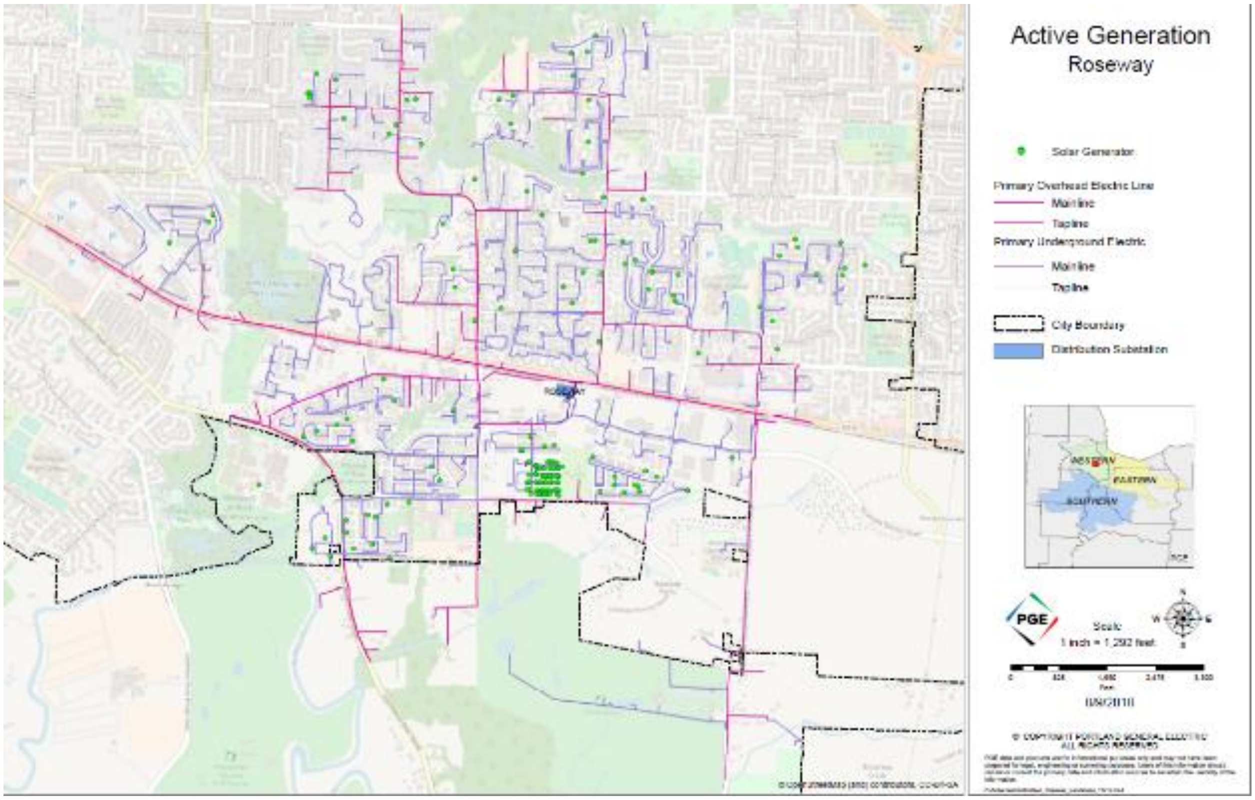


Figure 11 Roseway Substation Configuration



Appendix D Stakeholder (DRRC) Meetings

D.1 Minutes of Stakeholder (DRRC) Meetings

D.1.1 February 2018 DRRC Meeting

On February 23, 2018, PGE presented information on possible Testbed locations to the DRRC, and information on how PGE intended to establish participation, its understanding of "at scale" DR, and two possible phases for the project. The rationale for breaking the project into these phases was that:

- PGE wants to give the DRRC and Commission the opportunity, after an initial two and a half year funding period, to assess successes and consider whether to continue; and
- The Testbed can be more than DR development. Informed by PGE's decarbonization study, a phase two of the project can pursue development of flexible loads, which include DER, e.g., private solar, customer self-generation, and distribution system-sited & customer-sited energy storage.

Although the DRRC found merit in the two-phase approach, given the enormity of the task at hand to establish the Testbed, the DRRC advised and agreed to focus efforts on Phase I.

At the time of the February meeting, PGE had identified several substation sites for purposes of researching and advancing DR. PGE discussed its preference for at least three substations, its rationale for choosing a defined physical grid location for the Testbed and attempted to outline the benefits of such an approach.[90] Additionally, PGE discussed its approach to containing Testbed costs by using a "platform approach." This would establish participation using current cost-effective DR offerings. Once participation was established, PGE could offer new programs or iterations of current offerings. With this approach to voluntary participation, recruitment would drive marketing, education, and outreach efforts. The Testbed's original participation rate goal was 25% (more than four times the current rate of system-wide participation), which meant that marketing, education, and outreach costs were a significant portion of the budget presented to the DRRC at a subsequent meeting.

The 25% goal prompted a discussion at the DRRC of the meaning of "at scale." PGE explained that the original 25% figure was offered because of PGE's most recent DR potential study, which showed that the highest rate of DLC that could be expected from residential participation was 25%. Although PGE is not aware that this adoption rate has been seen in an energy company's service territory, a 25% target participation rate would achieve the goals of the Testbed set by the Commission.

At the end of the meeting, the DRRC agreed that physically siting the Testbed was the best approach to capture both the customer learnings and the potential grid system learnings when having a high concentration of DR. Finally, the DRRC asked PGE to come back to the next DRRC meeting with a proposal for three substations.

D.1.2 April 2018 Meeting

On April 6, 2018, PGE presented on the final three substations, the research undertaken to choose these substations, and a preliminary project budget. Additionally, PGE invited the three proposed Testbed hosting cities

[90] Presentation materials for this meeting can be found in D.2 .

to the DRRC meeting: Milwaukie, Hillsboro, and Portland.[91] This meeting was also the first time that PGE was able to share a draft budget for costs associated with a strategy to acquire 25% participation. An estimate was used for research and evaluation costs and no contingency was accounted for. Marketing costs were based on traditional approaches and strategies. The budget was also built around 25% participation (not 66% participation as proposed in this application). The costs were driven by participation: the more people who participate, the more money is spent on incentives.

The DRRC asked PGE to run an exercise to look at project costs for acquiring 70% and 90% participation. This work, combined with work undertaken at the RMI E-Lab Accelerator event, led PGE to revamp the project recruitment strategy.

D.1.3 Rocky Mountain Institute (RMI) E-Lab Accelerator Activity

In early May 2018, a subset of the DRRC (PGE, PNNL, OPUC, Energy Trust, NEEA, City of Milwaukie, City of Hillsboro) attended the RMI E-Lab Accelerator event. This was a by invitation-only event that RMI hosted for projects they are interested in assisting with development. The agenda proved valuable; City goals were better articulated and understood, and the project concept became better defined.[92] Highlights include an articulation that the customer value proposition is a key to success of the project. The enormity of the project lift was articulated and commitments from NEEA, Energy Trust, and PGE were made to continue work on new program development. RMI realized that an opt-out approach may be necessary to assure participation at the levels necessary to meet the projects goals.

D.1.4 June 2018 Meeting

PGE coordinated a team from across various PGE business lines, including Marketing, Research & Evaluation, T&D, Government Affairs, Finance, and Smart Cities. This was also the first meeting attended by the City of Portland. Additionally, Jon Wellinghoff attended, whose interest in the project was sparked by the PGE Testbed team's participation at the RMI E-Lab Accelerator where he serves as a member of faculty.

PGE presented the new strategy for accelerating participation, which called for using an opt-out PTR offering for all residential customers within the Testbed. It was important to PGE that CUB understand what the PTR was, how it functioned, and for CUB to express any concerns before moving forward. It was also important that all three cities understood that their citizens would be placed on an opt-out pilot. PGE articulated that the opt-out pilot and opportunity to receive rebates would be used, partly for recruitment, and that the further strategy was to migrate customers to DLC options where their response to events would be automated / less intrusive in their day-to-day affairs. Program analytics show PGE can expect about 66% participation in the Testbed by using an opt-out approach and retaining the opportunity to migrate those customers to DLC options.

The meeting also focused on a revised draft budget, which showed a projected cost of approximately $5.0 million over three years and a total potential load impact of between approximately five to six MW. The budget has since increased to more accurately reflect operating costs for each DR offering. These include slightly-higher staffing costs to embed a PGE representative in each site / community; which the City of Milwaukie has validated as key

[91] Presentation materials for this meeting can be found in D.2 .
[92] Ibid.

to the success of the Testbed. The City of Milwaukie clearly advocated for community representatives to build confidence with city personnel, as well as ensuring that the project engages the City's unique demographics, including a mix of high / low income, single family / MFR residences, and multiple spoken languages.

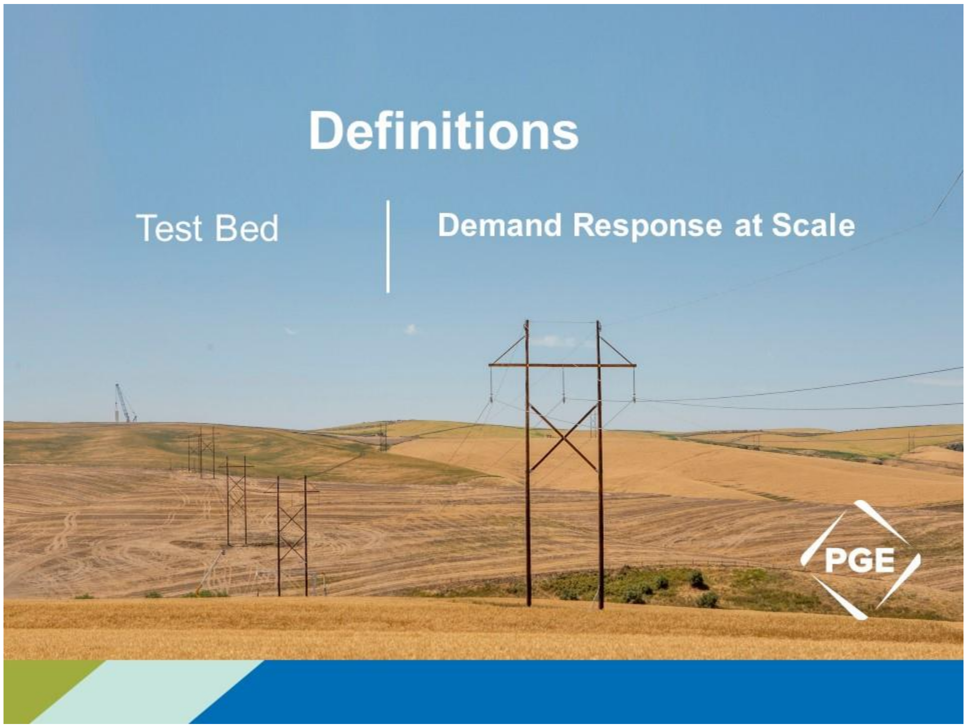
Other topics covered at this meeting included: A) the draft approach to research and evaluation; B) estimated megawatt savings; C) new programs to be developed for inclusion in the Testbed; and D) a draft Hosting Capacity study for each substation.

D.1.5 September 2018 Draft Application review by DRRC

PGE Staff issued a draft of the Testbed proposal to the members of the DRRC on September 14 requesting comments by September 28. Staff received verbal comments from Commission Staff during a face to face meeting on September 27. PGE staff additionally received comments from the staff at the Northwest Power and Conservation Council. Extensive comments were also received from staff at the Energy Trust of Oregon on the 28th and later October 1st. All comments received were posted to via SharePoint and e-mails were sent to DRRC members directing them to the PGE SharePoint site. The proposal went through revisions in order to address comments received from the DRRC. This final version is a result of the comment process.

D.2 Presentation Materials for Stakeholder (DRRC) Meetings

D.2.1 February Demand Response Review Committee Meeting Presentation



Test Bed

A platform for conducting rigorous, transparent, and replicable testing of new technologies. Research into new product development, new product platforms and environments.

At Scale

Concentrated high levels of adoption and participation that inform system and market potential of new technologies, products, platforms and environments.

Smart Neighborhoods

Work conducted in tandem with PGE customers and stakeholders to understand, through discrete investments, the pathway to a smart, clean, and affordable future interactive energy system for Oregon.

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"A problem well stated is a problem half solved."
- Charles Kettering
PGE
4


Interpreting the Commission Directive
PGE
5

Commission Set Goals

Need

Through 2020, acquire at least 77 MW (winter) and 69 MW (summer) of new demand response resources as a floor, while working to reach the demand response high case targets of 162 MW (summer) and 191 MW (winter)

Establish Test Bed

Test a number of hypotheses and critical assumptions about the potential.

Time is of the essence, PGE identified a 2021 resource gap. Action consistent with long term strategy

Accelerate DR Development

Within nine months of (August 8, 2017 present multiple viable demand response test bed sites to DRRC and by July, 2019 establish a test bed.

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Commission identified key information to be gathered from test bed programs

- Achievable potential informed by participation and savings rates; summer/winter peak.
- Program and customer costs under different scenarios; new construction, end-of-life replacements, retrofit and in combination with EE programs.
- Develop experience, program management best practices, cultivating PGE expertise.
- Moving from direct load control to long term strategies which include pricing programs (Stage 2), truly dynamic pricing…(Stage 3) and ultimately mechanisms akin to transactive coordination schemes.
- Develop specific information on PGE's need for human capacity and infrastructure associated with achieving different scales or DR deployment.

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Hypotheses and Critical Planning Assumptions to be Measured

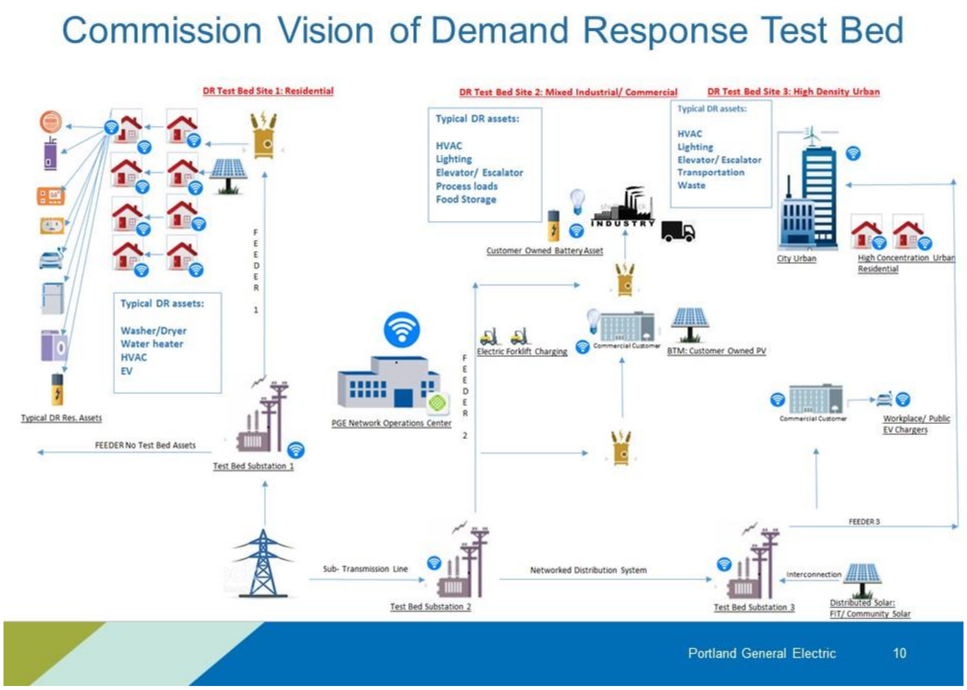
- Can customers be recruited in sufficient numbers to address significant peak and renewables integration?
- Does customer awareness and acceptance of energy efficiency offset unfamiliarity with DR?
- Forecast ultimate penetration and time periods to achieve them?
- Will DLC program customers, accept being dispatched with the frequency and duration needed to achieve substantial reduction in peak?
- Do pricing-based programs mitigate mandatory dispatch issues for consumers?
- Can Portfolios of DR offerings increase recruiting?
- Replacement programs, working with supply chain partners.
- Regional branding program
- Joint EE/DR programs
- Determine the level of customer service staff and program operating staff needed

"…we highlight the importance of these demand-side resources as a means to reduce the need for additional supply-side resources."

- Order 17-386

What was the Commission telling us?

- Invest in Demand Response (DR)
  - Verify DR as a capacity resource, to meet a limited number of capacity constrained hours.
- Possibly use this opportunity to develop and test distributed assets as resources.
  - Test whether there is a resource to serve demand.



Commission Vision of Demand Response Test Bed
DR Test Bed Site 1: Residential
DR Test Bed Site 2: Mixed Industrial/ Commercial
DR Test Bed Site 3: High Density Urban
Typical DR assets:
Washer/Dryer
Water heater
HVAC
EV
Typical DR Res. Assets
FEEDER 1
FEEDER No Test Bed Assets
Test Bed Substation 1
PGE Network Operations Center
Typical DR assets:
HVAC
Lighting
Elevator/ Escalator
Process loads
Food Storage
INDUSTRY
Customer Owned Battery Asset
Electric Forklift Charging
Commercial Customer
BTM: Customer Owned PV
FEEDER 2
Typical DR assets:
HVAC
Lighting
Elevator/ Escalator
Transportation
Waste
City Urban
High Concentration Urban Residential
Commercial Customer
Workplace/ Public EV Chargers
FEEDER 3
Sub- Transmission Line
Test Bed Substation 2
Networked Distribution System
Test Bed Substation 3
Interconnection
Distributed Solar: FIT/ Community Solar
Portland General Electric
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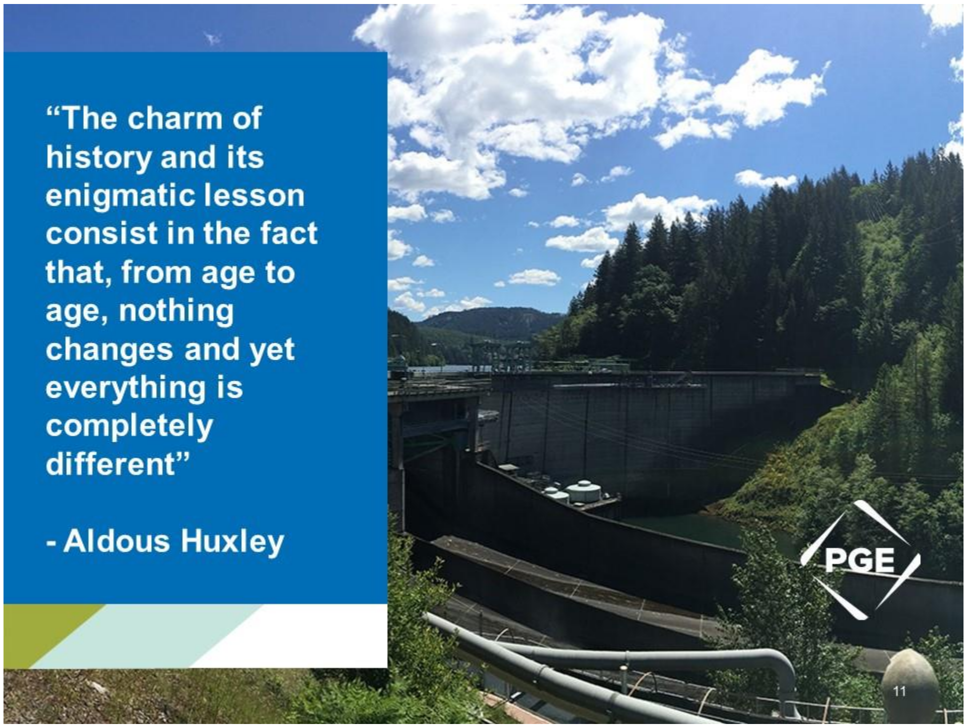

"The charm of history and its enigmatic lesson consist in the fact that, from age to age, nothing changes and yet everything is completely different"
- Aldous Huxley
PGE
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Customer Engagement and Program Development

Test Bed Establishment with Present Programs to Iteration

- The Test Bed will develop ≈2–10MW of Demand Response Capacity separately and additive to current programs while opening the opportunity to test:
  - Participation rates
  - Recruitment activities necessary to develop DR at scale
  - Further develop PGE internal Demand Response resource and program expertise
  - Develop a customer focused partnership and resource
  - Move through the development of demand response program structures from direct load control (Stage 1) to dynamic rate structures (Stage 2) into transactive coordination scheme (Stage 3).
  - Understand customer participation and dispatch tolerances.
  - How to co-package DSM programs, offerings.
  - Create a working relationship with third parties offering tech and those conducting installation

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Hypothesis and Critical Planning Assumption Research

- Localizing the DR Test Bed to substations allows us to develop a virtual power plant with operating characteristics and visualization.
- Identifying substations with a proper mix of customers that present various barriers to adoption allows us to understand how to recruit in sufficient numbers across the service territory, customer group and profile.
- The Brattle Group Study shows that the highest participation rate expected from DLC programs is 25%.
- We are looking to establish the Test Beds with present programs to focus as much on the customer relationship/partnership as we are resource acquisition.
  - Using the present DR program allows us to capitalize on the success of these programs while gaining insight into how to iterate to programs that are more customer friendly while supplying new DR capability, new DR services
    - Present Water heater program will allow us to study dynamic demand response and customer acceptance.
- We will be working with supply chain and with ETO to offer programs, installation, technology and incentives.
- We will have the opportunity to test DLC with TOU/PTR rate adoption.

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Identifying Potential/ Learning Through Customer Partnership

Three sites give us:

- Multiple opportunities to learn how to acquire at scale cost effectively.
- Deploy various strategies to interface with the customer as a partner and provider of service; "pro-sumer" development.
- Study procurement strategies and resource potential assessments.
- Customer variability, building variability; better accuracy for potential assessment.

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Platform Delivery Approach

For many products today, creating the architecture and design and all the modules from the ground up is no longer feasible, especially from the point of view of product quality, ease of implementation, and short product development schedules. Therefore, the trend is to create new product versions by intentionally reusing the architecture and design from an established platform.

PGE

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Applying the Platform Approach at PGE

PGE and its customers currently own and operate the electric delivery platform, data development and interface with system infrastructure.

PGE and our customers can explore how investment in the system can leverage the existing delivery platform to lower the cost of entry for customers to invest in a cleaner and more intelligent systems to meet future needs

The lessons learned in exploring this platform within the Test Bed, where financial and system risks can be contained, will hasten advancement and failure cycles, while identifying benefits and pathways to sustainable system structures, business models, market relationships and successful customer engagements.

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Business & Government Demand Response

Vision

Develop a demand response program designed for **PGE customers** that meets **their needs** and solves their **unique problems**.

Goals

- ✓ 27 MW curtailable load Jan 2021
- ✓ Program meets range of needs
- ✓ Transition legacy participants
- ✓ Contribute to customer sustainability goals

20 Event Hours Maximum per Season
Monthly Payment per kW

	Notification Period		
	18 hours	**4 hours**	**10 minutes**
Summer (June - September)			
11 am -4 pm	$1.68	$1.80	$1.91
4 pm - 8 pm	$1.95	$2.08	$2.22
8 pm - 10 pm	$0.39	$0.42	$0.45
All summer windows	$4.02	$4.30	$4.57
Winter (November - February)			
7 am - 11 am	$1.27	$1.35	$1.44
11 am -4 pm	$0.73	$0.78	$0.83
4 pm - 8 pm	$2.07	$2.22	$2.36
8 pm - 10 pm	$0.73	$0.78	$0.83
All winter windows	$4.80	$5.13	$5.46

80 Event Hours Maximum per Season
Monthly Payment per kW

	Notification Period		
	18 hours	**4 hours**	**10 minutes**
Summer (June - September)			
11 am -4 pm	$3.35	$3.58	$3.81
4 pm - 8 pm	$3.89	$4.16	$4.42
8 pm - 10 pm	$0.79	$0.84	$0.89
All summer windows	$8.03	$8.58	$9.12
Winter (November - February)			
7 am - 11 am	$2.53	$2.70	$2.87
11 am -4 pm	$1.46	$1.56	$1.65
4 pm - 8 pm	$4.14	$4.42	$4.70
8 pm - 10 pm	$1.46	$1.56	$1.65
All winter windows	$9.58	$10.23	$10.89

40 Event Hours per Season
Monthly Payment per kW

	Notification Period		
Windows	**18 hours**	**4 hours**	**10 minutes**
Summer (June - September)			
11 am -4 pm	$2.52	$2.69	$2.87
4 pm - 8 pm	$2.92	$3.12	$3.32
8 pm - 10 pm	$0.59	$0.63	$0.67
All summer windows	$6.04	$6.45	$6.86
Winter (November - February)			
7 am - 11 am	$1.90	$2.03	$2.16
11 am -4 pm	$1.09	$1.17	$1.24
4 pm - 8 pm	$3.11	$3.32	$3.54
8 pm - 10 pm	$1.09	$1.17	$1.24
All winter windows	$7.20	$7.70	$8.19

ENERGY PAYMENTS Mid-Columbia Electricity Index (Mid-C)

Nov 2017	Dec 2017	Jan 2018	Feb 2018	Jun 2018	Jul 2018	Aug 2018	Sep 2018
$29.95	$36.30	$29.88	$27.99	$18.17	$26.02	$29.24	$27.01

Multi-Family Water Heater Pilot

Pilot-to-Program Success Criteria

- Adoption by 10% of the top 50 largest MFR companies in PGE service territory
- Communications up-time of 80%+ during pilot.
- Control equipment defects of less than 5% annually
- Verification of capacity at 0.5kW/water heater or better
- Cost effectiveness reached when Phase 3 is completed or earlier
- Stable customer satisfaction ratings with residential customers in participating MFR
- Increased customer satisfaction among MFR management companies (business customers)
- 4.0MW capacity with 8,000 electric water heaters.

Program Objectives

- ✓ Build 5 MW demand response capacity
- ✓ Create a flexible, reliable resource
- ✓ Produce a positive customer experience
- ✓ Improve cost effectiveness

Bring Your Own Thermostat Pilot

Program Approach

- Recruit and connect existing WiFi-enabled thermostat to a DRMS platform.
- Keep costs low by leveraging existing thermostats
- Customers receive $25 for signing up and $25 per season in which they participate.
- Recruitment is driven by thermostat manufacturers and PGE.

Program Objectives

- ✓ Build 8 MW demand response capacity by 2021
- ✓ Create a flexible, reliable resource
- ✓ Produce a positive customer experience

Status

- ✓ 7,500 total connected t-stats as of 2/2018.
- ✓ 1KW per thermostat DR-capacity in the summer
- ✓ 0.9KW per thermostat DR-capacity in the winter

Pricing Pilot

Pilot Approach

- Test 12 different residential pricing programs:
  - 3x Opt-in TOU-rates
  - 3x Opt-in TOU+PTR rates
  - 1x Opt-in TOU+BDR rate
  - 3x PTR-rates
  - 1x BDR-rate
- 14,000 participating residential households.
- Pilot period: Summer 2016 through Winter 2017/2018

Program Objectives

✓ 0.2-0.4KW per customer peak shaving

✓ 38MW DR-capacity (post pilot) by 2021

✓ Potential to recruit at least 10%+ of PGE customers

✓ Optimize marketing

✓ 90% customer satisfaction

✓ Identify peak savings for BDR

✓ Identify peak savings for PTR

Direct T-Stat Installation Pilot

Pilot Approach

- Accelerate adoption of WiFi-enabled thermostats by offering free thermostat + installation to customers with qualifying HVAC.
- Focus: heat pump customers due to dual season DR-capacity
- Collaboration with Energy Trust to generate EE-savings and apply incentives towards product and installation costs.
- Create seamless integration between marketing, scheduling, installation, enablement, and administrative processing.

Pilot Objectives

✓ Drive 5,000 t-stat installation between 6/2018-4/2019.

✓ Build installer network and infrastructure.

✓ Build dual season DR-capacity

✓ Develop positive customer experience.

✓ Capture harder to reach customer groups (less tech savvy)


Project Phases
PGE
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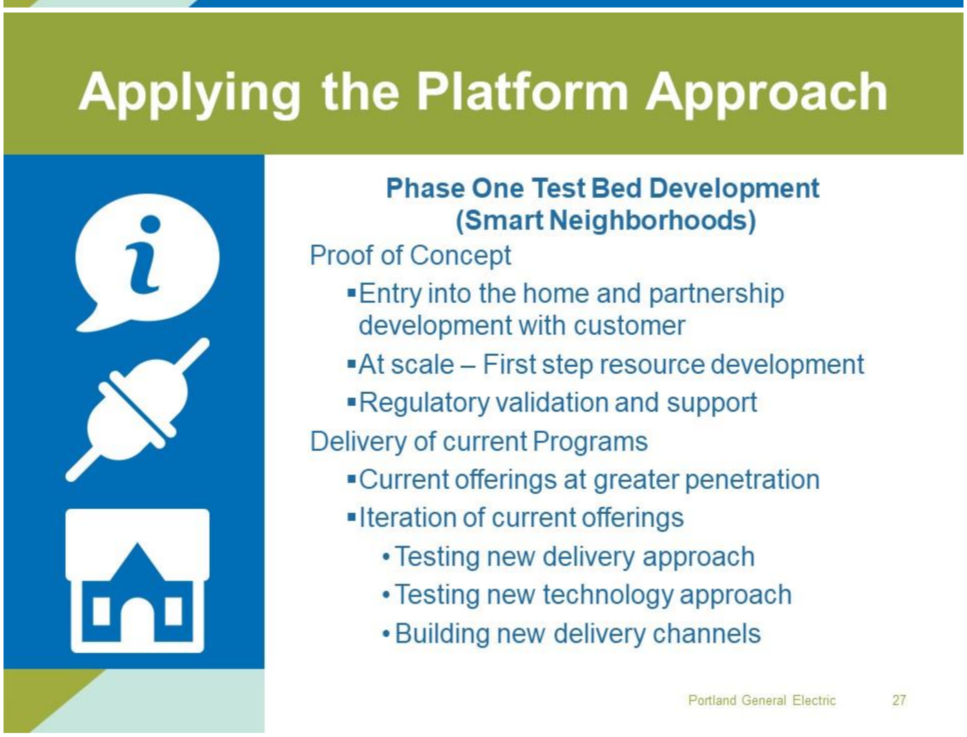
Applying the Platform Approach
Phase One Test Bed Development
(Smart Neighborhoods)
Proof of Concept
▪Entry into the home and partnership development with customer
▪At scale – First step resource development
▪Regulatory validation and support
Delivery of current Programs
▪Current offerings at greater penetration
▪Iteration of current offerings
• Testing new delivery approach
• Testing new technology approach
• Building new delivery channels
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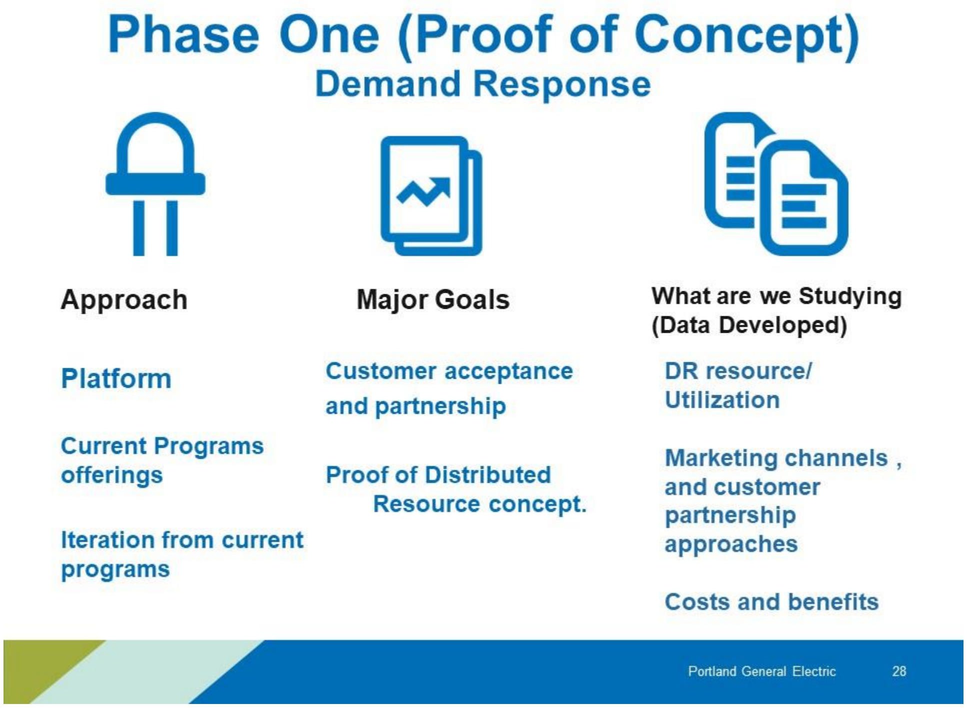
Phase One (Proof of Concept)
Demand Response
Approach
Platform
Current Programs offerings
Iteration from current programs
Major Goals
Customer acceptance and partnership
Proof of Distributed Resource concept.
What are we Studying (Data Developed)
DR resource/ Utilization
Marketing channels , and customer partnership approaches
Costs and benefits
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Phase Two
PGE
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Expanding the Platform and Opportunity

Phase Two Concept

Furthering the scale and depth of the partnership

- Exploring Demand Side Resource service and products
- Third parties are partners and funders
- Understanding the long term implications of the platform approach with third parties

Understanding the Smart Grid future

- DER participation beyond DR
- Demand Side Resource Development (Planning Implications, Test Case Learnings)
- Full Avoided cost study information
- Testing the viability of Distributed Resource Development (Programmatic, Product, Service, Outreach Development)
- Meeting City(s) vision for a smart clean energy future

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Applying the Platform Approach

Phase Two Smart Neighborhoods

Building from Phase One

- Customers now have an established highly engaged relationship/partnership
- Smart Grid vision now supported
  - (EE, DR, EVs, Storage, Micro-grid)

Customer Benefits

- Clean grid supply
- Engaged and enabled customers
- New delivery approaches for EE, DR, DER

PGE Benefits

- Meeting carbon reduction goals
- Resources to lower costs to all customers (net benefits).
- Meeting customer expectations of a smart, clean electric future.

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Funding by stage gates

1. **Concept and team contract development (This summer)**
2. **Implementation budget 2yrs plus evaluation (This summer)**
3. **Year 3-5 budget request after success evaluation (2020)**

2018 Milestone Dates

Milestone Dates	Activity
2/23/2018	DRRC Kick-off Meeting
3/23/2018	DRRC Review of Proposed Progress Report
4/24/2018	Regular Public Meeting – Progress Report to Commission
5/18/2018	Propose Final Site Selection to DRRC
6/15/2018	File Funding Proposal Phase 1
6/19/2018	Regular Public Meeting – Commission Update
7/31/28	Target for Approval Order
8/16/2018	Public Announcement of Site Selection
9/21/2018	Field Activity Begins

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DRRC High-level Vision

- As subject matter experts each of us is here to help develop the project, envision and guide the project to a successful implementation and future state.
- We are seeking opportunities to extract value for the customer, the utility and the system.
- We are here to learn how to develop the DR/DER vision, our roles in the development and deployment of DR/DER.
- We want everyone here to be a part of the developing and deploying DR/DER and to help each of us find our place in the Test Bed.
- We believe the Test Bed gives all of us the opportunity to understand the potential of DR and possibly the DER future state.

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Role of the DRRC

- The DRRC is an advisory group comprised of the regions subject matter experts who assist with the development of the DR Test Bed and the programs operating within the Test Bed.
- The DRRC will assist PGE staff with Test Bed development decisions, program development decisions, budget development, communication of the project, identifying costs and benefits for customers, PGE, the region and the Commission.
- The DRRC offers guidance with the power to influence the structure of demand response offerings and activities undertaken by PGE.
- The DRRC will be influential regarding the strategic direction of demand response resource development.
- The DRRC has the opportunity to be influential with program proposals before the Commission.

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Site assessment

Data from two groups (Customer Accounts and Transmission and Distribution) have contributed overlapping data sets. Customer Accounts provided customer persona profile data by sector and Res. Sub-sector. This data was overlaid with studies from Transmission and Distribution to identify promising substations for the development of a highly active demand response resource.

Criteria for substation project inclusion:

- High Growth
- Relieve Transmission congestion on the South of Allston Transmission path (summer concern)
- Relieve Distribution capacity limitations under contingency
- Opportunity to research end of life, equipment deferral value proposition
- Enable/Improve micro-grid capabilities and system resiliency.

Customer information that influenced sub-station site inclusion:

- Several residential subgroups including low income and mobile homes.
- Cities willingness and eagerness to partner on such projects
- City of Milwaukee, Hillsboro and Portland interest in smart building development and customer offerings
- New building growth
- Substation load growth
- Broad mix of customer types and customer personas

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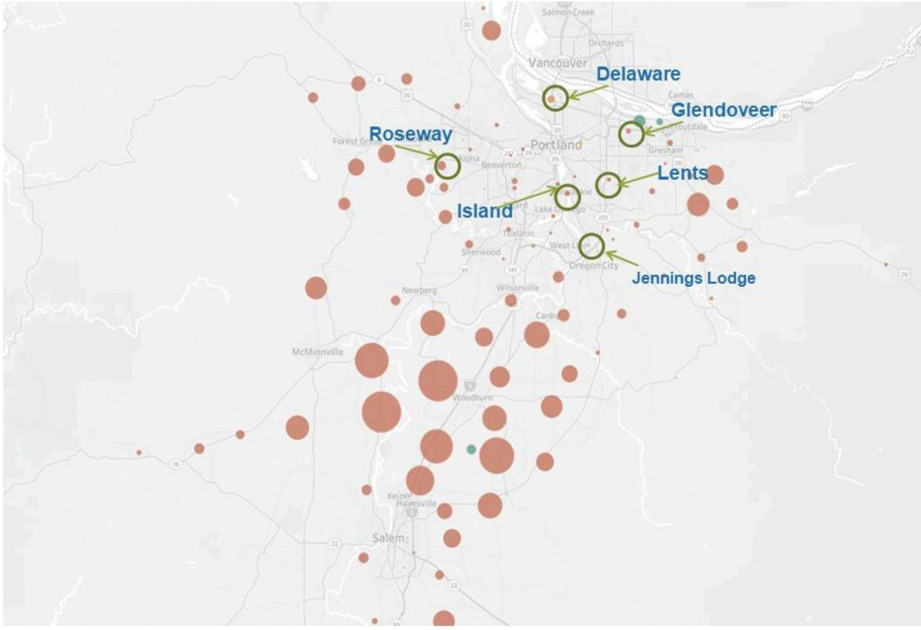

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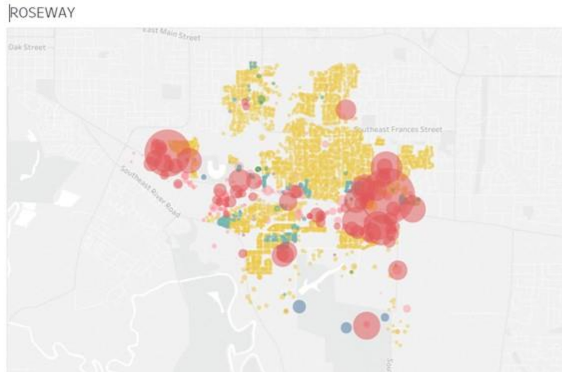
PGE has Identified Five Substations as potential sites for inclusion in the Demand Response Test Bed

Roseway Substation

ROSEWAY



Customertype
- Agricultural
- DirectAccess
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

Servcity: BEAVERTON 33; HILLSBORO 4,892

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	6	37,201	70,622	14,456	489%	0	0	0
DirectAccess	1	11,553	12,921	11,975	108%	0	0	0
SmallCI	459	633,897	638,651	709,950	90%	0	0	0
LargeCI	69	2,302,886	2,505,865	2,354,780	106%	0	0	0
Residential..	752	563,957	510,400	797,945	64%	0	752	0
Residential..	69	83,976	54,516	137,380	40%	69	0	0
Residential..	3,537	2,751,751	3,095,347	3,115,992	99%	0	0	3,537
Residential..	32	21,864	24,017	26,307	91%	0	0	0

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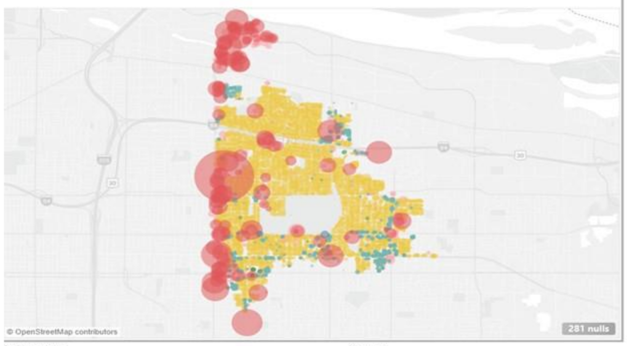
Glendoveer Substation

GLENDOVEER



Customertype
- Agricultural
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

Servcity: PORTLAND 10,010

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	5	12,271	31,678	462	6852%	0	0	0
SmallCI	692	1,119,225	1,123,552	1,266,059	89%	0	0	0
LargeCI	118	2,921,192	3,002,457	3,200,176	94%	0	0	0
Residential..	3,151	2,136,823	1,660,297	3,338,666	50%	0	3,151	0
Residential..	110	101,672	62,576	176,930	35%	110	0	0
Residential..	5,859	5,233,080	5,133,714	6,636,768	77%	0	0	5,859
Residential..	75	57,925	55,163	77,033	72%	0	0	0

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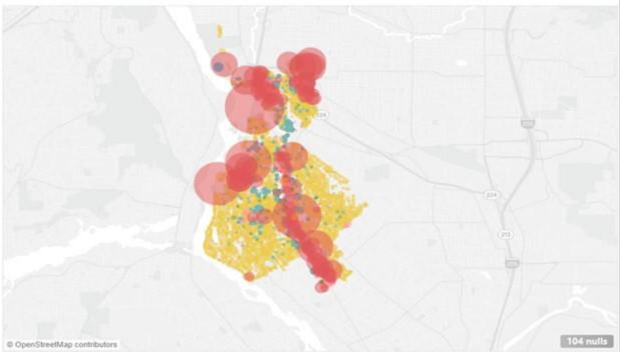
Island Substation



Customertype
- Agricultural
- DirectAccess
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

Servcity

HAPPY VALLEY	MILWAUKIE	PORTLAND	TUALATIN
1	8,992	129	1

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	1	13,475	21,000	6,137	342%	0	0	0
DirectAccess	2	10,981	10,086	12,228	82%	0	0	0
SmallCI	1,091	1,693,317	1,653,413	1,821,056	91%	0	0	0
LargeCI	114	4,797,835	4,744,480	4,907,735	97%	0	0	0
Residential..	2,995	1,986,489	1,579,834	2,870,252	55%	0	2,995	0
Residential..	306	263,525	188,988	380,242	50%	306	0	0
Residential..	4,548	4,305,165	3,913,566	5,178,810	76%	0	0	4,548
Residential..	66	58,185	56,012	66,725	84%	0	0	0

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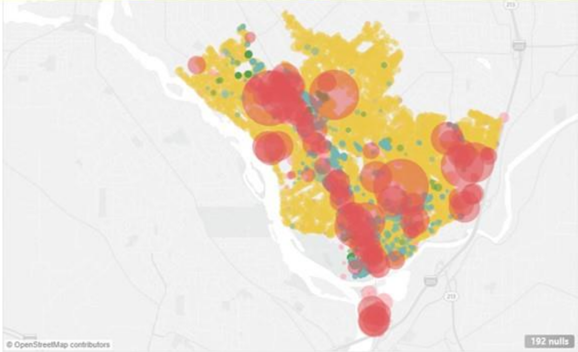
Jennings Lodge Substation



Customertype
- Agricultural
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

Servcity

GLADSTONE	MILWAUKIE	OREGON CITY	PORTLAND
4,480	5,148	29	75

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	1	1,375	2,207	343	644%	0	0	0
SmallCI	718	1,126,343	1,094,179	1,252,080	87%	0	0	0
LargeCI	103	2,234,112	2,176,035	2,368,926	92%	0	0	0
Residential..	2,318	1,645,761	1,361,759	2,338,279	58%	0	2,318	0
Residential..	580	562,496	398,890	845,620	47%	580	0	0
Residential..	5,933	5,603,167	5,364,459	6,564,135	82%	0	0	5,933
Residential..	79	69,913	66,076	83,901	79%	0	0	0

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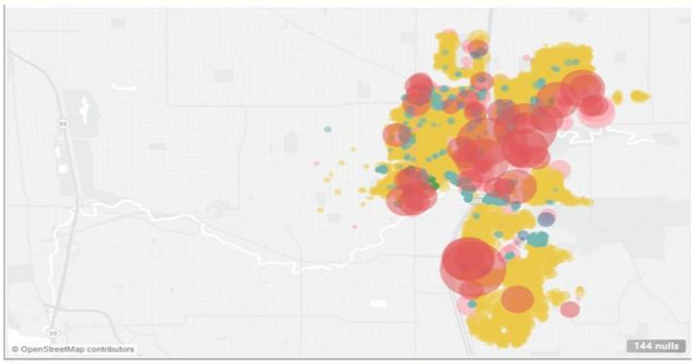
Lents



Customertype
- Agricultural
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

Servcity

CLACKAMAS	HAPPY VALLEY	PORTLAND
31	708	6,957

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	3	9,522	11,286	98	11516%	0	0	0
SmallCI	571	1,037,801	962,269	1,175,301	82%	0	0	0
LargeCI	53	1,125,806	1,187,999	1,085,307	109%	0	0	0
Residential..	2,023	1,309,018	1,139,348	1,816,562	63%	0	2,023	0
Residential..	211	167,884	112,029	261,871	43%	211	0	0
Residential..	4,731	4,437,920	3,978,407	5,707,428	70%	0	0	4,731
Residential..	104	79,508	76,555	97,211	79%	0	0	0

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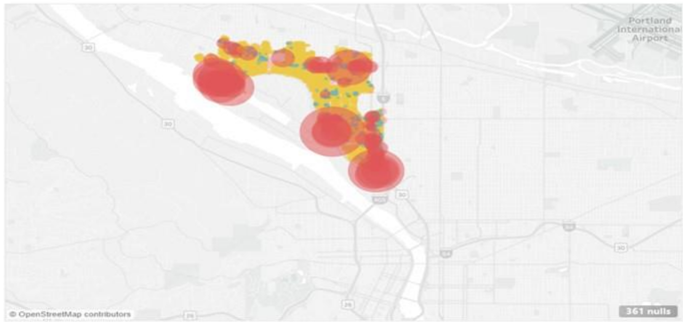
Delaware

DELAWARE



Customertype
- DirectAccess
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

Servcity: PORTLAND 8,458

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
DirectAccess	1	5,457	6,237	4,987	125%	0	0	0
SmallCI	575	1,009,602	999,866	1,118,949	89%	0	0	0
LargeCI	88	3,038,701	3,243,108	3,087,493	105%	0	0	0
Residential..	1,477	642,022	513,739	942,426	55%	0	1,477	0
Residential..	5	4,976	3,185	7,977	40%	5	0	0
Residential..	6,221	4,613,784	4,176,157	5,836,632	72%	0	0	6,221
Residential..	91	55,823	50,534	69,946	72%	0	0	0

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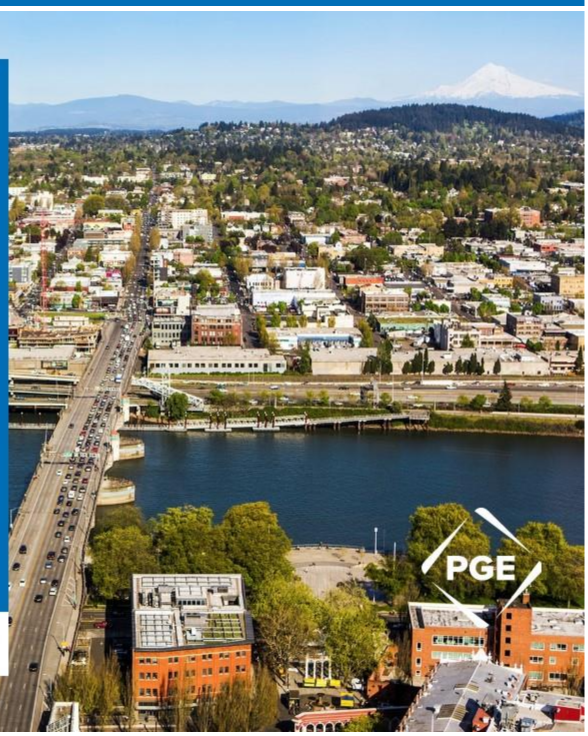
Customer information for each substation



PGE believes the customer is the most important part of the Demand Response Test Bed

The Customer is the Central Focus of the Test Bed

- Though the Test Bed was conceived as a resource replacement opportunity demand response is a customer controlled resource.
- PGE believes that customer engagement is the key to success of any demand response program. Building Demand Response "at scale" will require intense customer engagement.
- Thus site selection for Test Bed development was significantly informed by the mix of customers that take service from each substation.
  - PGE is looking to engage with a variety of customers who demonstrate various challenges to demand response development in order to learn how to succeed throughout the service territory not with a chosen type of preferable customers.

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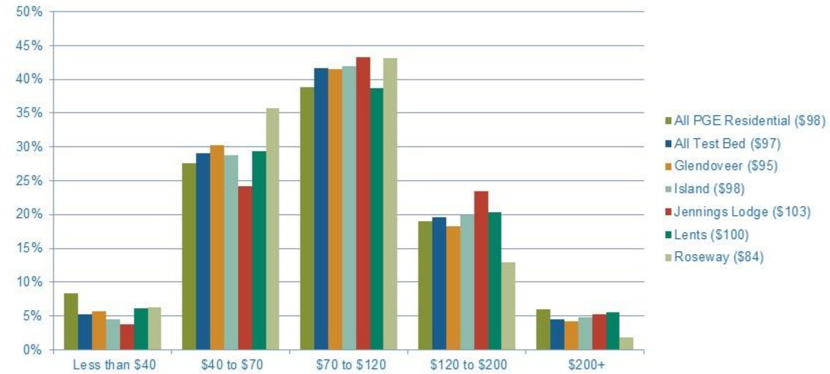
Overall KWh Potential

	ANNUAL KWH	PERCENT OF TEST BEDS IN RES AND BIZ	PERCENT OF ALL TEST BEDS
Residential			
GLENDOVEER	91929477	24%	15%
ISLAND	79905603	21%	13%
JENNINGS LODGE	95035837	25%	15%
LENTS	72705407	19%	12%
ROSEWAY	41113483	11%	7%
ALL RESIDENTIAL TEST BEDS	380689807	100%	61%
Business			
GLENDOVEER	48415109	20%	8%
ISLAND	77278840	31%	12%
JENNINGS LODGE	40173693	16%	6%
LENTS	25262516	10%	4%
ROSEWAY	55905814	23%	9%
ALL BUSINESS	247035972	100%	39%
Total			
GLENDOVEER	140344586		22%
ISLAND	157184443		25%
JENNINGS LODGE	135209530		22%
LENTS	97967923		16%
ROSEWAY	97019297		15%
GRAND TOTAL	627725779		100%

Insights:
- The kWh usage is about 60% residential/40% business
- Roseway is the smallest—it has about half the residential kWh as the other Beds, but has the highest kWh/business meter (next slide). Roseway also has the most distinctive residential profile. Roseway will see the most rapid new building development.
- Island is the biggest overall, with a third of the business kWh
- Glendoveer and Jennings Lodge are very similar, with Glendoveer having slightly more business kWh

Portland General Electric 49

Average Monthly Bill



Insights:

- Average monthly bill amounts are listed in the key to the graph for each group
- Roseway has the lowest average bill, due in part to fewer homes with electric heat
- Jennings Lodge and Lents have higher than All PGE Residential average bills

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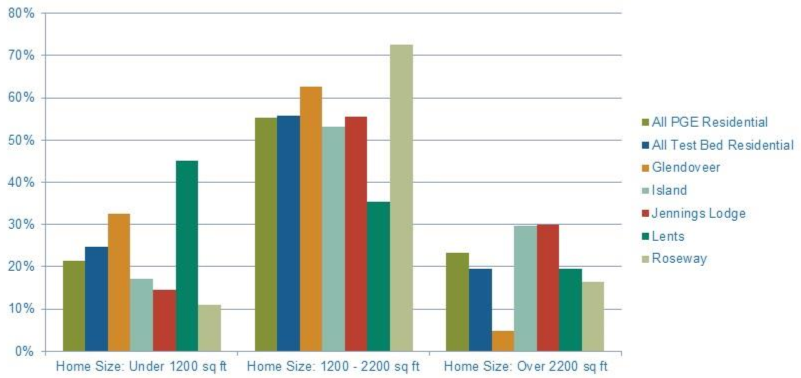
Home Size



Insights:

- Glendoveer has very few large homes
- Island and Jennings Lodge have similar distributions, with the most large homes (each has 30% over 2200 sq feet)
- Lents has a very high percentage of small homes (this is largely due to the size of single-family homes--and they do not have a high multi-family percentage)
- Roseway has a very high percentage of mid-sized homes, and relatively few small and large homes

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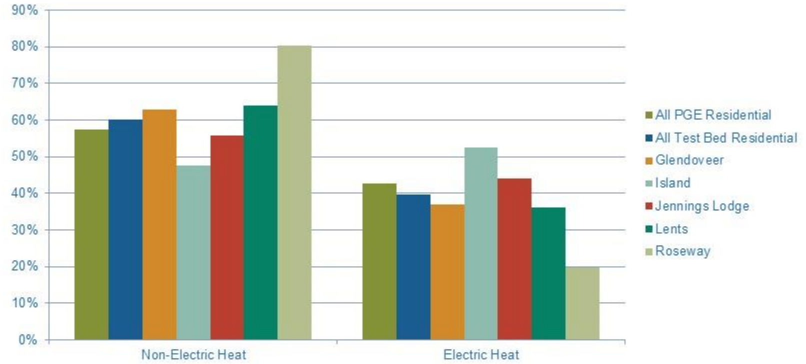
Electric or Non-Electric Heat



Insights:

- Roseway has the highest percentage (80%) of non-electric heat; Glendoveer and Lents have higher-than-average non-electric heat
- Island has the highest percentage of electric heat—over 50%
- Jennings Lodge is close to the All PGE Residential percent electric, at 44%

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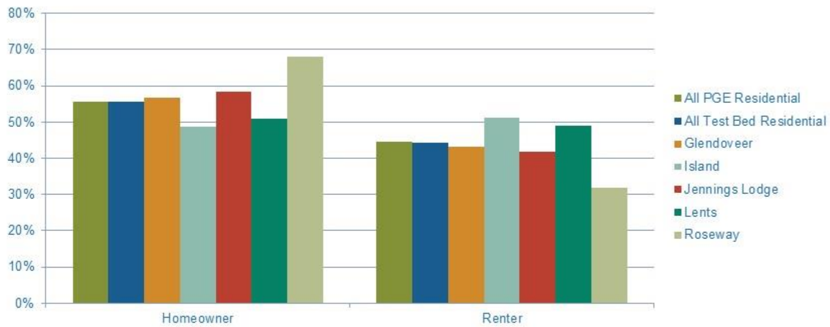
Owner or Renter



Insights:

- Roseway has a relatively high Homeowner percentage (68%)
- Island and Lents have more Renters than average (about 50%)

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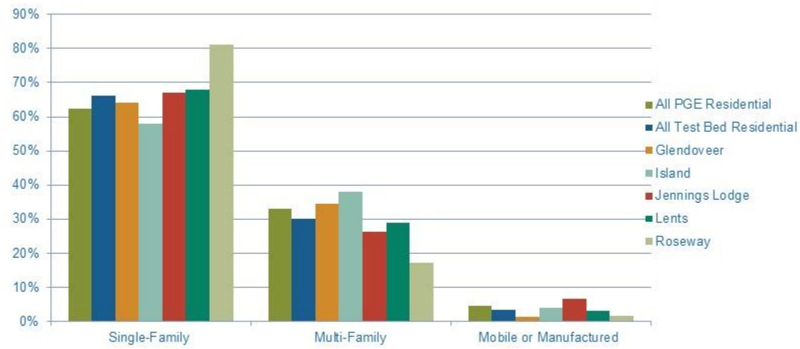
Home Type



Insights:
- All Test Beds have a higher percentage of Single-Family homes than All PGE Residential, except Island
- Roseway has the highest percent Single-Family (81%)
- Jennings Lodge has the highest percent of Mobile/Manufactured homes (7%--590 homes)

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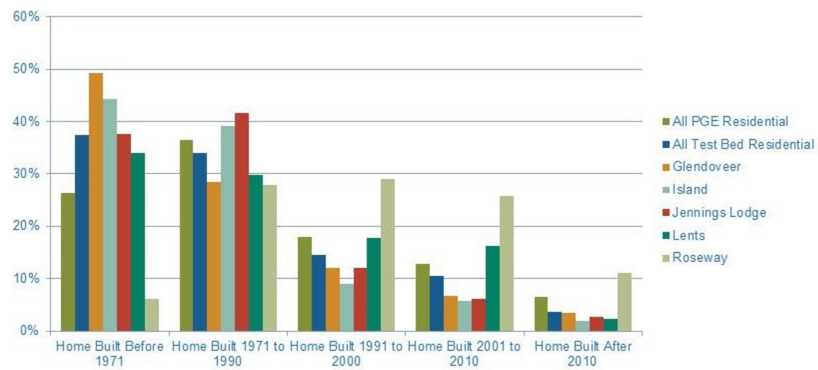
Year Home Built



Insights:
- Roseway has (by far) the newest homes, with only 6% built before 1971
- Glendoveer has the oldest homes, with nearly 50% built before 1971
- Island and Jennings Lodge both have older homes, with about 80% built before 1990
- Lents leans towards older homes. About a third of the Lents homes were build between 1991 and 2010, but there has been little growth since then

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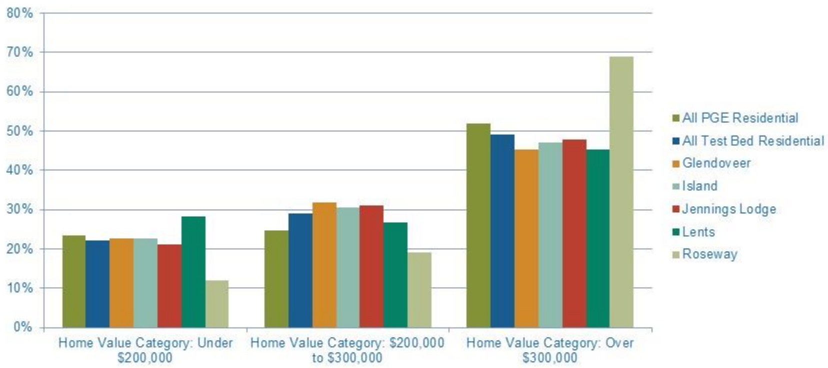
Home Value



Insights:

- Lents has the lowest home values
- Roseway has the highest home values, with 70% over $300,000
- The other Test Beds have home values that are a little lower than All PGE Residential

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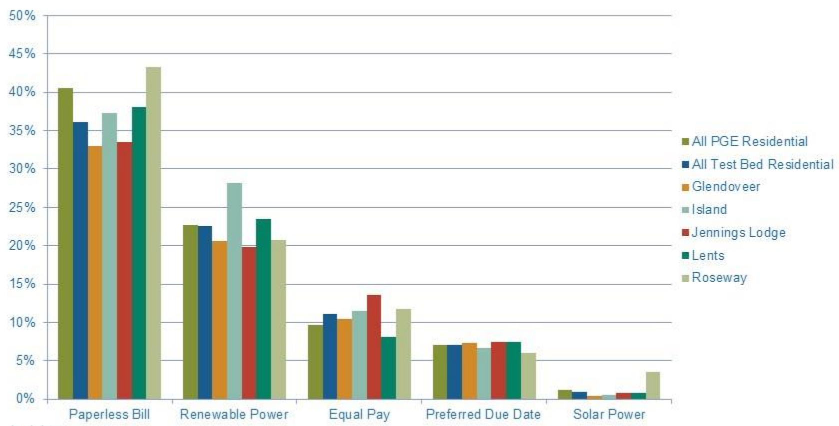
Engagement in PGE programs



Insights:

- Except for Roseway, Test Bed customers are less likely than All PGE Residential to be on Paperless billing
- Except for Island and Lents, Test Bed customers are less likely than All PGE Residential to buy Renewable Power
- Jennings Lodge is most likely to use Equal Pay, to even-out their monthly PGE payments
- Roseway customers are 4 times more likely than All PGE Residential to have Solar Power on their home. 156 homes in Roseway have Solar Power.

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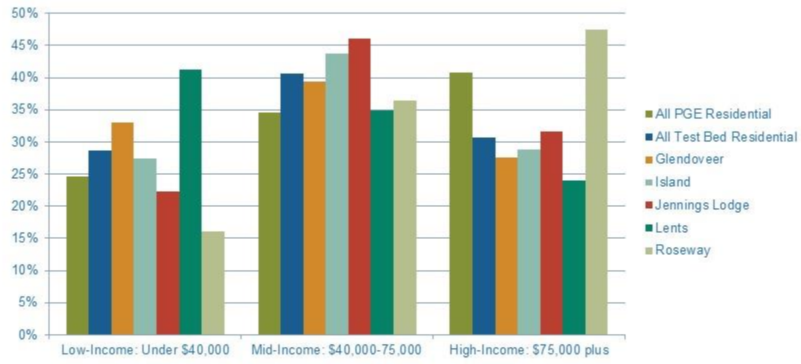
Estimated Household Income



Insights:

- Roseway has the highest income distribution, and is the only Test Bed with a higher-than-average income distribution; Jennings Lodge is 2nd highest
- Lents has the lowest income distribution; Glendoveer is 2nd lowest

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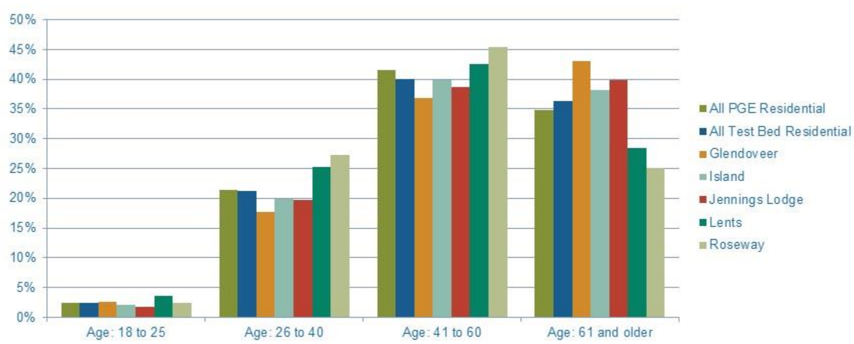
Age



Insights:

- Glendoveer has the oldest age distribution
- Jennings Lodge and Island also lean older
- Lents leans younger
- Roseway has the youngest age distribution

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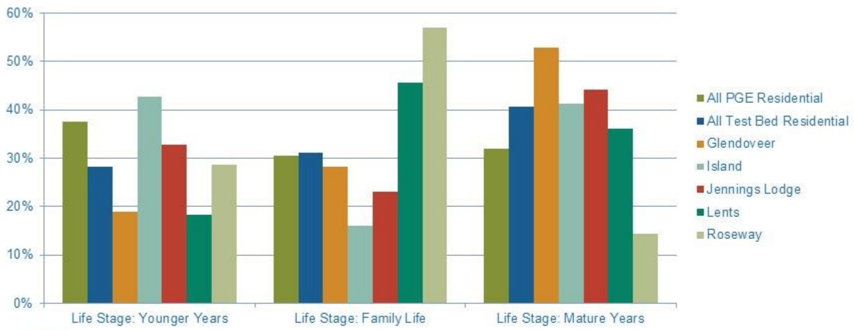
Life Stage



Insights:

- Life Stage is purchased from a different source than Age, and it's definitions revolve around life's stages involving children, but it's intended to apply to people who don't have kids too:
  - "Younger Years" is the stage "before children"
  - "Family Life" is the stage where non-adult children are living in the home
  - "Mature Years" are the "empty-nester" years
- Glendoveer has the oldest population, with a high percentage in the Mature Years stage
- Island is a mix of older and younger, with very few in the Family Life state
- Jennings Lodge is also a mix of old and new, with a higher percentage in Mature Years (44%) then Younger Years (33%)
- Lents has a high percentage of both Family Life (46%) and Mature Years (36%)
- Roseway is very high on Family Life (57%), and has a low percent in Mature Years (14%)

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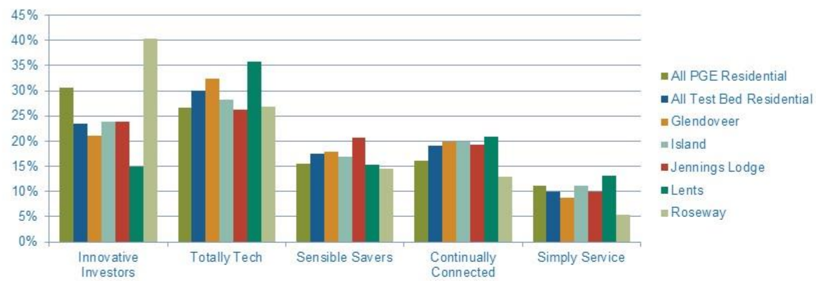
PGE Residential Segments



Insights:

- Innovative Investors are more affluent customers, and often participate in "green" programs
  - Roseway is the only Test Bed with a high percentage of Innovative Investors
- Totally Techs are more likely engage with PGE through electronic means and are often early adopters of new technologies
  - Lents and Glendoveer have high Totally Tech percentages
- Sensible Savers are lower income, but live within their means and have good PGE credit scores. They are often willing to invest to save money in the long run
- Continually Connected customers have PGE payment issues and contact us frequently to manage those issues
  - All of the Test Bed groups have slightly more-than-average percentages in this segment, except Roseway
- Simply Service customers tend to be younger, renters who move often and have low PGE bills.
  - Roseway has very few Simply Service customers (5%)

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Delaware Substation Characteristics

OVERALL KWH POTENTIAL		
Annual kWh--Residential	54,974,528	
Annual kWh--Business	34,997,125	
Annual kWh--Total	89,971,653	
AVERAGE MONTHLY BILL	$ 97.65	
Bill: Less than $40		14%
Bill: $40 to $70		35%
Bill: $70 to $120		36%
Bill: $120 to $200		13%
Bill: $200+		2%
ELECRTIC OR NON-ELECTRIC HEAT		
Non-Electric Heat		82%
Electric Heat		18%
OWNER OR RENTER		
Homeowner		58%
Renter		42%
HOME TYPE		
Single-Family		77%
Multi-family		23%
Mobile or Manufactured		0%

ELECRTIC OR NON-ELECTRIC HEAT	
Non-Electric Heat	82%
Electric Heat	18%
OWNER OR RENTER	
Homeowner	58%
Renter	42%
HOME TYPE	
Single-Family	77%
Multi-family	23%
Mobile or Manufactured	0%
ENGAGEMENT IN PGE PROGRAMS	
Paperless Bill	52%
Renewable Power	41%
Equal Pay	8%
Preferred Due Date	6%
Solar Power	1%
ESTIMATED HOUSEHOLD INCOME	
Low-Income: Under $40,000	24%
Mid-Income: $40,000-75,000	46%
High-Income: $75,000 plus	30%
PGE RESIDENTIAL SEGMENTS	
PGE Segment: Sensible Savers	8%
PGE Segment: Innovative Investors	42%
PGE Segment: Simply Service	9%
PGE Segment: Continually Connected	12%
PGE Segment: Totally Tech	29%

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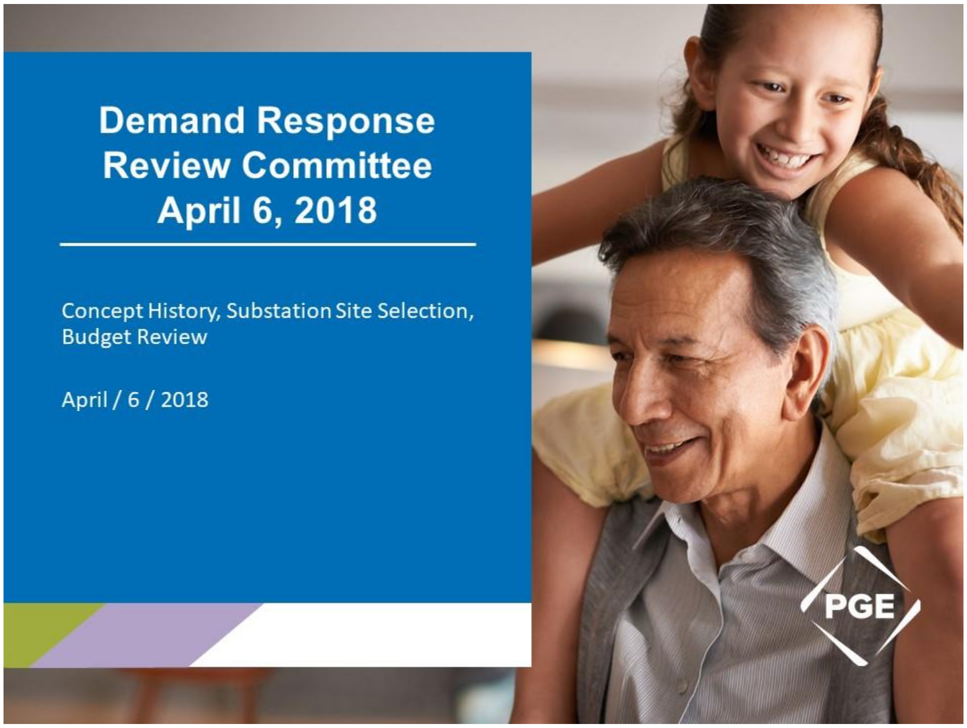
Which 3 of the 6 Substations are Best for the Test Bed Project?

- Roseway stands out from the other Test Beds—it has all the attributes that the other 4 lack, compared to All Residential. It also has the lowest average PGE bills, the most non-electric heat and newer homes. It would add variety to the mix
- Lents stands out for other reasons. Located in urban Multnomah County, it has many lower income families, some with PGE credit issues, but it is high on technology propensity and enrollment in Renewable Power. It would be interesting to see if these attributes drive program participation.
- Between Glendoveer, Island and Jennings Lodge, the choice is more nuanced. Out of 40 attributes/values, they have similar values for 21 of them. We will need to decide which combination of attributes best fits the program, and compliments the other Test Beds.
- Delaware is a recent addition identified by T&D because of a recent decision to invest in distribution automation at the substation. Additionally, University of Portland has begin exploring investments in solar plus storage for their campus. Keiser interstate has been working with PGE on resiliency and energy efficiency upgrades.

Portland General Electric 63

D.2.2 April Demand Response Review Committee Meeting Presentation



Site assessment

Data from two groups (Customer Accounts and Transmission and Distribution) have contributed overlapping data sets. Customer Accounts provided customer persona profile data by sector and Res. Sub-sector. This data was overlaid with studies from Transmission and Distribution to identify promising substations for the development of a highly active demand response resource.

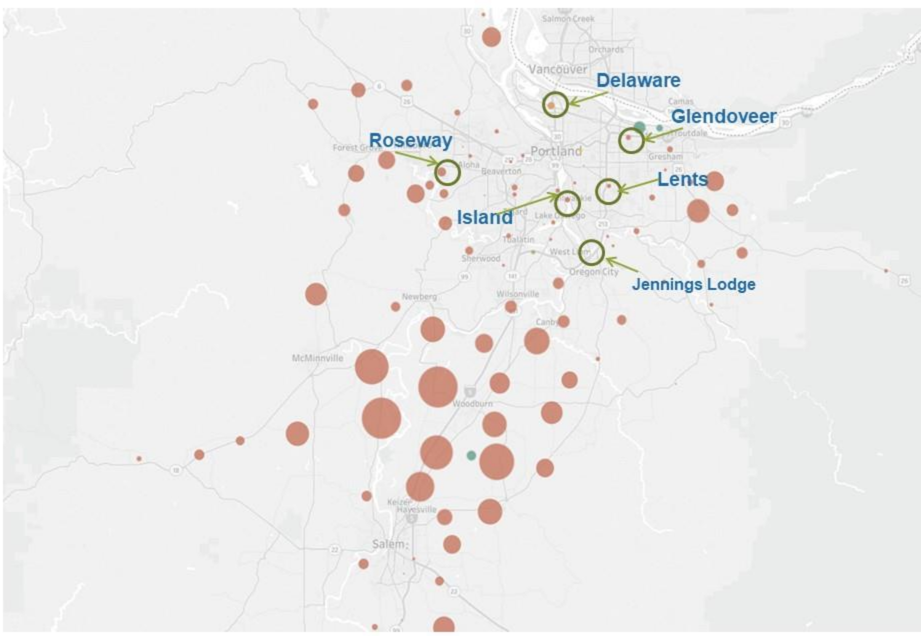
Criteria for substation project inclusion:

- High Growth
- Relieve Transmission congestion on the South of Allston Transmission path (summer concern)
- Relieve Distribution capacity limitations under contingency
- Opportunity to research end of life, equipment deferral value proposition
- Enable/Improve micro-grid capabilities and system resiliency.

Customer information that influenced sub-station site inclusion:

- Several residential subgroups including low income and mobile homes.
- Cities willingness and eagerness to partner on such projects
- City of Milwaukee, Hillsboro and Portland interest in smart building development and customer offerings
- New building growth
- Substation load growth
- Broad mix of customer types and customer personas

3

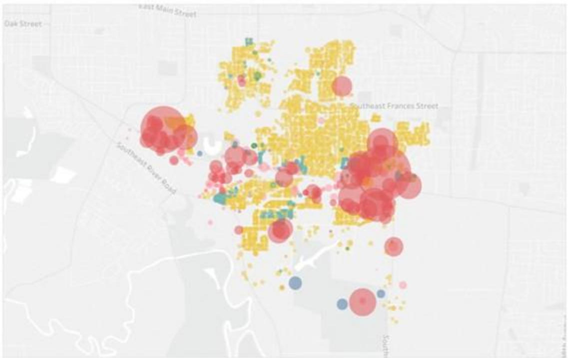


Portland General Electric 4

PGE has Identified Five Substations as potential sites for inclusion in the Demand Response Test Bed

Roseway Substation

ROSEWAY



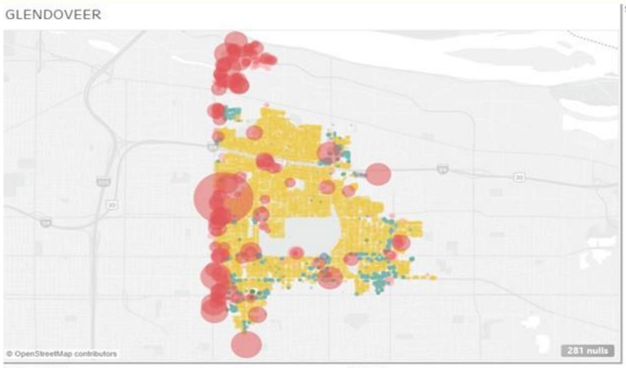
Customertype
- Agricultural
- DirectAccess
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

	Servcity							
	BEAVERTON				HILLSBORO			
	33				4,892			
Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	6	37,201	70,622	14,456	489%	0	0	0
DirectAccess	1	11,553	12,921	11,975	108%	0	0	0
SmallCI	459	633,897	638,651	709,950	90%	0	0	0
LargeCI	69	2,302,886	2,505,865	2,354,780	106%	0	0	0
Residential..	752	563,957	510,400	797,945	64%	0	752	0
Residential..	69	83,976	54,516	137,380	40%	69	0	0
Residential..	3,537	2,751,751	3,095,347	3,115,992	99%	0	0	3,537
Residential..	32	21,864	24,017	26,307	91%	0	0	0

5

Glendoveer Substation

GLENDOVEER

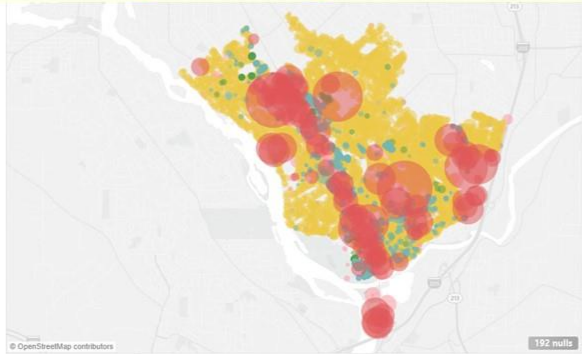


Customertype
- Agricultural
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

	Servcity							
	PORTLAND							
	10,010							
Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	5	12,271	31,678	462	6852%	0	0	0
SmallCI	692	1,119,225	1,123,552	1,266,059	89%	0	0	0
LargeCI	118	2,921,192	3,002,457	3,200,176	94%	0	0	0
Residential..	3,151	2,136,823	1,660,297	3,338,666	50%	0	3,151	0
Residential..	110	101,672	62,576	176,930	35%	110	0	0
Residential..	5,859	5,233,080	5,133,714	6,636,768	77%	0	0	5,859
Residential..	75	57,925	55,163	77,033	72%	0	0	0

Portland General Electric 6

Jennings Lodge Substation



Customertype: Agricultural, LargeCI, Residential-MF, Residential-MH, Residential-SF, Residential-Unknown, SmallCI

Servcity	GLADSTONE	MILWAUKIE	OREGON CITY	PORTLAND
	4,480	5,148	29	75

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	1	1,375	2,207	343	644%	0	0	0
SmallCI	718	1,126,343	1,094,179	1,252,080	87%	0	0	0
LargeCI	103	2,234,112	2,176,035	2,368,926	92%	0	0	0
Residential..	2,318	1,645,761	1,361,759	2,338,279	58%	0	2,318	0
Residential..	580	562,496	398,890	845,620	47%	580	0	0
Residential..	5,933	5,603,167	5,364,459	6,564,135	82%	0	0	5,933
Residential..	79	69,913	66,076	83,901	79%	0	0	0

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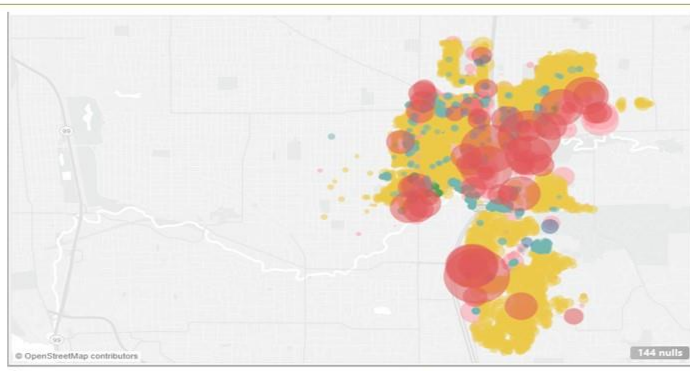
Lents



Customertype: Agricultural, LargeCI, Residential-MF, Residential-MH, Residential-SF, Residential-Unknown, SmallCI

Servcity	CLACKAMAS	HAPPY VALLEY	PORTLAND
	31	708	6,957

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	3	9,522	11,286	98	11516%	0	0	0
SmallCI	571	1,037,801	962,269	1,175,301	82%	0	0	0
LargeCI	53	1,125,806	1,187,999	1,085,307	109%	0	0	0
Residential..	2,023	1,309,018	1,139,348	1,816,562	63%	0	2,023	0
Residential..	211	167,884	112,029	261,871	43%	211	0	0
Residential..	4,731	4,437,920	3,978,407	5,707,428	70%	0	0	4,731
Residential..	104	79,508	76,555	97,211	79%	0	0	0

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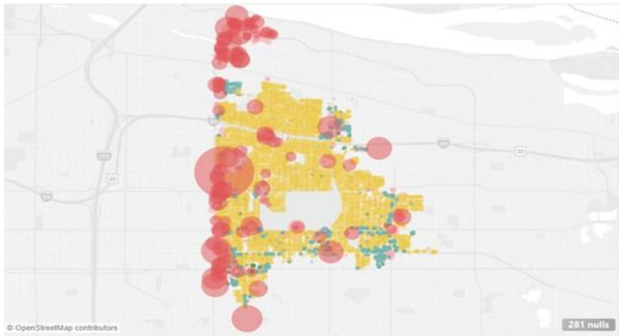
Glendoveer Substation

GLENDOVEER



Servcity

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
								PORTLAND
								10,010
Agricultural	5	12,271	31,678	462	6852%	0	0	0
SmallCI	692	1,119,225	1,123,552	1,266,059	89%	0	0	0
LargeCI	118	2,921,192	3,002,457	3,200,176	94%	0	0	0
Residential..	3,151	2,136,823	1,660,297	3,338,666	50%	0	3,151	0
Residential..	110	101,672	62,576	176,930	35%	110	0	0
Residential..	5,859	5,233,080	5,133,714	6,636,768	77%	0	0	5,859
Residential..	75	57,925	55,163	77,033	72%	0	0	0

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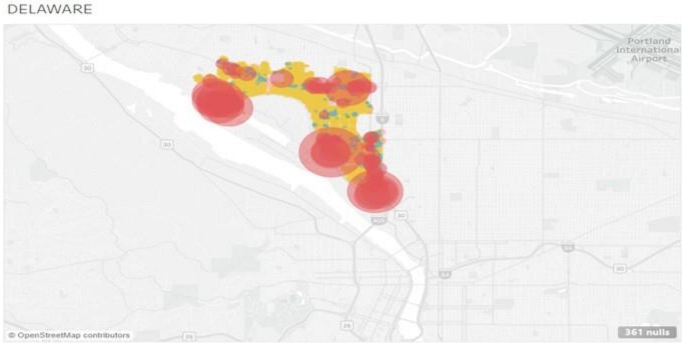
Delaware

DELAWARE

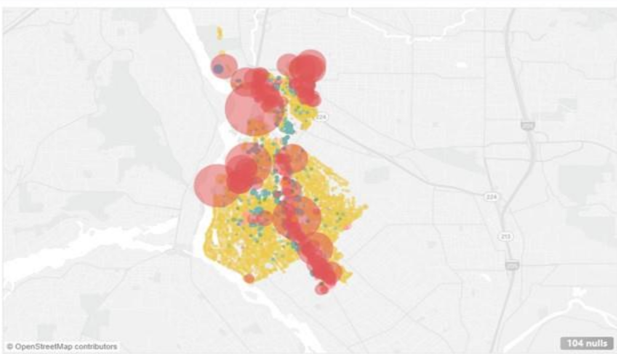


Servcity

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
								PORTLAND
								8,458
DirectAccess	1	5,457	6,237	4,987	125%	0	0	0
SmallCI	575	1,009,602	999,866	1,118,949	89%	0	0	0
LargeCI	88	3,038,701	3,243,108	3,087,493	105%	0	0	0
Residential..	1,477	642,022	513,739	942,426	55%	0	1,477	0
Residential..	5	4,976	3,185	7,977	40%	5	0	0
Residential..	6,221	4,613,784	4,176,157	5,836,632	72%	0	0	6,221
Residential..	91	55,823	50,534	69,946	72%	0	0	0

Portland General Electric 10

Island Substation



Customertype
- Agricultural
- DirectAccess
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

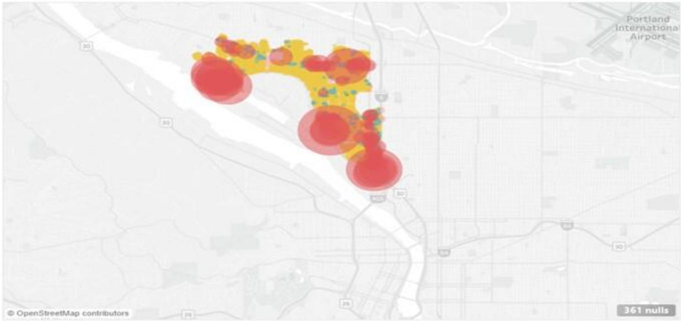
Servcity			
HAPPY VALLEY	MILWAUKIE	PORTLAND	TUALATIN
1	8,992	129	1

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	1	13,475	21,000	6,137	342%	0	0	0
DirectAccess	2	10,981	10,086	12,228	82%	0	0	0
SmallCI	1,091	1,693,317	1,653,413	1,821,056	91%	0	0	0
LargeCI	114	4,797,835	4,744,480	4,907,735	97%	0	0	0
Residential..	2,995	1,986,489	1,579,834	2,870,252	55%	0	2,995	0
Residential..	306	263,525	188,988	380,242	50%	306	0	0
Residential..	4,548	4,305,165	3,913,566	5,178,810	76%	0	0	4,548
Residential..	66	58,185	56,012	66,725	84%	0	0	0

Portland General Electric 12

Delaware

DELAWARE



Customertype
- DirectAccess
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

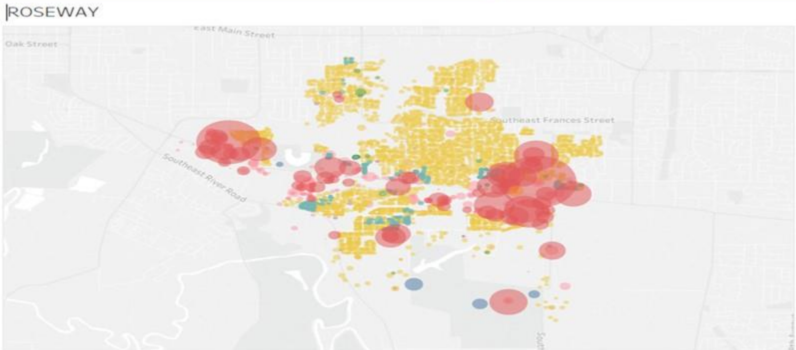
Servcity: PORTLAND — 8,458

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
DirectAccess	1	5,457	6,237	4,987	125%	0	0	0
SmallCI	575	1,009,602	999,866	1,118,949	89%	0	0	0
LargeCI	88	3,038,701	3,243,108	3,087,493	105%	0	0	0
Residential..	1,477	642,022	513,739	942,426	55%	0	1,477	0
Residential..	5	4,976	3,185	7,977	40%	5	0	0
Residential..	6,221	4,613,784	4,176,157	5,836,632	72%	0	0	6,221
Residential..	91	55,823	50,534	69,946	72%	0	0	0

Portland General Electric 13

Roseway

ROSEWAY



Customertype
- Agricultural
- DirectAccess
- LargeCI
- Residential-MF
- Residential-MH
- Residential-SF
- Residential-Unknown
- SmallCI

Servcity: BEAVERTON — 33; HILLSBORO — 4,892

Customerty..	Service Points	Avg Kwh	Avgkwhsu..	Avgkwhwi..	Summer to Winter Lo..	Mobile Homes	Mutifamily Homes	Single Family Ho..
Agricultural	6	37,201	70,622	14,456	489%	0	0	0
DirectAccess	1	11,553	12,921	11,975	108%	0	0	0
SmallCI	459	633,897	638,651	709,950	90%	0	0	0
LargeCI	69	2,302,886	2,505,865	2,354,780	106%	0	0	0
Residential..	752	563,957	510,400	797,945	64%	0	752	0
Residential..	69	83,976	54,516	137,380	40%	69	0	0
Residential..	3,537	2,751,751	3,095,347	3,115,992	99%	0	0	3,537
Residential..	32	21,864	24,017	26,307	91%	0	0	0

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Substations

Delaware

- Planned for reconstruction by end of 2019
- Modern SCADA and DA scheme in development
- University of Portland Solar + Storage
- Kaiser Interstate Campus

Roseway

- New Construction
- Planned for future reconstruction
  - Communication
  - Visualization
  - Remote operation
- Customer mix includes residential subsets

Island

- Multifamily and high concentration of commercial business
- High number of electrically heated homes
- Challenging recruitment
- High profile site for the City

Portland General Electric 15

Delaware

Compared to All Residential

- **MORE likely**
  - Multnomah County
  - Urban
  - Older, smaller homes with higher value; more single-family
  - High Green Affinity
  - High Comfort Consumption
  - Non-electric heat, lower usage/bills
  - Renewable power, Paperless bill
  - "Family Life" life stage
  - Innovative Investors
- **And, to a lesser extent:**
  - Web Registered
  - Electronic payment
  - Lower Tech Propensity
- **LESS likely**
  - Electric Heat
  - Older
  - Large home
  - Inexpensive or multi-family home
  - High Income
  - Spanish speaking
- **And, to a lesser extent:**
  - Payment Issues
  - High Tech Propensity
  - High Investment Capacity

Portland General Electric 16

Island

Compared to All Residential

- **MORE likely**
  - Clackamas County
  - Suburban
  - Older, larger homes
  - Electric heat
  - Medium income
  - "Mature Years" life stage
  - Medium or Low Green Affinity
  - Low Tech Propensity
  - Rent their home
  - Call PGE's Call Center
  - Have payment issues
  - Receive energy assistance

And, to a lesser extent:
  - Multi-family homes
  - Renewable Power
  - Younger Years life stage
  - Not-excellent PGE Credit Rating
  - Single

- **LESS likely**
  - High Green Affinity
  - "Family Life" life stage
  - High income
  - High Investment Capacity
  - New homes, high home value
  - Non-electric heat
  - Professional occupation
  - Spanish speaking
- And, to a lesser extent:
  - Pay electronically
  - Married
  - Household size of 3+
  - High Tech Propensity
  - Innovative Investor segment

Portland General Electric 17

Roseway

Compared to All Residential

- **MORE likely**
  - Washington County
  - Suburban
  - "Family Life" life stage, children at home
  - Newer, single family, medium-sized, high value homes
  - Homeowners
  - Non-electric heat, lower PGE bill
  - Solar Power
  - Higher Income
  - Medium and High Investment Capacity
  - High Affordability Level
  - Innovative Investor segment
  - Good PGE credit
  - Medium Information Action Orientation

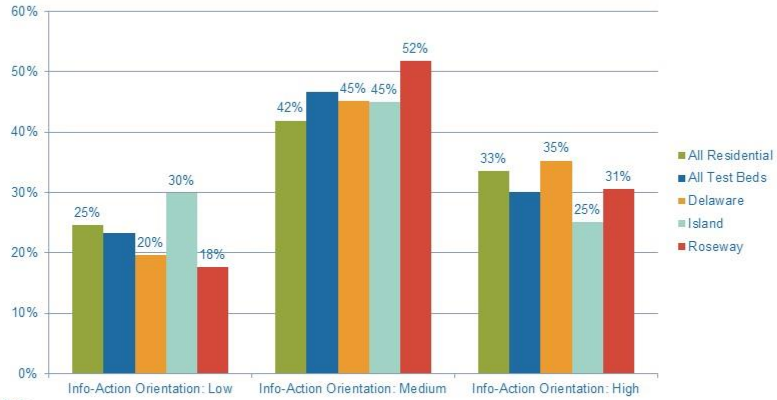
And, to a lesser extent:
  - Pay electronically
  - E-mail on file

- **LESS likely**
  - Electric Heat
  - Older, smaller, multi-family homes
  - Rent their home
  - "Mature Years" life stage, older
  - "Younger Years" life stage
  - PGE Credit issues
  - Low Income

And, to a lesser extent:
  - Mail payment
  - Simply Service segment
  - High Tech Propensity

Portland General Electric 18

Information-Action Orientation



Insights:

- This attribute tells us if customers are likely to consume information about the DR program—a prerequisite to enrollment and participation
- All PGE Residential is 25% Low, 42% Medium and 33% High
- Delaware and Roseway have about the same percentage of medium and high scores: Delaware at 80% and Roseway at 83%. Both have about a third with high scores
- Island has the lowest scores: 75% have a Low or Medium score

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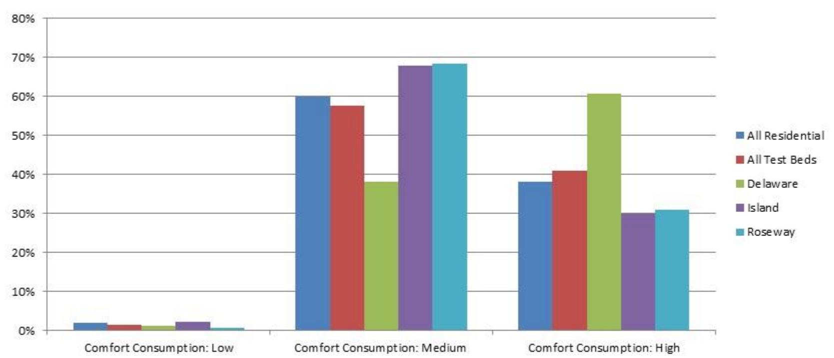
Comfort Consumption

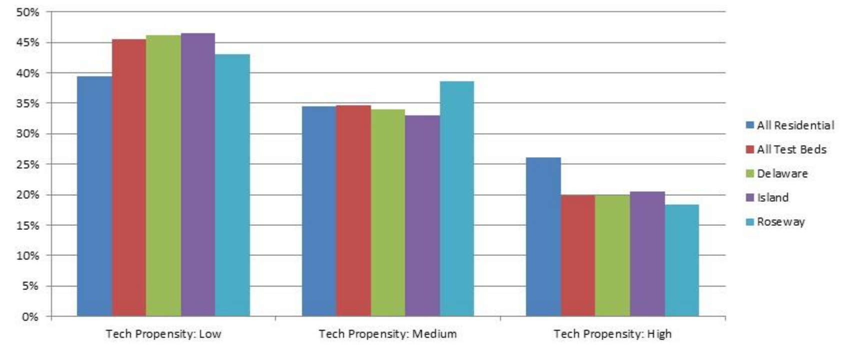


Insights

- This attribute tells us about whether the customer is comfortable spending more for energy (not whether or not they actually do spend more). The higher the score, the more likely it is that the customer would be motivated by environmental impacts of the program, over saving money by participating.
- Island and Roseway have nearly identical distributions—mostly medium.
- Delaware has a very high score, relative to All Residential, Island and Roseway.

20

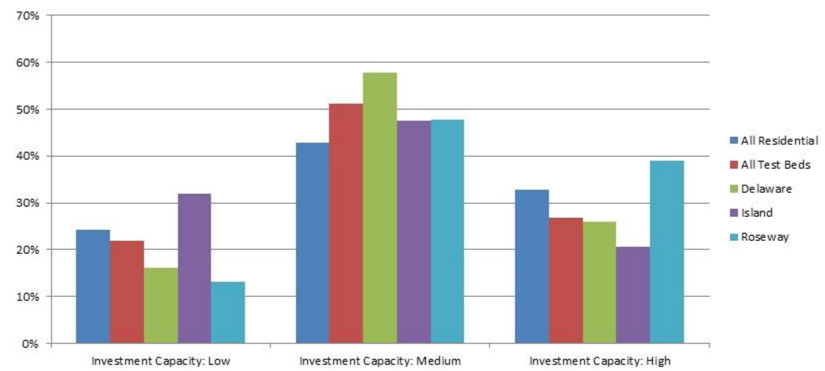
Tech Propensity



Insights
- Tech Propensity tells us if a customer has a propensity to adopt new-ish technologies .
- The Test Beds have lower-than-average scores on Tech Propensity. Marketing messaging should feel non-technical.

21

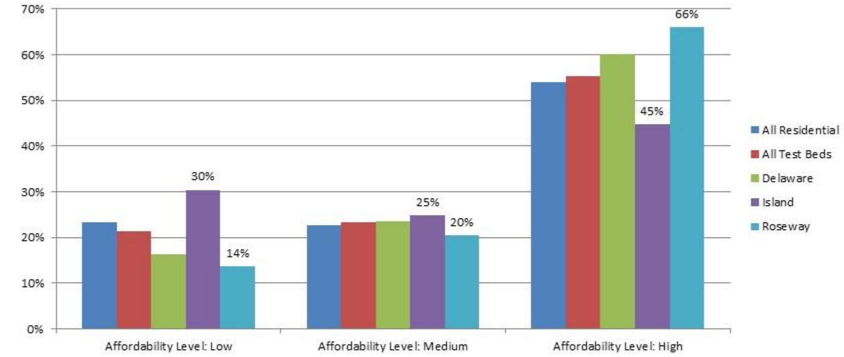
Investment Capacity



Insights:
- If ability to invest (e.g. in a NEST thermostat) is important to program participation, high scorers would be more likely to enroll (see also, Affordability Level)
- Roseway pops as the outlier among the Beds, and is higher than All PGE Residential.
- Delaware is solidly in the Medium Investment Capacity category.
- Island has lower-than-average Investment Capacity.

22

Affordability Level

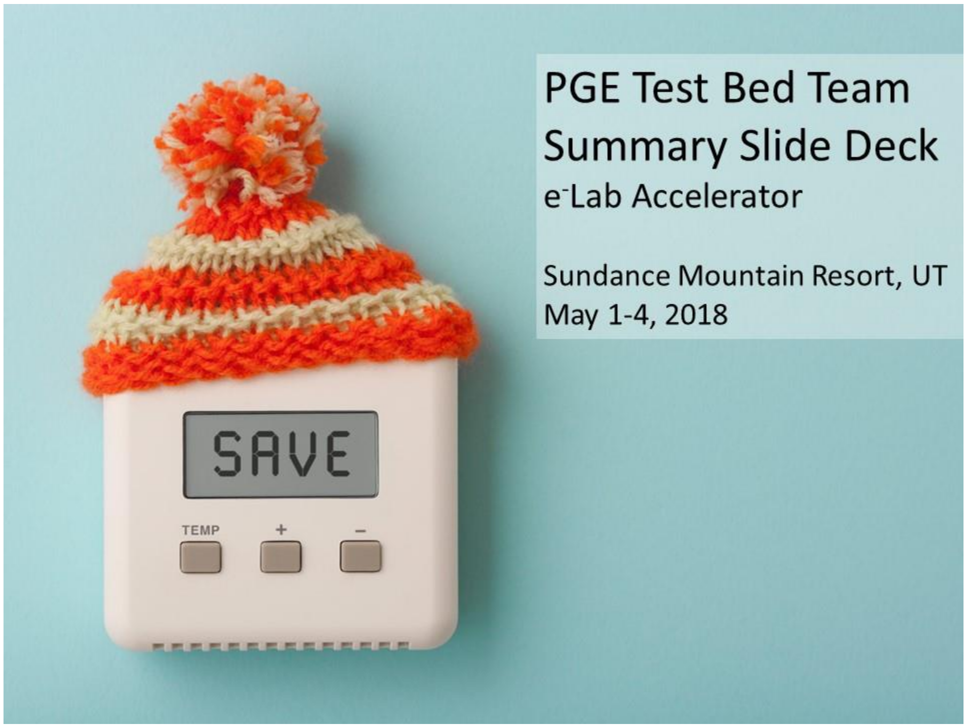


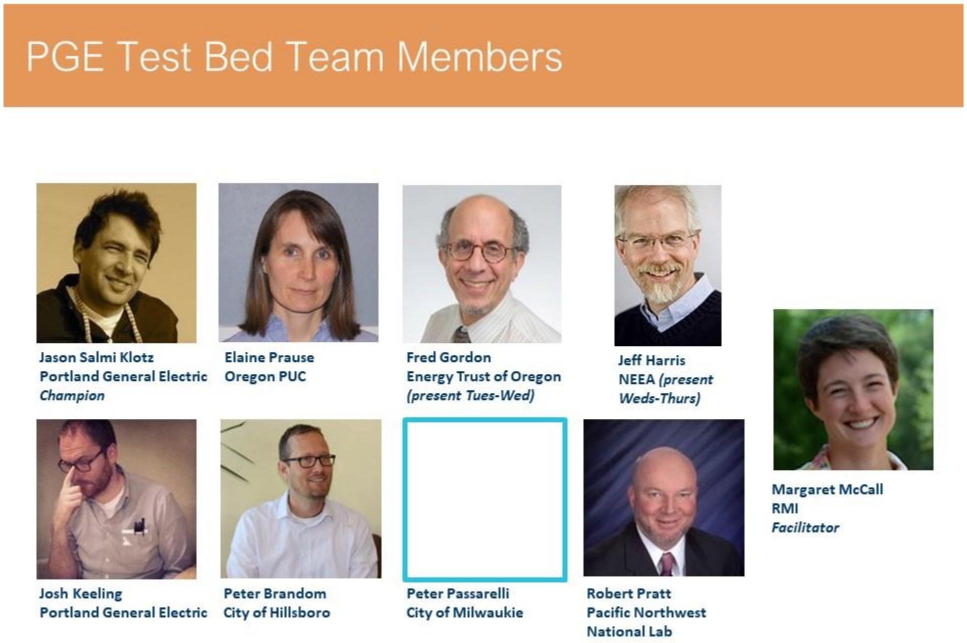
Insights:

- High Affordability Level scores indicate existence of discretionary spending money and cost-consciousness. If discretionary money is important to participation, high scorers would be more likely to enroll. If cost-consciousness would likely prompt participation, customers with Low Affordability Level scores may be good targets --they might have relatively high interest in the financial rewards from participation.
- Roseway has the highest scores—and is higher than All PGE Residential, with 66% High Scores. Delaware is higher-than-average.
- Island has the highest percentage of Low scores—30% and they are lower-than-average.

23

D.2.3 Rocky Mountain Institute (RMI) E-Lab Accelerator Re-Cap Presentation





PGE Test Bed Team Objectives

The PGE Test Bed team pursued two objectives at eLab Accelerator based on interviews Margaret (the team facilitator) had done with all team members in advance and refined on Day 1 of the event:

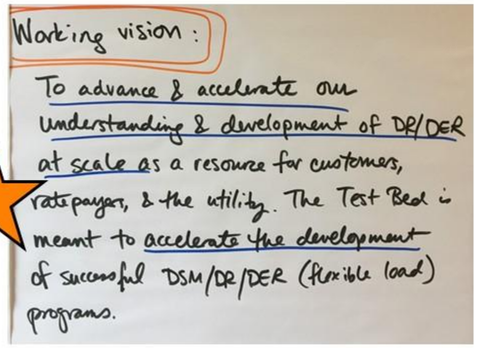
1. **Prioritize the core objectives of the Test Bed**
2. **Develop approaches to iterate on current & new DR programs to achieve top strategic objectives, & understand next steps involved**

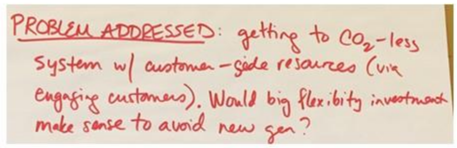
Throughout this deck, an orange star denotes points and conclusions in the team's work that were particularly relevant to their objectives

Tuesday

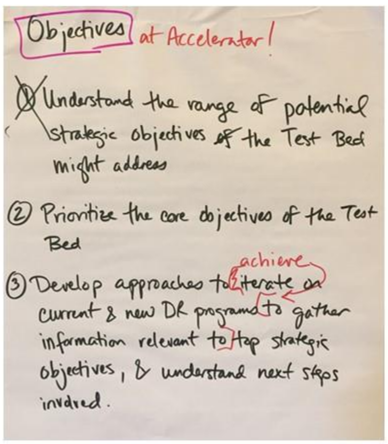
First team time on Tuesday (1/2)

- eLab Accelerator kicked off on Tuesday with introductions of all 13 teams, the process, and the faculty
- There was one hour of team time, in which the PGE Test Bed team:
  - **Did a check-in which led to a discussion about the roles of the city reps**
  - **Got clearer on a "working vision" to ground the discussion**
  - **Collected questions and changes to the objectives**
  - Discussed what's already established vs. what constitutes open questions to be addressed
  - Named some things that are out of scope (e.g., fine-tuning any internal/external messaging)
  - Discussed the problem addressed by the Test Bed

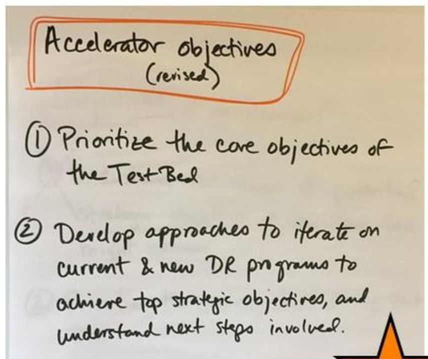




First team time on Tuesday (2/2)



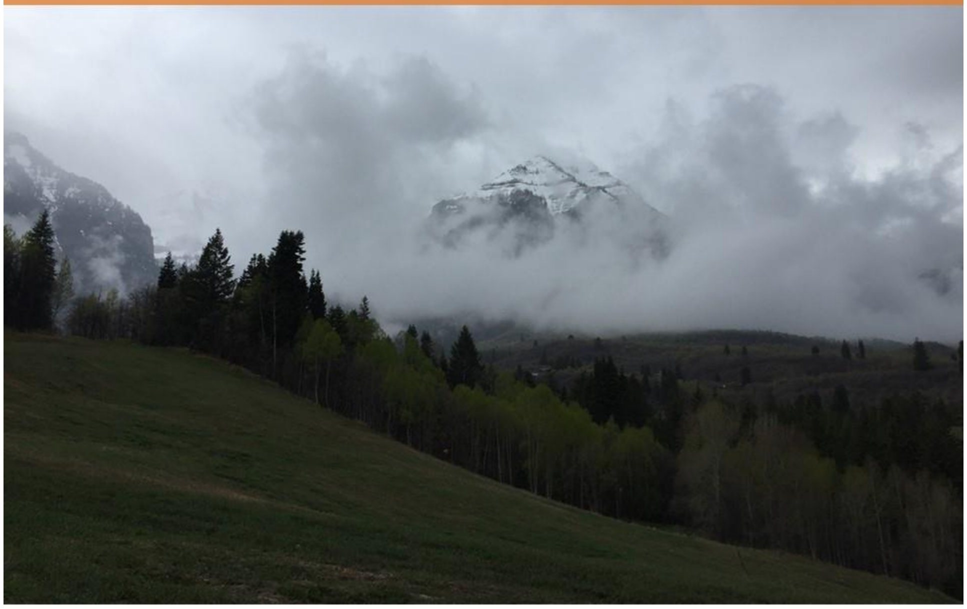
Original objectives



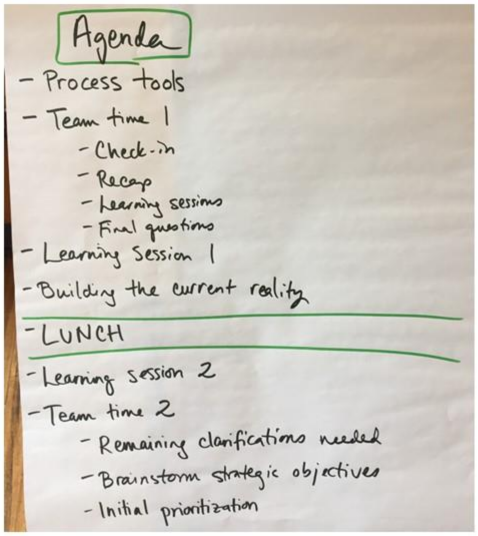
Revised objectives

The team revised their objectives for Accelerator during their time together on Day 1

Wednesday

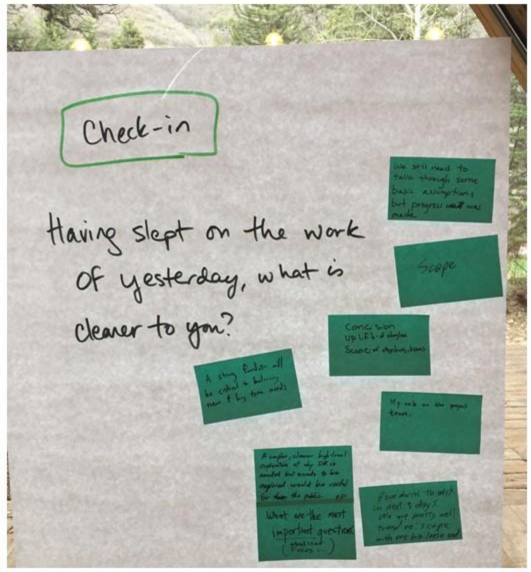


Wednesday agenda



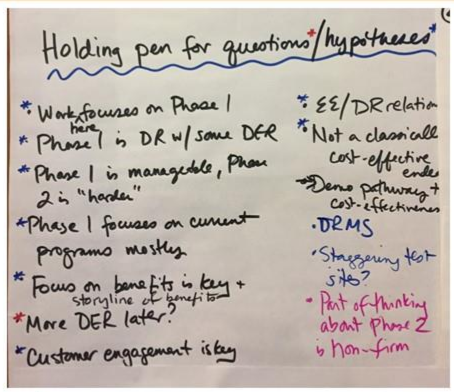
Check-in

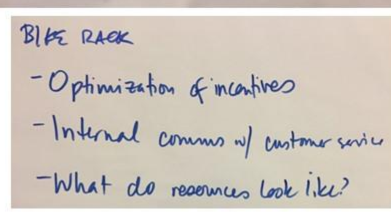
The team kicked off Wednesday morning by checking in about what was becoming clearer to them after their first time together



Question/hypothesis holding pen/bike rack

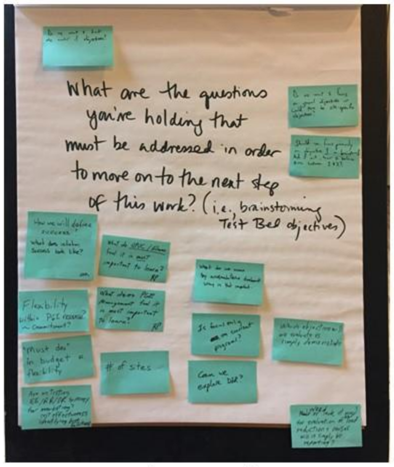
In order to maintain focus, the team agreed to the use of a "holding pen" (later supplemented with a "bike rack") for questions and hypotheses that were important but diverged from the discussion at hand



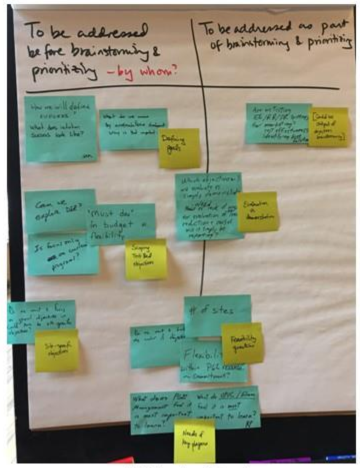


Essential questions to address (1/2)

To further understand questions that were essential to answer up front versus questions that could wait, the team generated questions that they felt needed answered before they could discuss the Test Bed objectives.



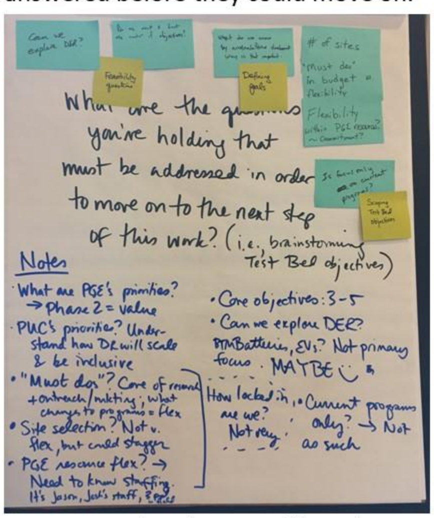
Question generation



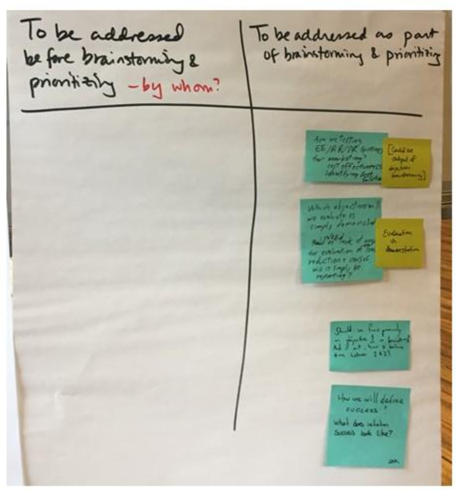
Initial prioritization

Essential questions to address (2/2)

The team then either addressed or deprioritized the questions they'd felt needed to be answered before they could move on.



Questions that were addressed



Questions that could be answered later

Learning sessions (1/3)

The team then split up to attend learning sessions given by Accelerator faculty.

Sonia Aggarwal -- "Well, I guess if I were in their position…"
As if engineering challenges weren't complicated enough, the social and financial structures we have overlaid on the electricity system are perhaps even more complex. **This session is about understanding the motivations of the people you need to convince or work with to realize your vision.** Zoom out and look at the system from the outside, so you can see how to change it. Depending on the topics participants are most interested in, this session could cover utility financial motivations, regulatory motivations, financial motivations of wholesale market participants, or other related topics.

Pete Bronski -- Developing audience-centric messaging that resonates
OK, so you have a great idea, an inspiring project, a world-changing solution. Wonderful! But adoption and scaling don't happen in a vacuum. That's where messaging comes in. **Learn how to build brands, develop core messaging, and tell narratives that resonate with your target audiences and stand out from the competition.**

Coreina Chan -- New utility models for serving low-income communities
Technological and regulatory opportunities and imperatives are creating space for new utility approaches to connecting low-income households to clean energy benefits. **This learning session will explore some of these trends and emerging models, as well as host a conversation about the changing roles of customers and necessity of collaboration for these models to be successful.**

Steve Corneli -- Market reforms for rapid decarbonization
How do we get the right mix of large scale renewables and distributed resources like flexible load and storage to achieve the high levels of clean energy (100%) needed to address climate change? This is a growing challenge for state and federal policy makers, as well as innovators, utilities and all those who care about the climate. **This learning session will frame the problem and introduce the idea of a configuration market to help solve the resource mix, cost recovery and business model challenges associated with rapid decarbonization.**

Mark Dyson -- Clean energy portfolios as cost-effective alternatives to gas-fired generation
There is >100 GW of new gas-fired capacity that has been announced for construction in the US. However, as costs for renewable energy and batteries fall, and new capabilities emerge from these technologies and advanced demand-side management, there is mounting evidence that "clean energy portfolios" of alternative resources can be cheaper than building new power plants, and may soon out-compete even the operating costs of existing gas plants. **This learning session will preview new RMI research on this emerging market dynamic, and host a conversation about implications across the utility industry.**

Lorenzo Kristov -- Value propositions for distributed resources
What are the major sources of value that, if monetized, would revolutionize DER commercial viability? As the recent FERC technical conference on DER aggregation demonstrated, DER developers want better access to wholesale markets because that's where they believe the money is, while ironically, conventional power plants are bemoaning the shrinking of wholesale market prices and revenues. **This session will explore potentially vast sources of societal benefits and DER value that don't rely on wholesale markets and are waiting to be quantified to become commercially accessible.**

Learning sessions (2/3)

(Continued)

Carl Linvill -- DER policy trends: a snapback challenge
To say that DER policy is active may be the understatement of the decade. From DER tariff design, distribution, rate designs, DER interconnection rules, distribution grid planning and hosting capacity analysis to retail choice and Community Choice Aggregation, DER aggregation, and wholesale market designs, the playing field of DER policy is vast. **The purpose of this session is to apply an RMI construct, the "Snapback Analysis," to DER policy implementation options. (This concept refers to the idea that when aspiring to do something fundamentally different, it is advantageous to start not with what's happening today and stretch forward, but rather to start from the future desired state and stretch back.)** DER policy implementation options that can survive the "Snapback Challenge" represent the forward-looking policies that offer the most promise of delivering us from the legacy platforms we know to the transformational platforms we want.

Tom Starrs -- Distributed energy resources and large-scale renewables: Competing or symbiotic resources?
Among renewable energy advocates, some believe that distributed energy resources are the key to decarbonization and a sustainable energy future, while others believe that large-scale renewable resources (e.g. solar and wind farms, perhaps with storage) provide a grerater opportunity. **This learning session will explore the assumptions behind these alternative schools of thought, and suggest that not only is one not inherently "better" than the other but that the two are co-dependent and need each other to reach their full potential.** This will be a wide-ranging discussion that will touch on the characteristics of renewable energy resources, the value and scalability of DER, the low cost of large-scale wind and solar, and the challenges of grid integration in a high-renewables future.

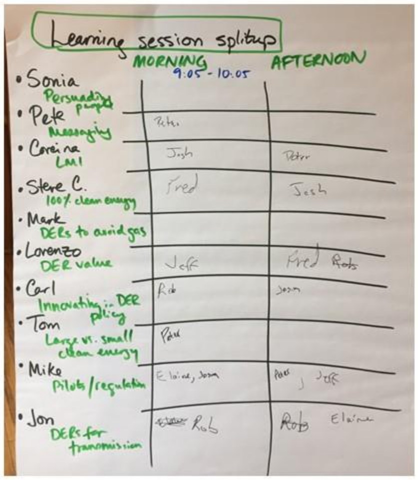
Mike Sullivan -- Get your game on! What innovation is needed for utilities to actively support a DER-rich future?
Nearly every electric utility in the country has multiple DER pilots underway and more are being launched every day. Indeed, most are of the microgrid variety, but that is where the similarities end. Many of the pilot differences are rooted in varying public policy and regulatory constructs. So, what DER policy and future model assumptions should utilities plan for? **This learning session will explore some innovation steps that utilities can take while the complex public policy issues are shaking out.**

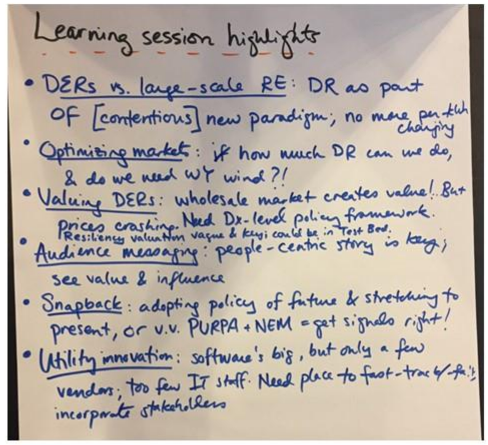
Elaine Ulrich -- Supporting innovation across domains: Bringing people, analysis, insight and technology together to create clean energy solutions
Since the launch of the SunShot initiative in 2011, the U.S. Department of Energy solar office (SETO) has administered over $2B in grants, cooperative agreements, prizes and challenges; supported technical assistance to hundreds of state and local entities; and published thousands of analyses and papers, yet these investments are dwarfed by the over $100 billion in capital deployed in U.S. solar. **This learning session will outline strategies SETO has targeted to help partners get the most out of their programs and projects in a rapidly changing technology and policy landscape.**

Jon Wellinghoff -- Using ATTs for ATS: Come find out what this means and why it's important
Advanced transmission technologies were specifically identified by Congress in 2005 as technologies that FERC should promote. What are they? Most of the technologies that people generally think of as DERs. FERC took up the responsibility to promote these technologies in transmission planning in 2011 when they issued Order 1000. **Come find out how Advanced Transmission Technologies (DERs) may be used under Order 1000 to provide Alternative Transmission Solutions to conventional transmission problems, and why that's important to the deployment of DERs.**

Learning sessions (3/3)

The team reconvened after each of the two sets of sessions to report back learnings relevant to the PGE Test Bed team.

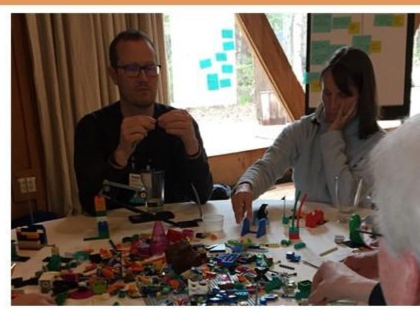




Modeling the current reality (1/3)

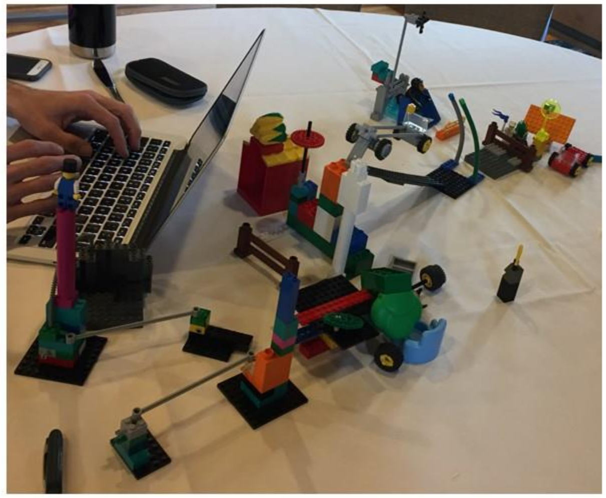
The team was then asked to use Legos to collaboratively build a model based on the following prompt:

Build a model of the current state of demand response in the Pacific Northwest, drawing on social, political, economic, and technical forces at play.

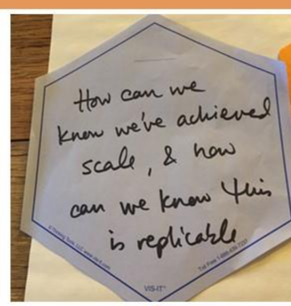


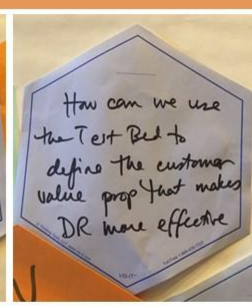
Modeling the current reality (2/3)

The team pared down the model as shown at right, with components representing (non-exhaustively) barriers, the regulator/stakeholders, various customers, Bonneville, momentum going into the future, a disconnected grid, a perfect future state, an ivory tower, and the Test Bed stuck in a poorly-connected present system.



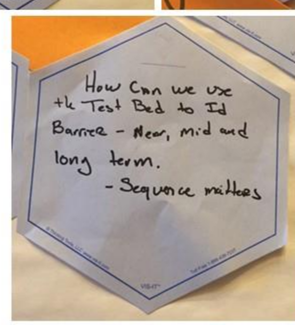
Modeling the current reality (3/3)





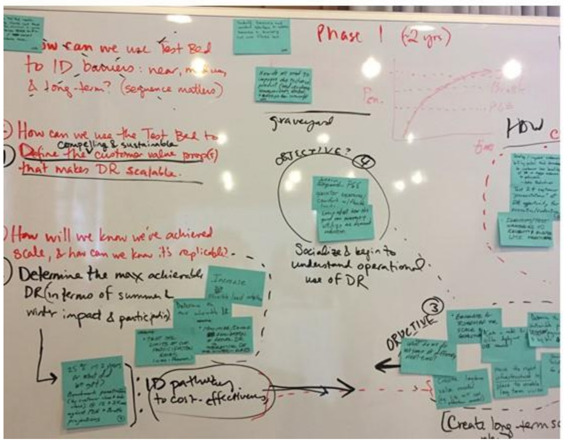
Three important questions arose from the collaborative building of the Lego model:

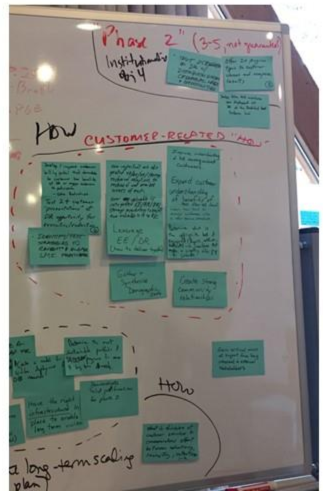
1. **How can we use the Test Bed to ID barriers (near, mid, and long term)? Sequence matters**
2. **How can we use the Test Bed to define the customer value prop that makes DR more effective?**
3. **How can we know we've achieved scale, & how can we know this is replicable?**



Prioritizing Test Bed objectives (1/2)

The team then collaboratively tackled their first Accelerator objective (prioritize the core objectives of the Test Bed), using the three Lego-generated questions to help sort the results *(see close-ups of post-its in appendix)*





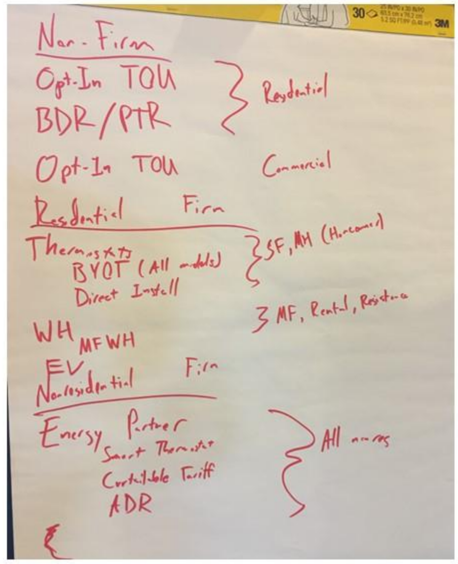
Prioritizing Test Bed objectives (2/2)

The group agreed on four core Test Bed objectives:

1. **Define the compelling & sustainable customer value prop(s) that makes DR scalable**
2. **Determine the max achievable DR (in terms of summer & winter impact and participation)**
3. **Create long-term scaling plan**
4. **Socialize and begin to understand operational use of DR**

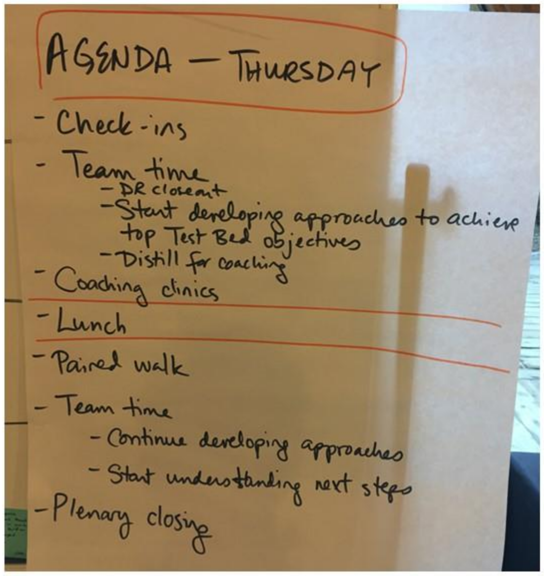
Overview of existing PGE DR programs

To close the day and start backgrounding the group in preparation for the following day's discussion, Josh Keeling gave an overview of PGE's demand response programs



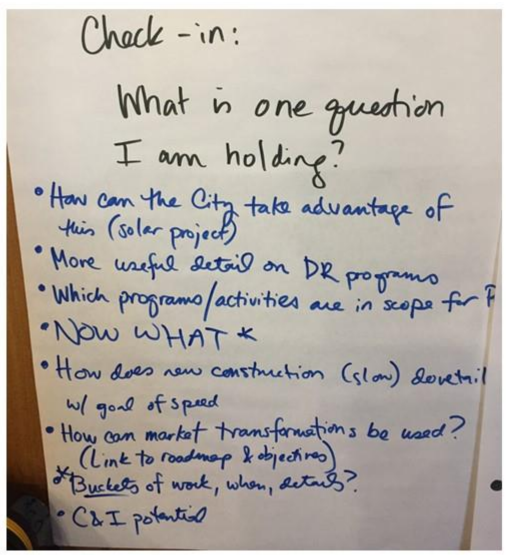
Thursday

Thursday agenda



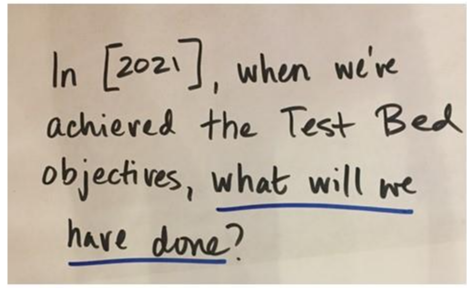
Check-in

The team kicked off Thursday by articulating a question they were still holding



Approach to achieve Test Bed objectives (1/5)

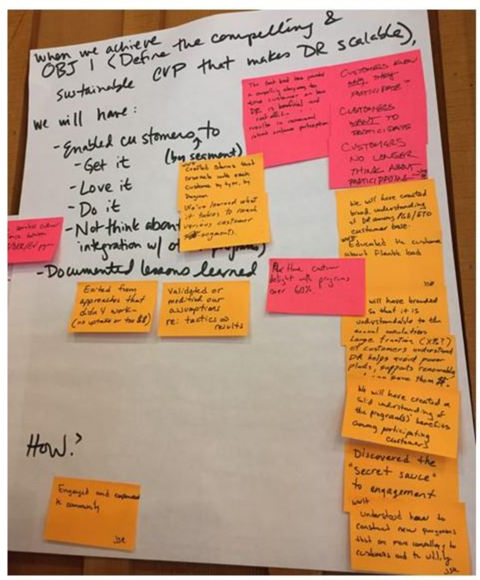
To start articulating their approach to achieving the Test Bed objectives (i.e., their second Accelerator objective), the team dug deeper into the four objectives by answering the following question (modeled on Amory Lovins' "snapback" hypothesis about designing for a future state): **when we've achieved the Test Bed objectives, what will we have done?**



Approach to achieve Test Bed objectives (2/5)

When we achieve Test Bed Objective 1 ("Define the compelling & sustainable customer value prop(s) that makes DR scalable"), **we will have:**

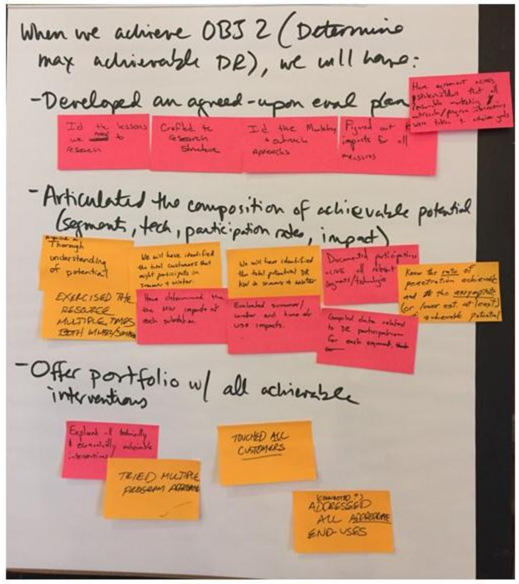
- **Enabled customers, by segment, to:**
  - **Get it**
  - **Love it**
  - **Do it**
  - **Not think about it (including integration w/ other programs)**
- **Documented our lessons learned**



Approach to achieve Test Bed objectives (3/5)

When we achieve Test Bed Objective 2 ("Determine the max achievable DR (in terms of summer & winter impact and participation)"), **we will have:**

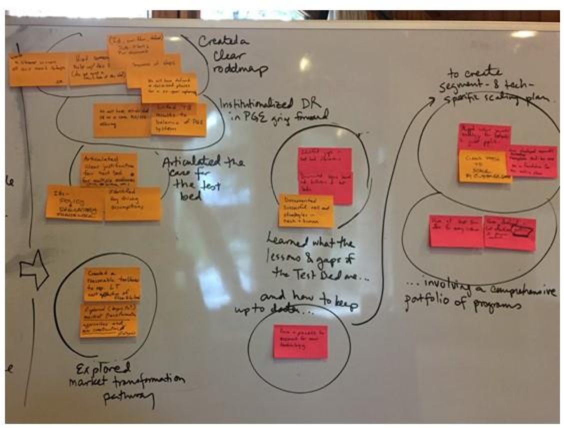
- **Developed an agreed-upon evaluation plan**
- **Articulated the composition of achievable potential (segments, technology, participation rates, impact)**
- **Offered a portfolio w/ all achievable interventions**



Approach to achieve Test Bed objectives (4/5)

When we achieve Test Bed Objective 3 ("Create long-term scaling plan"), **we will have:**

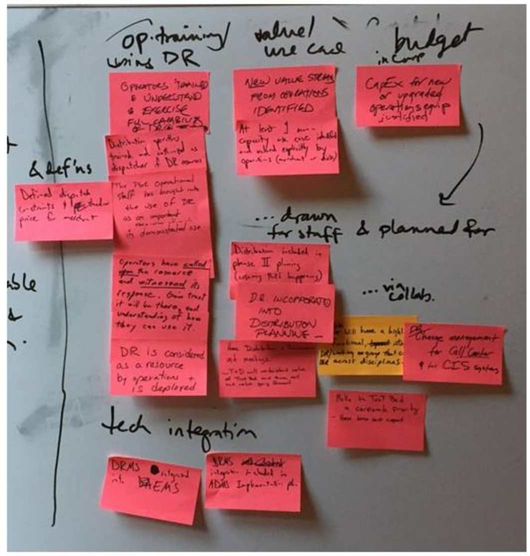
- **Created a clear roadmap**
- **Institutionalized DR in PGE**
- **Articulated the case for the Test Bed**
- **Explored the market transformation path**
- **Learned what both the lessons and the gaps of the Test Bed are…**
- **…and how to keep them up to date…**
- **…to crate a segment- and tech-specific scaling plan…**
- **…involving a comprehensive portfolio of programs.**



Approach to achieve Test Bed objectives (5/5)

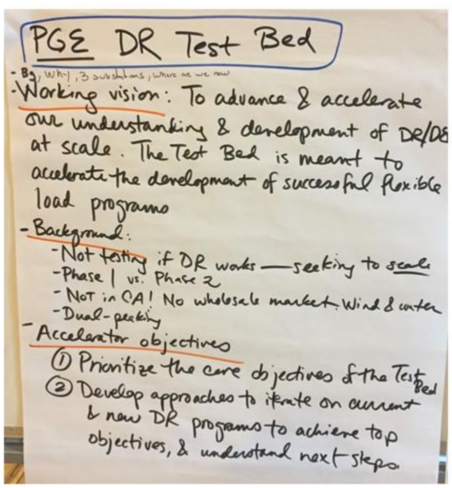
When we achieve Test Bed Objective 4 ("Socialize and begin to understand operational use of DR"), **we will have:**

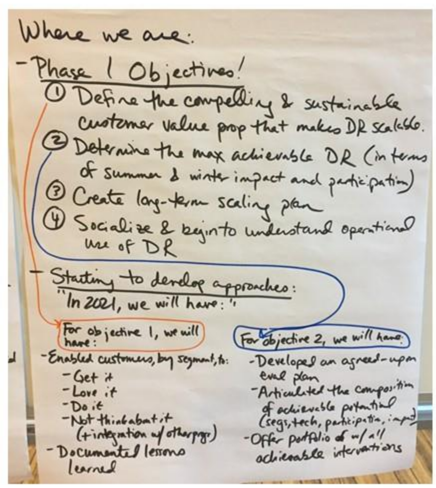
- **Conducted operational training using DR, & made relevant definitions**
- **Articulated the value/use case...**
- **...drawn from staff and planned for via collaboration with staff**
- **Done tech integration**
- **Incorporated into budget**



Coaching clinic (1/2)

Before lunch on Thursday, the team presented the current state of their work for feedback from two other groups

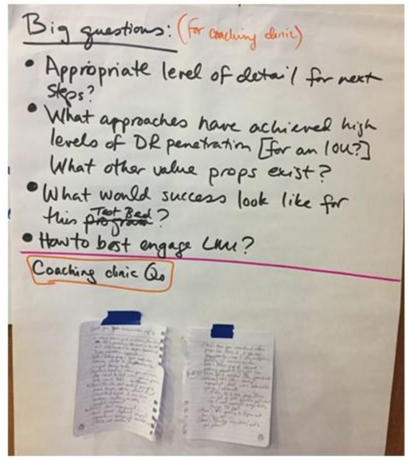




Coaching clinic (2/2)

The team came in with some high-level questions for the other groups. The other groups articulated several "coaching questions" for the PGE team to consider, including:

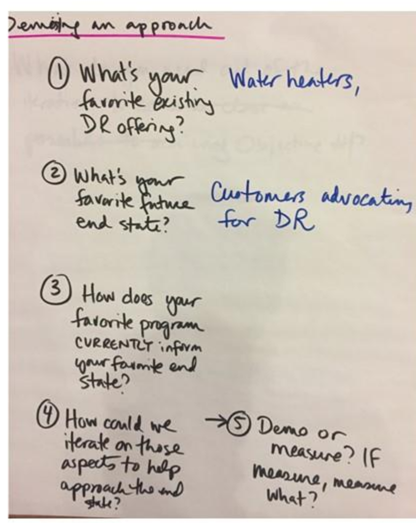
- Kill the term "DR" and replace with something alliterative, familiar, and positive, e.g., "Surge Savers"
- Have you considered value props for DERs and if DR can piggyback, esp. for CO2 mitigation. Consider pairing w/ community solar
- LMI side = early engagement is important. Add LMI stakeholder groups/advocates
- If doing DR & DER programs, there are lots of DER benefits people want. Don't have separate programs, and make sure not to *do things TO people*
- How do anticipated benefits break down between local level and bigger grid, and how between customer/system/society—think about benefit accrual
- Customer engagement: think about segments beyond segments (e.g., groups of buildings where you can bypass individual building owners)
- Why not start with a very ambitious goal?
- If we know there are saturation effects w/ customer programs, how do you reconcile that with staging
- Relevant to messaging
    - Include the "why" and how you picked the 3 substations
    - Don't forget the value prop of decarbonization / avoided peaking plant is valuable; consider gamification of avoided CO2
    - If the point of the Test Bed is to figure out how big the potential for DR is, say so!
    - Clarify the objective and the relationship to the gas plant / future decarb goals



Demonstrating an approach to achieving the Test Bed objectives (1/2)

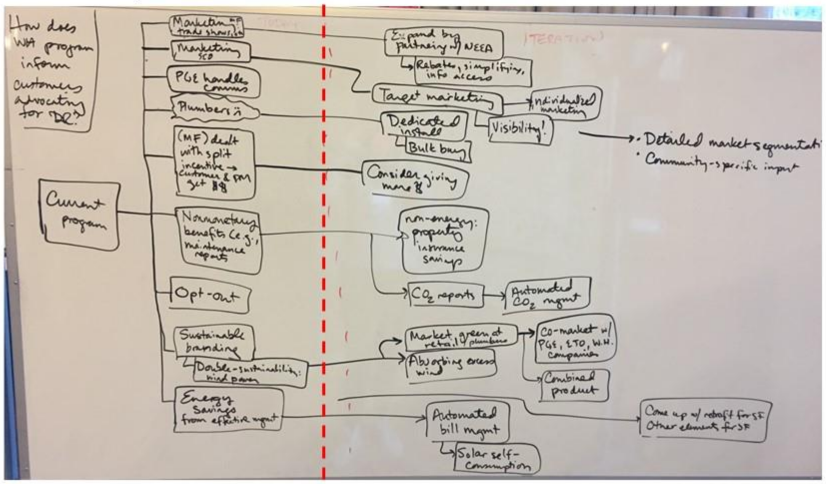
To explore a more granular example of what it would look like to achieve the Test Bed objectives (or, in this case, part of Test Bed Objective #1), the team discussed how they might iterate on current PGE DR offerings to achieve a desired end state.

The team chose to explore the existing **water heater** program offering to see how it currently informs, and could be iterated on to further inform, the future end state of **customers loving (and advocating for) DR.**



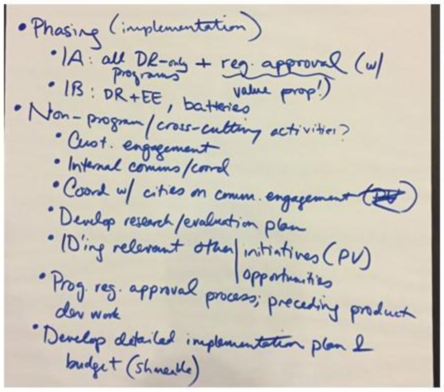
Demonstrating an approach to achieving the Test Bed objectives (2/2)

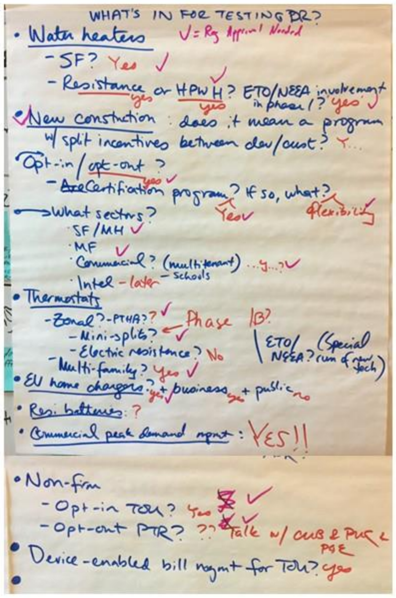
The team brainstormed attributes of PGE's current water heater program that inform how much customer love/advocate for DR (to the left of the red dotted line), and imagined how those program's attributes might evolve in the Test Bed to make customers love/advocate for DR even more (to the right of the red dotted line).

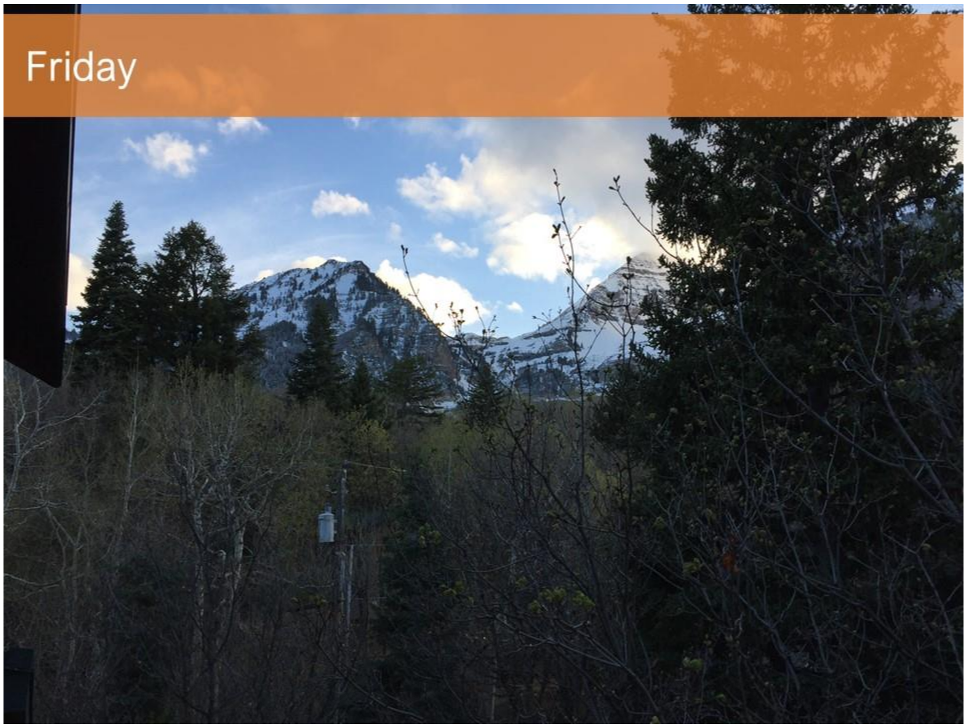


Scoping the limits

The team ended Thursday with a discussion of what's on the table for the Test Bed, and an articulation of phasing and high-level activities. *Purple check marks indicate that regulatory approval is needed*

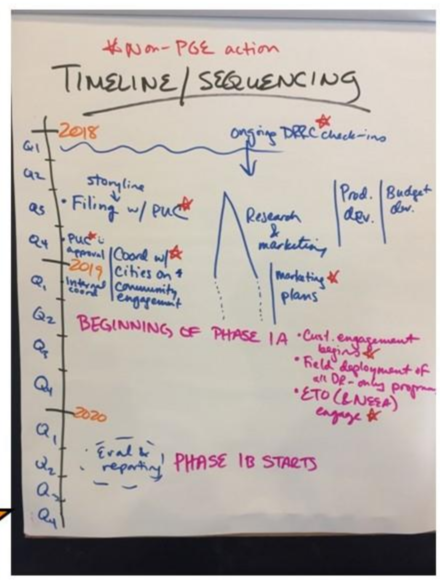






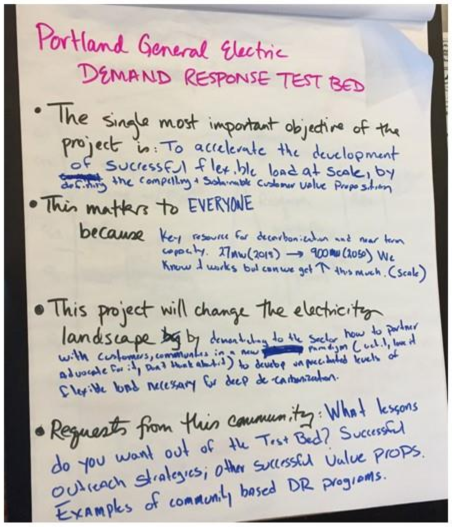
Final check-in and timeline work

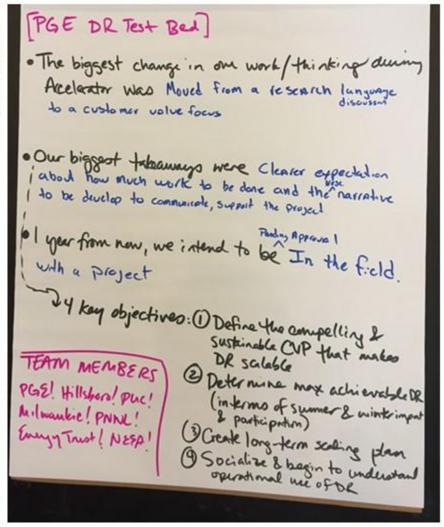
On the final morning the team checked in on things they were excited about and on any remaining concerns they had about the work. The team generally felt very excited about the progress and joint understanding achieved at Accelerator. Remaining questions/concerns existed around sequencing/timeline and how to package offerings to customer and to the PUC. As a result of the first concern, the team did a quick exercise to generate a timeline for the work.



Final presentation for sharing

The team assembled a presentation for the other 12 teams showcasing their work.

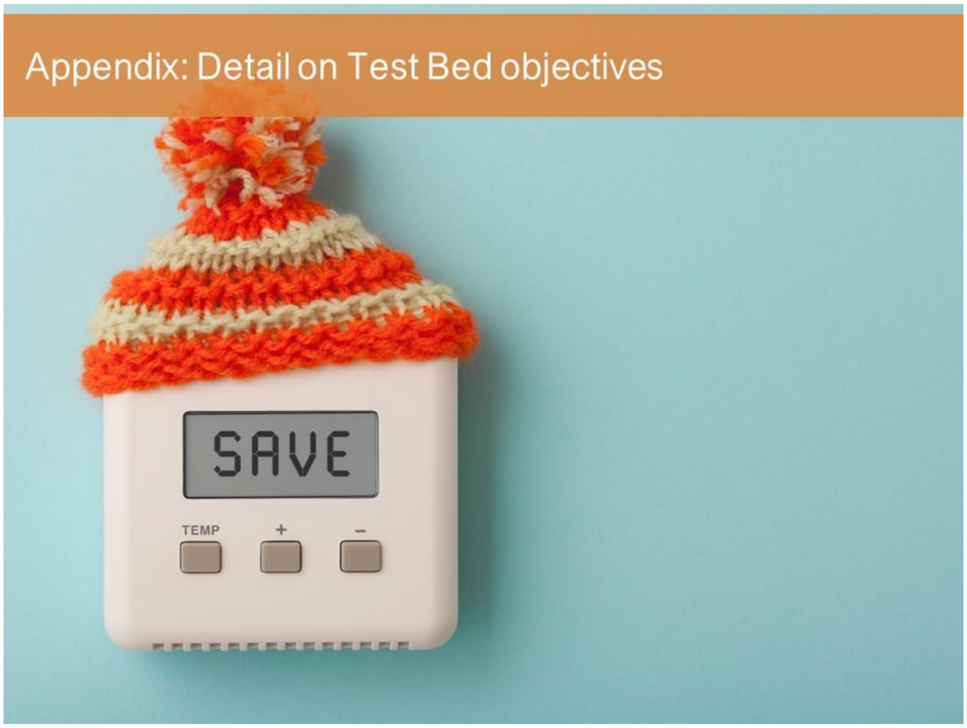




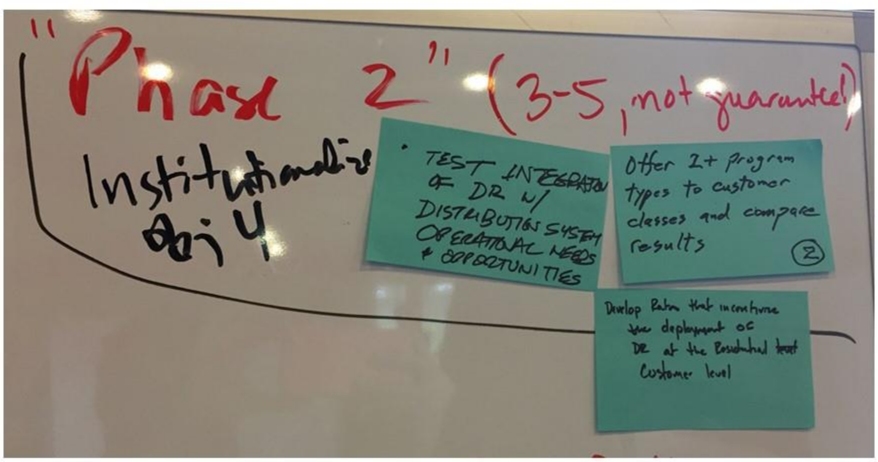
Final presentation feedback

The presentation was structured with lots of opportunity for other eLab Accelerator participants to offer feedback, including:

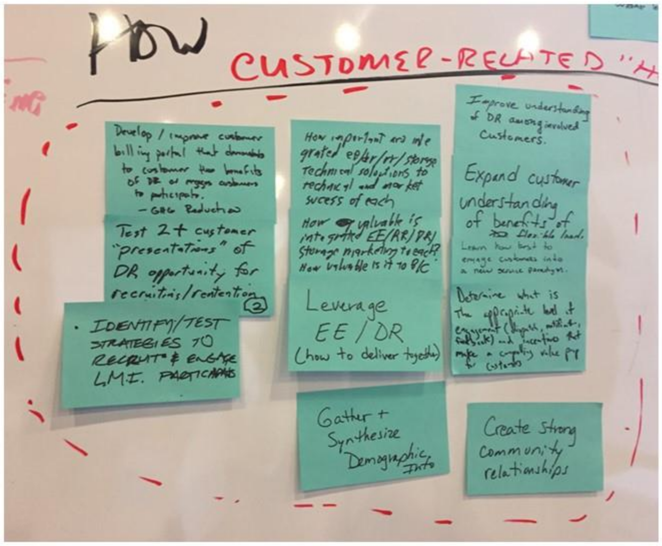
- 25% flexible load message is important—people think the grid can't take more variable renewables!
- What's the granularity of control? Check out CEE's geotargeting of DR in Minnesota (Megan Hoye)
- Consult w/ a campaign manager—Solarize campaign (artificial deadlines) are super effective. Look to find third parties interested in learning lessons, and partner!
- Challenge around integrating lots of DR/DER services to balance RE, high penetration on Dx grid gets complex…how are you going to deal with this so you can actually schedule it in?
- To what extend are you thinking about partnering with third-party providers? Thinking of Stem pilot in CA—deploying batteries but really deploying smart controls
- Cheers to a utility not intent on owning the asset!
- Concern with rolling out multiple programs simultaneously?
- HPWH: tradeoffs between efficiency and flexibility? Consider re-examining the value prop you think exists in the context of huge long-term flexibility goals
- Challenge your staging DR first, DER next—successful programs offer the things people want, which is rarely just DR
- Have you considered load disaggregation?
- Usually communities haven't done a really in-depth resource potential study—consider it
- Consider raising incentives and rates now, not later, since you'd do it later anyway but can get more benefit now
- If savings show up on the bill it's a powerful reinforcement
- Low-income: math/literacy issues in understanding the DR/flexible load program. Translate for Chinese, Vietnamese, Russian, Spanish. Also: empowerment. We are going to help you get empowered; we are not going to empower
- How is it being paid for? Any effort to get the regulator to capitalize?
- If this is the future how does it change the model? Engagement from environmental



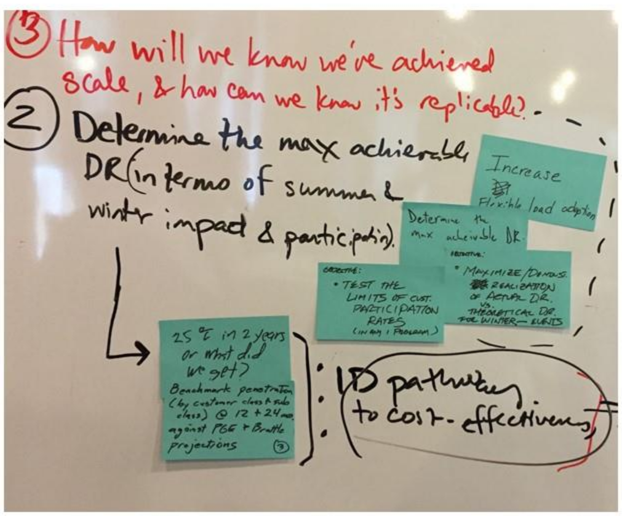
Detail: Test Bed objectives, Phase 2



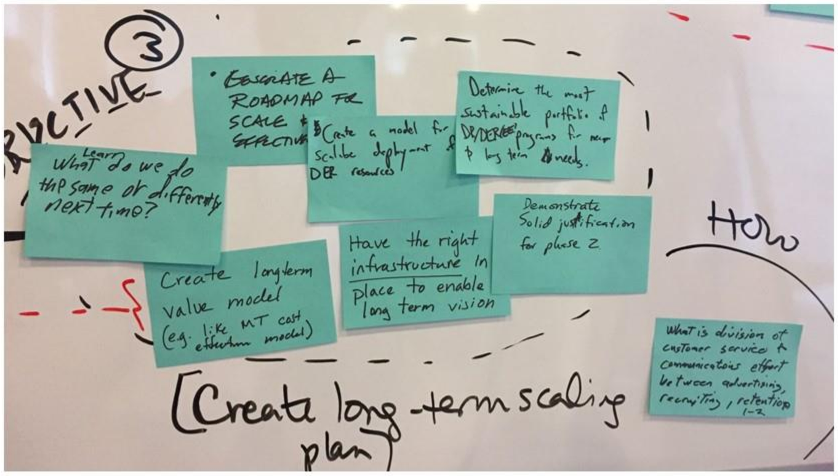
Detail: the "how" of Test Bed objective 1



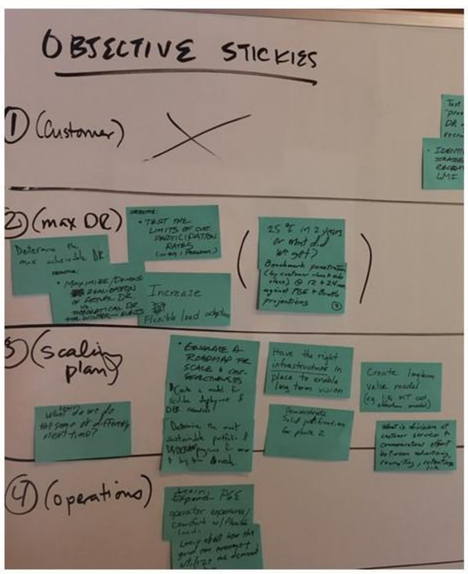
Detail: the "what" of Test Bed objective 2



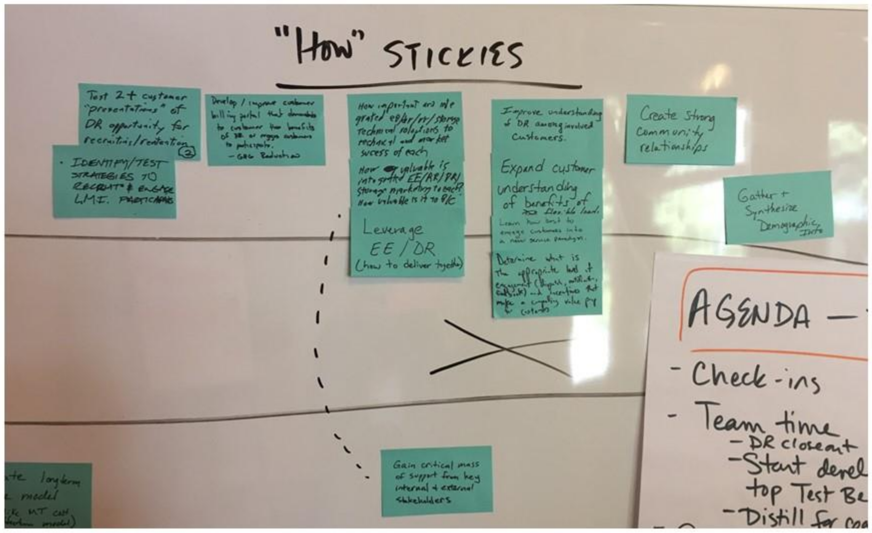
Detail: the "what"/"how" of Test Bed objective 3



Detail: the "what" of all Test Bed objectives



Detail: the "how" of all Test Bed objectives

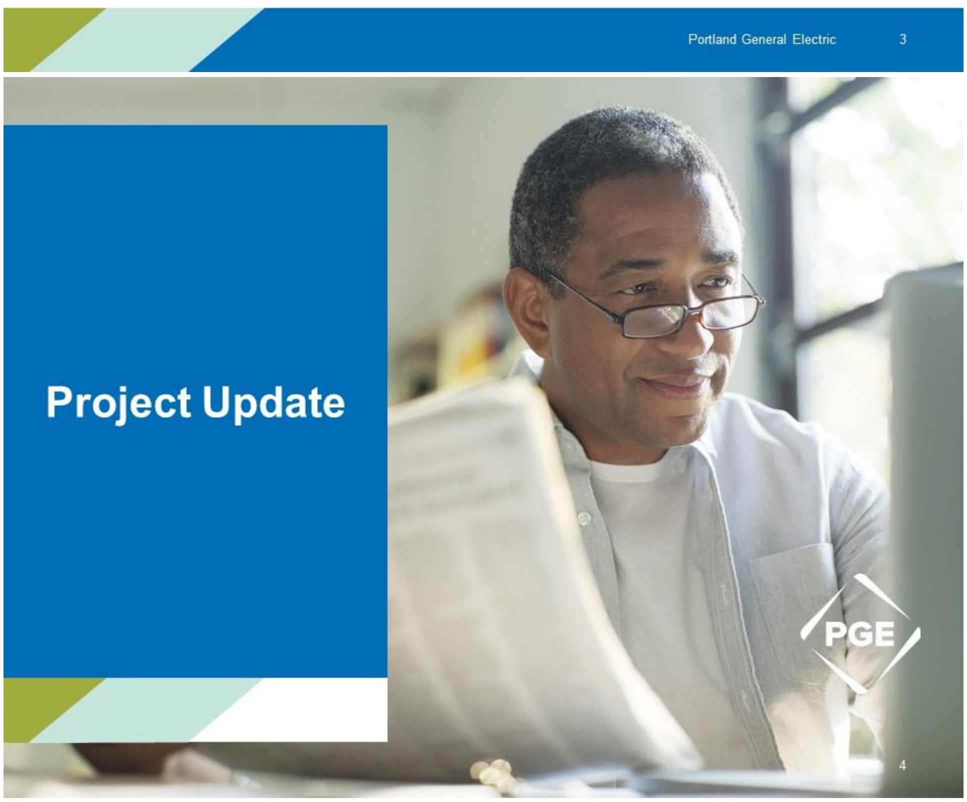


D.2.4 June Demand Response Review Committee Meeting Presentation

New Member Observer Discussion

Entertaining new members to the DRRC

It has been raised that perhaps PGE should either invites new members to join the DRRC or allow observers. PGE would like to discuss the possibility of each and the roles.



PGE Test Bed Team Objectives

- The PGE Test Bed team pursued two objectives at eLab Accelerator based on interviews that Margaret (the team facilitator) did with all team members in advance and refined on Day 1 of the event:

1. **Prioritize the core objectives of the Test Bed**
2. **Develop approaches to iterate on current & new DR programs to achieve top strategic objectives, & understand next steps involved**

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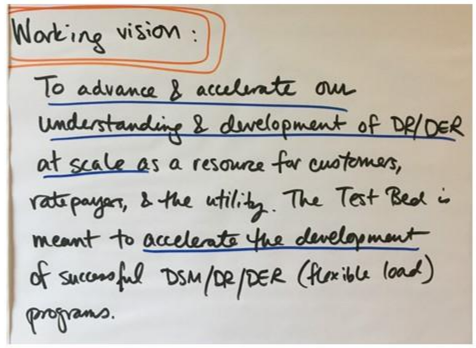
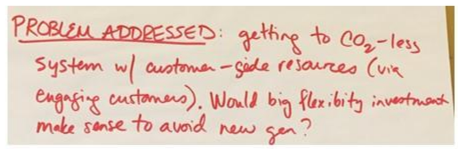
First team time on Tuesday (1/2)

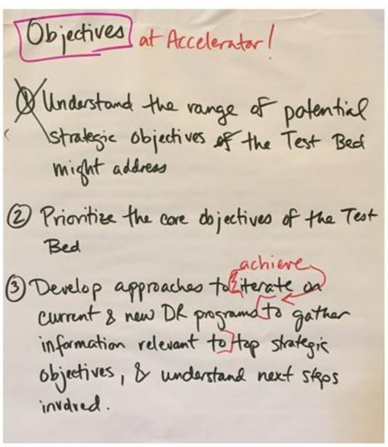
The RMI Team addressed many of the same questions the DRRC has raised.

- **Did a check-in which led to a discussion about the roles of the city reps**
- **Got clearer on a "working vision" to ground the discussion**
- **Collected questions and changes to the objectives**
- Discussed what's already established vs. what constitutes open questions to be addressed
- Named some things that are out of scope (e.g., fine-tuning any internal/external messaging)
- Discussed the problem addressed by the Test Bed

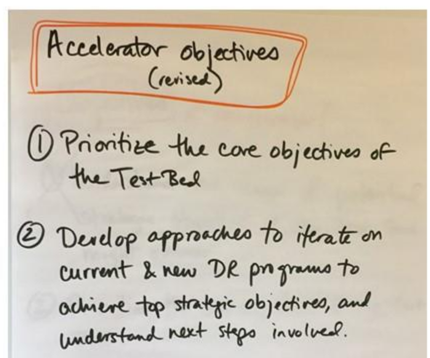




First team time on Tuesday (2/2)



Original objectives



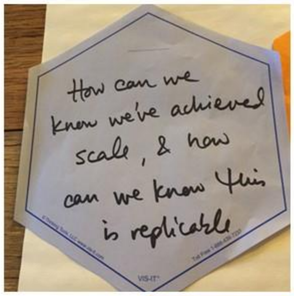
Revised objectives

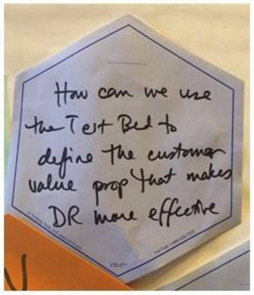
The team revised their objectives for Accelerator during their time together on Day 1

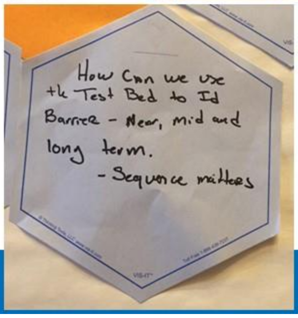
Modeling the current reality (3/3)

Three important questions arose from the collaborative building of the Lego model:

1. **How can we use the Test Bed to ID barriers (near, mid, and long term)? Sequence matters**
2. **How can we use the Test Bed to define the customer value prop that makes DR more effective?**
3. **How can we know we've achieved scale, & how can we know this is replicable?**







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Prioritizing Test Bed objectives (2/2)

The group agreed on four core Test Bed objectives:

1. **Define the compelling & sustainable customer value prop(s) that makes DR scalable**
2. **Determine the max achievable DR (in terms of summer & winter impact and participation)**
3. **Create long-term scaling plan**
4. **Socialize and begin to understand operational use of DR**

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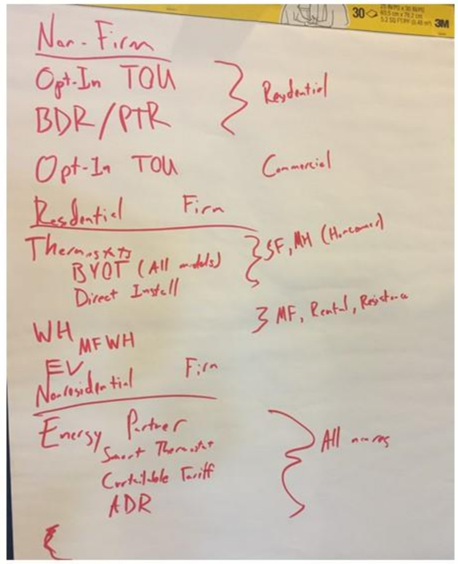
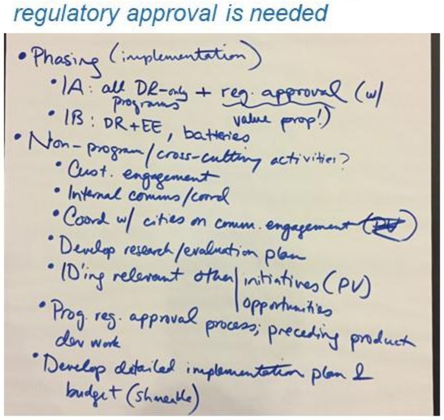
Overview of existing PGE DR programs

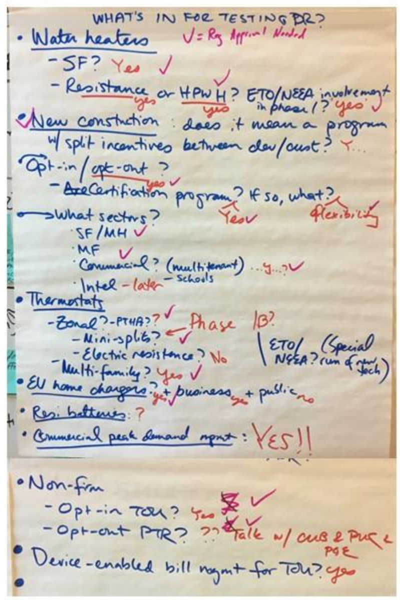
To close the day and start backgrounding the group in preparation for the following day's discussion, Josh Keeling gave an overview of PGE's demand response programs



Scoping the limits

The team ended Thursday with a discussion of what's on the table for the Test Bed, and an articulation of phasing and high-level activities. *Purple check marks indicate that regulatory approval is needed*





What is the Test Bed

Current Measures

SF – Thermostats
- Direct Install
- BYOT

MF – Water Heaters

Business and Government Demand Response

Flex
- PTR
- TOU

New Measures

SF – Water heaters
- Retrofit
- New replacement

MF Thermostats
- Electric resistance
- Direct install

Commercial - Thermostats
- BYOT

SF New Construction Bundle
- T-stat, WH,EV, storage ready

TE – Chargers SF
TE – Chargers MF
TE – Chargers Fleet/Business
Batteries – UM 1856, Resi, Commercial

Emerging Measures

SF – Thermostats (Mini-splits)
MF – Thermostats PTHP, mini-splits
Commercial Peak Demand Management

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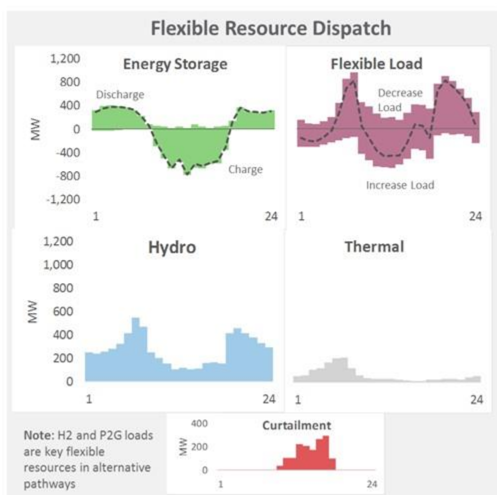
Balancing solutions

In a deeply decarbonized future, flexibility in the electricity system is provided by both generators and loads



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As more end uses are served by electricity, ensuring that these loads can be met flexibly is a critical strategy for reducing the cost of decarbonizing

Flexible loads

Pathways incorporate massive adoption of flexible loads in the long term

Flexible load participation by 2050

- 75% of light duty vehicle load
- 75% of water heating load
- 50% of space conditioning load
- 50% of clothes washing and drying load

Nature of flexible loads

- Dynamic, can help integrate renewables over short timescales
- Maintains quality of energy service delivery to customers

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Test Beds Where DR becomes Flexible Load

PGE will be using the Test Bed to develop a new type of resource called flexible load.

Impetus for the Development of Flexible Load is De-carbonization, Renewable and DER Development

- DR has traditionally structured as a peak load mitigation strategy either through dynamic rate structures of direct load control programs.
- Traditional DR programs are available for a very limited number of hours of the year for limited energy services
- Through modeling and observations from other markets in the US and internationally PGE has realized that up to 25% of our resources must come from the demand side or "flexible load."
- This means that PGE must begin to develop and learn how to develop a resource in partnership with our customers that is available for many different energy services at all hours of the day through-out the year.

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Program Development Strategy

- PGE plans to place all residential customers in the Test Bed on Opt-out PTR.
- Because PTR is a limited run time, limited availability resource that will help meet the 2021 capacity gap identified in the 2016 IRP it has immediate strategic value if it demonstrates success in the Test Bed.
- However, we will be looking to migrate Test Bed participants to direct load control programs (T-Stats, Water Heaters, EV chargers, batteries) in order to begin building flexible load capabilities.

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Benefits of the Test Bed to Date

Coordination of Activity and New Thinking
The Test bed is Already Yielding Benefits

1. The Test Bed is a strategic initiative supported by the executive team within PGE
2. The Test Bed will help us inform the FERC on post Order 841 Technical discussion and proposed DER wholesale market inclusion rules.
3. Test Bed is helping PGE to coordinate with ETO and NEEA.
4. The Test Bed grants us a venue for other funded research opportunities, thus leveraging ratepayer funding to extract a great number and level of benefits
5. Leveraging Oregon and national expertise to inform and help develop the project

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Test Bed Benefits: Research

Distribution System Planning Benefits

- Research how to optimize the distribution system and local resources.
- We are learning from other entities that multiple challenges arise with high penetration and reliance on local resources. (Frequency, feedback, voltage)
- We believe that Test Bed will give us an opportunity to understand how to plan for the operation of a distribution system to serve local and broad grid services/resources needs
- We were recently visited by the Commonwealth Scientific and Industrial Research Organization who may be interested in assisting with distribution research inside the Test Bed.

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Test Bed Benefits: External Project Funding

- PGE is not ready to work with other regional utilities to lower project costs
- Grant funding from US DOE is rarely available for widget procurement
- PGE did reach out to PNNL who is working with PGE, BPA and other NW utilities on CTA-2045 demand Response enabled water heaters to see if there was an opportunity to leverage the Test Bed to seek additional sub-project funding to continue and augment our CTA-2045 work with a greater number of water heaters inside one of the Test Bed sites.
- PGE is working with PNNL to develop a proposal that would meet the project activity types that US DOE may be interested in funding.
- This funding if awarded would not substitute for ratepayers dollars but would leverage the work of the Test bed to attract funding that would advance our DR work.

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Google Earth Fly-In

DR Program Participation

Total and Eligible Residential Meters within Test Bed

Cell phone contact estimated at 60% of all residential customers: cap on total DR enrollment

Eligible Meters					
Meter Type	Total	Thermo-stat	Water Heaters	PTR	TOU
SFR	14,306	75%	30%	60%	100%
MFR	5,197	10%	95%	60%	100%
Mobile Home	380	90%	90%	60%	100%
Total	19,883	11,591	9,571	11,930	19,883
Percent of All Meters	100%	58%	48%	60%	100%

Participation Target
Aggressive Scenario

Aggressive Scenario					
Meter Type	Thermo-stat	Water Heaters	PTR	TOU	Total
Participation Rate					
SFR	25% / 19%	25% / 8%	remainder	5% / 5%	
MFR	25% / 3%	50% / 48%	remainder	5% / 5%	
Mobile Home	25% / 23%	25% / 23%	remainder	5% / 5%	
Participants					
SFR	2,682	1,073	4,113	715	8,584
MFR	130	2,469	260	260	3,118
Mobile Home	86	86	38	19	228
Total	**2,898**	**3,627**	**4,411**	**994**	**11,930**
Total Load Impact by December 2020 (MW)					
Winter	0.53	1.45	0.65	-	2.63
Summer	1.96	2.18	0.39	0.07	4.59
Per Participant Load Impact (kW)					
Winter	0.76	0.40	0.15	-	
Summer	0.89	0.60	0.09	0.10	

Participation Target
Moderate Scenario

Moderate Scenario					
Meter Type	Thermo-stat	Water Heaters	PTR	TOU	Total
Participation Rate (goal, goal x eligible meter share)					
SFR	13% / 9%	13% / 4%	remainder	5% / 5%	
MFR	13% / 1%	25% / 24%	remainder	5% / 5%	
Mobile Home	13% / 11%	13% / 11%	remainder	5% / 5%	
Participants					
SFR	1,341	536	5,991	715	8,584
MFR	65	1,234	1,559	260	3,118
Mobile Home	43	43	124	19	228
Total	**1,449**	**1,814**	**7,673**	**994**	**11,930**
Total Load Impact by December 2020 (MW)					
Winter	0.26	0.73	1.13	-	**2.12**
Summer	0.98	1.09	0.68	0.07	**2.81**
Per Participant Load Impact (kW)					
Winter	0.76	0.40	0.15	-	
Summer	0.89	0.60	0.09	0.10	

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Commercial and Industrial Budget

Commerical & Industrial High Level Budget	
SMB conversion	25%
Large conversion	40%
Total customers enrolled	**577**
Marketing	$ 90,000
Sales/Outreach	$ 50,000
Provisioning	$ 250,288
Equipment	$ 478,246
Incentives	$ 137,715
Project Management	$ 70,000
Total	**$ 1,076,249**
Type	DR potential (kW)
Small	1,092
Medium	618
Large	165
Total	**1,875**
$/kW	574

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Residential Marketing Budget

Residential Marketing Tactic		
Digital advertising	$	270,000
Search engine marketing		
Digital advertising/social advertising		
Direct mail/Email marketing	$	80,000
Targeted direct mail and email combo sent to each neighborhood		
Community events/partnerships	$	100,000
Tabling and sponsorships at fair/festivals		
Working with businesses on gamemifiction of outreach		
Work with Energy Partner business customers to engage their customers		
Influencer marketing	$	150,000
Identify influential/ community leaders in each neighborhood, get them on board to talk about programs through social media or at events, community forums, etc.		
Model homes - in each neighborhood	$	10,000
PGE employee or influencer home enrolled in all DR program - utilized to showcase, take pictures of home, create profile of home, and utilize in case studies, social media and for tours.		
TV, radio, print*	$	60,000
Local or community/neighborhood papers, local radio (OBP, NPR)		
* This is for TV placement only and does not account for production costs		
Total	**$**	**670,000**

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Test Bed Budget

Budget Category	2018	2019	2020	Total
Residential DR				
Programs		580,000	620,000	**1,200,000**
Marketing	268,000	268,000	134,000	**670,000**
Residential total	*268,000*	*848,000*	*754,000*	***1,870,000***
Industrial DR				
Programs		470,000	470,000	**940,000**
Marketing	36,000	36,000	18,000	**90,000**
Industrial total	*36,000*	*506,000*	*488,000*	***1,030,000***
Research	60,000	60,000	60,000	**180,000**
Evaluation			`	**450,000**
PGE limited term FTE	85,000	510,000	510,000	**1,105,000**
Contingency	33,000	33,000	33,000	**99,000**
IT	12,000	12,000	12,000	**36,000**
Test Bed Total	**494,000**	**1,969,000**	**1,857,000**	**4,770,000**

6.47MW Aggressive
4.69MW Moderate

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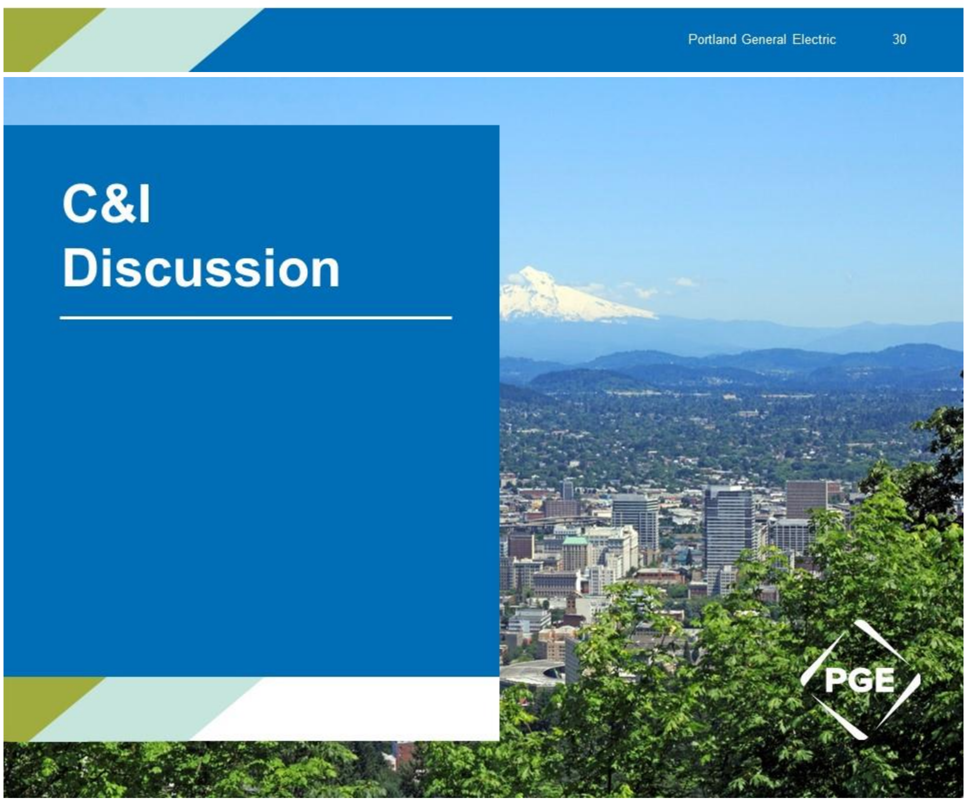
Five Year Residential Program Budget

Variable Program Participation Costs

Excludes all fixed costs associated with existing programs

	2019	2020	2021	2022	2023
Moderate Scenario					
Ongoing	$470,000	$500,000	$510,000	$520,000	$530,000
One-time	$320,000	$320,000	$0	$0	$0
Total	$790,000	$820,000	$510,000	$520,000	$530,000
Aggressive Scenario					
Ongoing	$490,000	$550,000	$560,000	$570,000	$580,000
One-time	$630,000	$650,000	$0	$0	$0
Total	$1,120,000	$1,200,000	$560,000	$570,000	$580,000



Business vs. Residential DR

More custom and complex

- Fewer, larger customers
- Load profile evaluation
- Concerned about impact on operations
- Longer sales cycle, one-on-one outreach
- Higher acquisition cost per customer
- Predominantly custom curtailment plans

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C&I DR Redesign

Flexible, rewarding program to meet customer needs

	Prior C&I	C&I	Smart Thermostat Small/Med, Multi-rate
Participation	110 customers, ~1% mkt 10.6 MW actual	305 customers, ~23% mkt 26MW goal	500 customers, ~0.5% mkt 1MW goal
Seasons	Winter(W): Dec-Feb Summer(S): Jul-Sep	Winter(W): Nov-Feb Summer(S): Jun-Sep	Winter(W): Nov-Feb Summer(S): Jun-Sep
Events	W/S: 12-10 W: 6-11	W/S: 11-4, 4-8, 8-10 W: 7-11	No constraint
Notification	10 minute	18 hour, 4 hour, 10 min	4 hour
Hours	40 per season	20, 40, 80 per season	150 per season
Event Duration	1-5 hours Paid time participated	1-5 hours Paid time participated	1-5 hours Paid if 50% participation during event hours
Incentives	Free installation Capacity: $5.67/kW-mo Energy: $0.125/kWh	Free installation Capacity:~$2 to $11/kW-mo Energy: ~$0.029/kWh (Mid-C)	Free thermostat $60 per season

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70%-90% Participation Exercise

	Scenario 1	Scenario 2	Scenario 3	Ongoing?
SMB conversion	25%	70%	90%	
Large conversion	40%	70%	90%	
Total customers enrolled	577	1,630	2,100	
Marketing	$ 90,000	$ 270,000	$ 405,000	No
Sales/Outreach	$ 50,000	$ 410,116	$ 875,289	10% ongoing costs
Provisioning	$ 250,288	$ 706,359	$ 916,764	10% ongoing costs
Equipment	$ 478,246	$ 1,360,639	$ 1,764,714	No
Incentives	$ 142,810	$ 1,450,940	$ 2,654,020	100% ongoing costs
Project Management	$ 70,000	$ 178,107	$ 203,902	10% ongoing costs
Total	$ 1,081,343	$ 4,376,162	$ 6,819,690	

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70%-90% Participation Exercise

MW Savings Potential

DR potential (kW)			
Type	**Scenario 1**	**Scenario 2**	**Scenario 3**
Small	1,092	3,081	3,965
Medium	618	1,783	2,300
Large	165	451	642
Total	**1,875**	**5,315**	**6,908**
$/kW	$ 577	$ 823	$ 987

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How to mitigate the fear DR negatively impacts operations?

Operations

Money back guarantee

- Offer money back guarantee if operations are adversely affected to cover cost.
- Limits to impact e.g., temp won't go up more than X degrees
- Warranty on equipment and labor.
- Provide contractual guarantees to reimburse any losses due to set-up or event participation.
- PGE takes out insurance to cover any losses we need to cover, create "insurance" rider

We got your back

- Tell customer that we will contact them after each event to see how things went and answer any questions. They don't need to follow up with us.
- Promise customer that they can call a skilled professional (give them number) and any time for help during an event or outside of an event for support.

Super Flexibility

- Let customer pick their own event times for every event e.g., if event from 4 to 8 they can just participate from 4 to 5 if they want.
- Reiterate that customer is in control and can always opt-out of an event if they want.

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How might we take away the fear DR negatively impacts operations?

Operations

Minimum participation

- Only 1 to 3 events per year. Emergency load only.

Operation could improve

- Educate that with PGE's assistance: engineering resources, portal showing real time usage - they may become more efficient.

Resiliency Add-Ons

- Microgrid-lite, we help you set up (select, install) a microgrid and even help offset cost.

Money you can count on

- Guarantee a standard monthly payment. No retaliation for non-performance during an event. Increase for over-performing.

Make money and come out ahead

- Present the business case.

Reduce risk and anxiety

- Identify load not part of critical processes. Start with small and easy loads to build confidence.

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How might we take away the fear DR negatively impacts operations?

Operation

Customer testimonials

- Share experiences of like industries, use similar participant loads e.g., pump stations as examples, develop industry-specific case studies
- Normalize DR participation via case studies, enabling connection to similar customers.

Practiced mentor pair up

- Pair up with practiced mentor; connect prospective with current customers for support, reimburse the customer that provides the advice?

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How might we design programs with a enrollment requirement?

Requirement

Building Codes

- Advance commercial building code.
- Code for new buildings (title 24) to assure the new building is flexible load ready.

ETO channel

- Any ETO project must have a DR component

Other

- Opt-out demand response program
- Default Critical Peak Pricing
- Opt-out CPP or VPP like in California.
- Higher rate if not on demand response
- Rate changes/reduces when enrolled; rate "7DR" would be 1 cent/kWh less than Rate 7 w/out DR
- New emergency DR programs. Note: this cannibalizes other flexible load potential.
- Higher demand charges. Offer peak demand management to offset.
- PTP - peak time pay (vs. rebate)
- DR get carbon adder in carbon accounting under cap and trade
- State Statute/ rulemaking
- ODOE or other agency building code compliance audits

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How might we create enough of an incentive ($ or non-monetary) to make it worth participating?

Incentives

DER Add-Ons

- Free batteries for signing up for DR
- Cost offset for EV charging if DR enabled and enrolled
- More dollars for storage
- Enhanced incentive if spent on DSM/RE
- Incremental incentive for IDMS project (EE+DR+Storage)
- Package with other offering or show how incentives could leverage for resiliency products behind the meter storage or self generation

Name your Price

- Tell us how much you need to be paid
- Find other incentives. If money if not enough what other incentives might work; positive press, fend off legislative action

Free Tech

- Free BSM to reduce energy costs
- Free training
- Include tech to enhance current functionality

Healthy Competition/Gamification

- Establish comparison w/ peers
- Ads comparing load shift

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How might we create enough of an incentive ($ or non-monetary) to make it worth participating?

Incentives

Progressive Incentive

- Increase payment or pay structure where payment increases as we add more events.
- Tiered reward system
- Tie incentive payout to 501(c)(3) donation
- Offer tax rebate
- Structure incentive payout to be derivative of event savings (v flat fee/rate)

Community Appeal

- Part of a larger group supporting community action
- Tie incentive payout to specific environmental or habitat project of their choice…PGE adds marching dollars

Other

- Front loaded incentive (w/firm 10 year contract) we pay up front costs for customer for approved program
- Provide building system improvement

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Questions?

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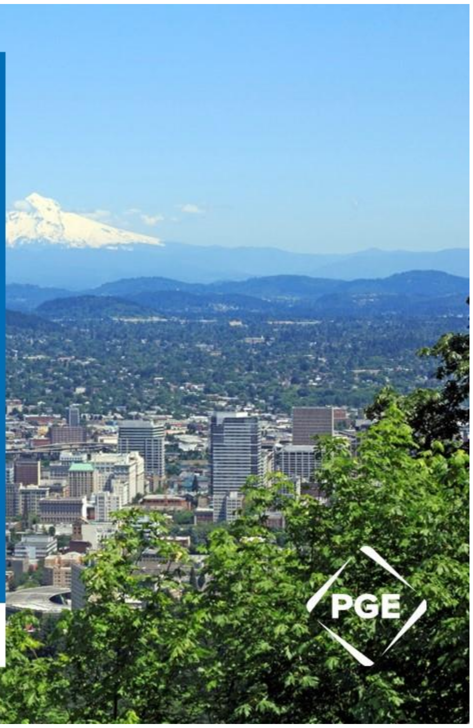
DR Testbed

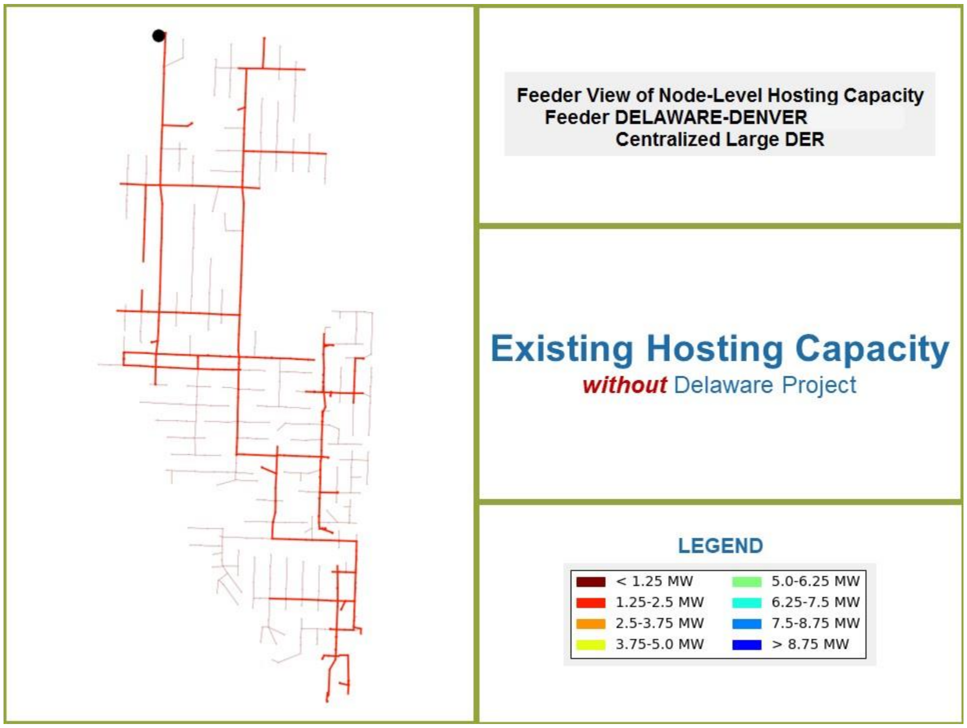
Hosting Capacity Study
T&D Planning

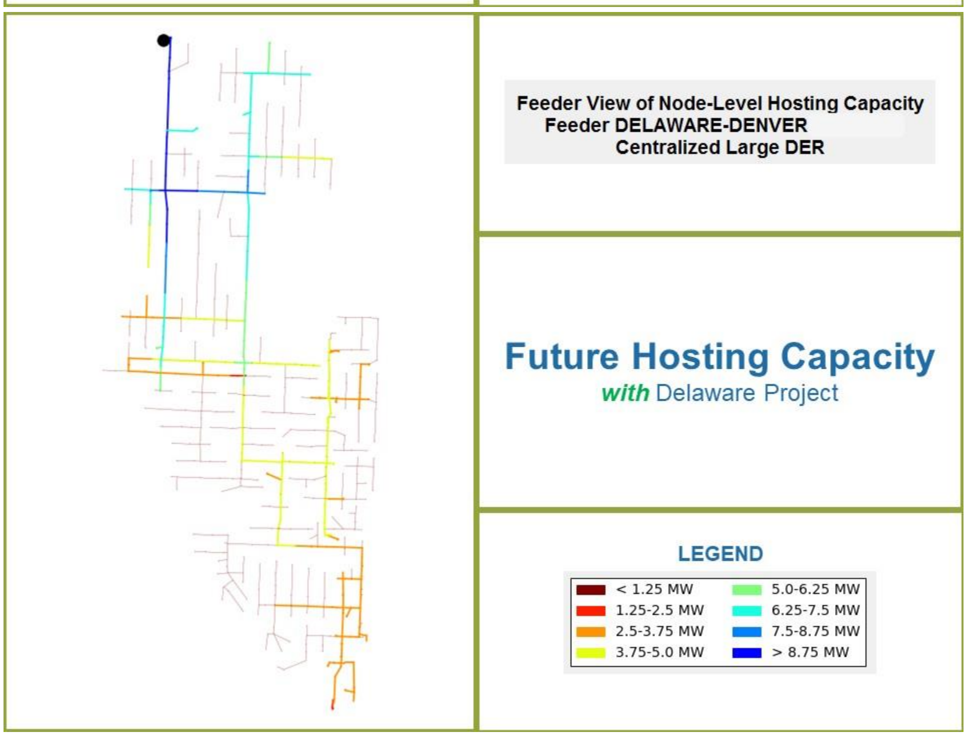


Delaware Substation

Hosting Capacity Study: DR Testbeds
T&D Planning

45


Feeder View of Node-Level Hosting Capacity
Feeder DELAWARE-DENVER
Centralized Large DER
Existing Hosting Capacity
without Delaware Project
LEGEND
< 1.25 MW
1.25-2.5 MW
2.5-3.75 MW
3.75-5.0 MW
5.0-6.25 MW
6.25-7.5 MW
7.5-8.75 MW
> 8.75 MW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Feeder DELAWARE-DENVER
Centralized Large DER
Future Hosting Capacity
with Delaware Project
LEGEND
< 1.25 MW
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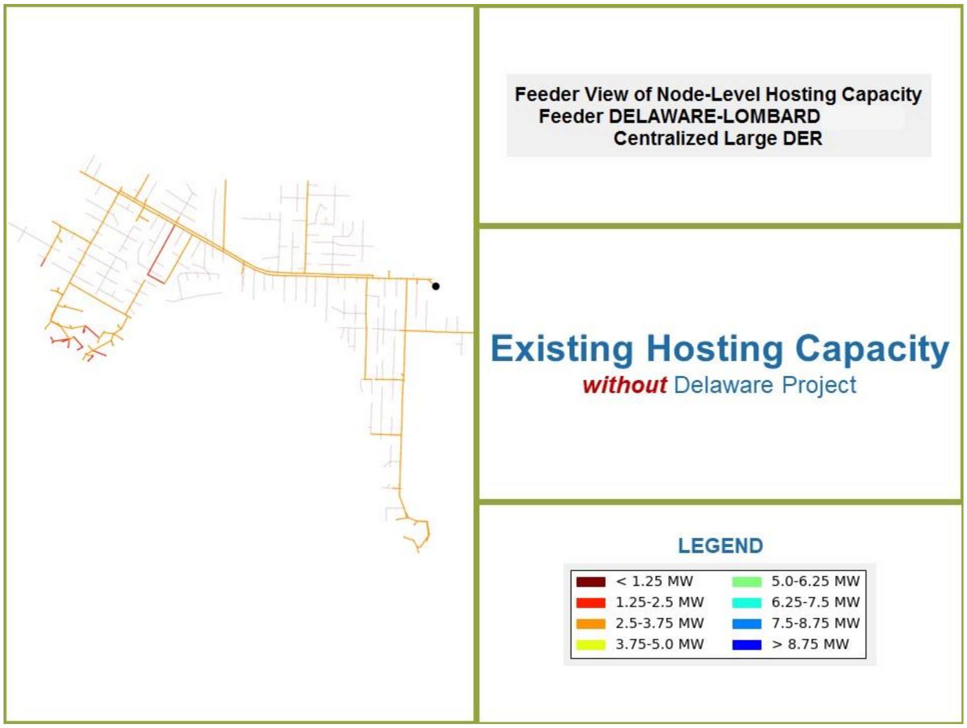
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Feeder DELAWARE-LOMBARD
Centralized Large DER
Existing Hosting Capacity
without Delaware Project
LEGEND
< 1.25 MW
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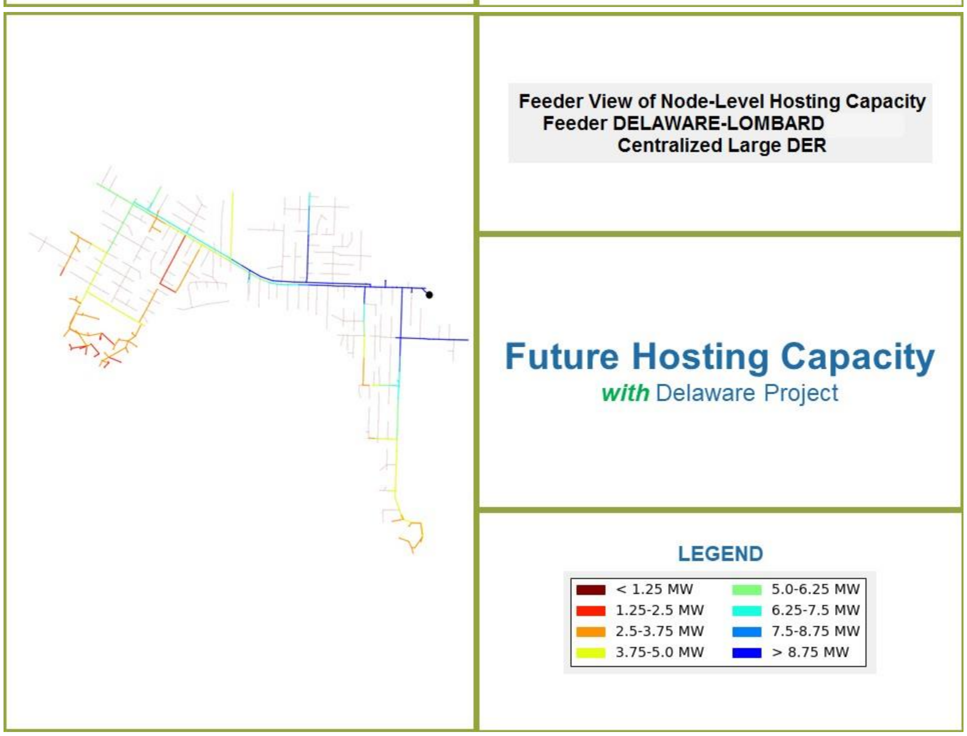
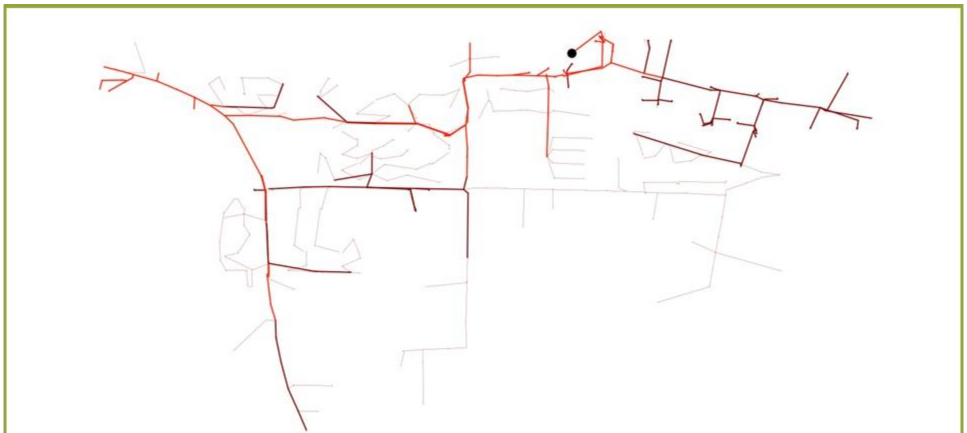
2.5-3.75 MW
3.75-5.0 MW
5.0-6.25 MW
6.25-7.5 MW
7.5-8.75 MW
> 8.75 MW


Feeder View of Node-Level Hosting Capacity
Feeder DELAWARE-LOMBARD
Centralized Large DER
Future Hosting Capacity
with Delaware Project
LEGEND
< 1.25 MW
1.25-2.5 MW
2.5-3.75 MW
3.75-5.0 MW
5.0-6.25 MW
6.25-7.5 MW
7.5-8.75 MW
> 8.75 MW

Roseway Substation

Hosting Capacity Study: DR Testbeds
T&D Planning

50

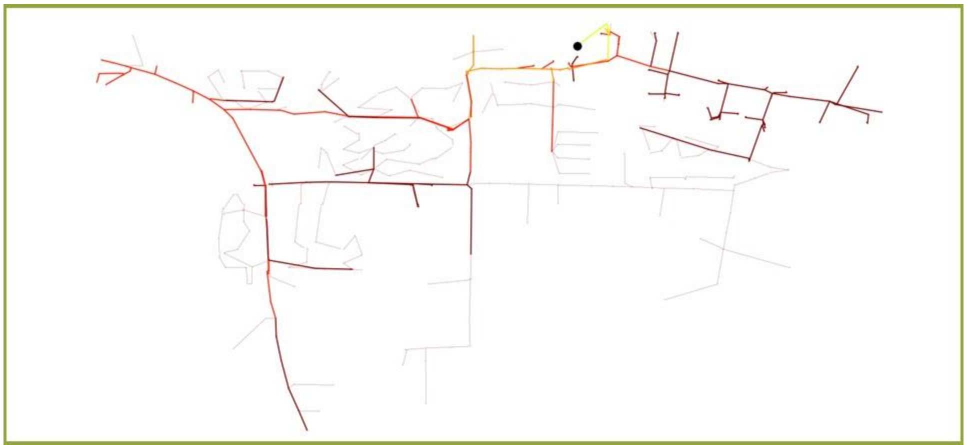


Existing Hosting Capacity
without Roseway Project

Feeder View of Node-Level Hosting Capacity
Feeder ROSEWAY-ALEXANDER
Centralized Large DER

LEGEND

< 1.25 MW
1.25-2.5 MW
2.5-3.75 MW
3.75-5.0 MW
5.0-6.25 MW
6.25-7.5 MW
7.5-8.75 MW
> 8.75 MW



Future Hosting Capacity
***with* Roseway Project**

Feeder View of Node-Level Hosting Capacity
Feeder ROSEWAY-ALEXANDER
Centralized Large DER

LEGEND

< 1.25 MW	5.0-6.25 MW
1.25-2.5 MW	6.25-7.5 MW
2.5-3.75 MW	7.5-8.75 MW
3.75-5.0 MW	> 8.75 MW

Feeder View of Node-Level Hosting Capacity
Feeder ROSEWAY-ROSEWAY 13
Centralized Large DER

Existing Hosting Capacity
***without* Roseway Project**

LEGEND

< 1.25 MW	5.0-6.25 MW
1.25-2.5 MW	6.25-7.5 MW
2.5-3.75 MW	7.5-8.75 MW
3.75-5.0 MW	> 8.75 MW

Feeder View of Node-Level Hosting Capacity
Feeder ROSEWAY-ROSEWAY 13
Centralized Large DER

Future Hosting Capacity
with Roseway Project

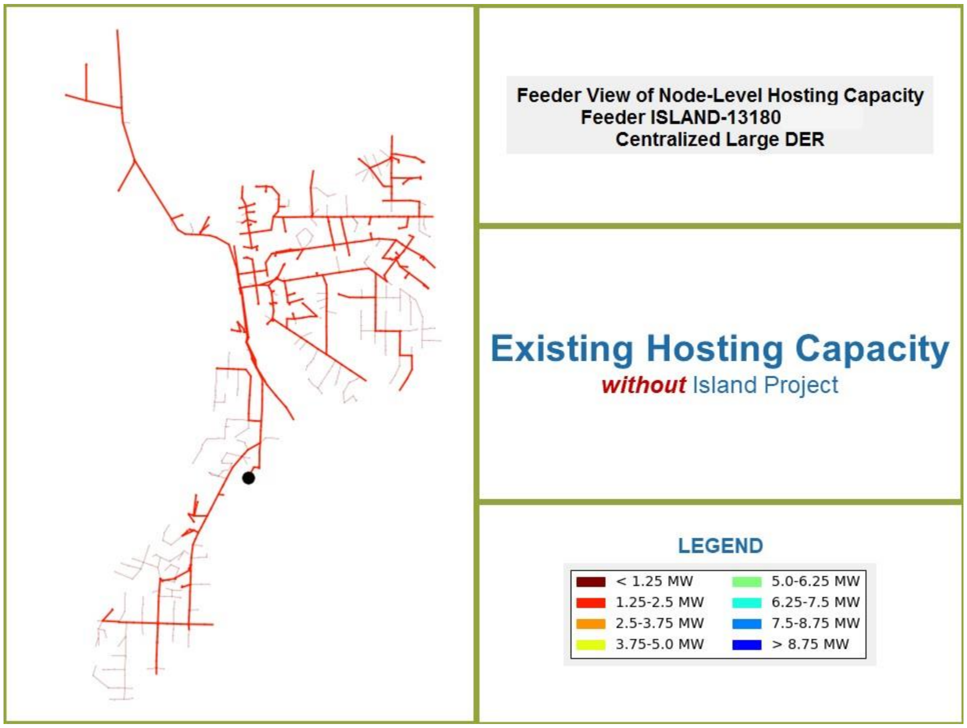
LEGEND

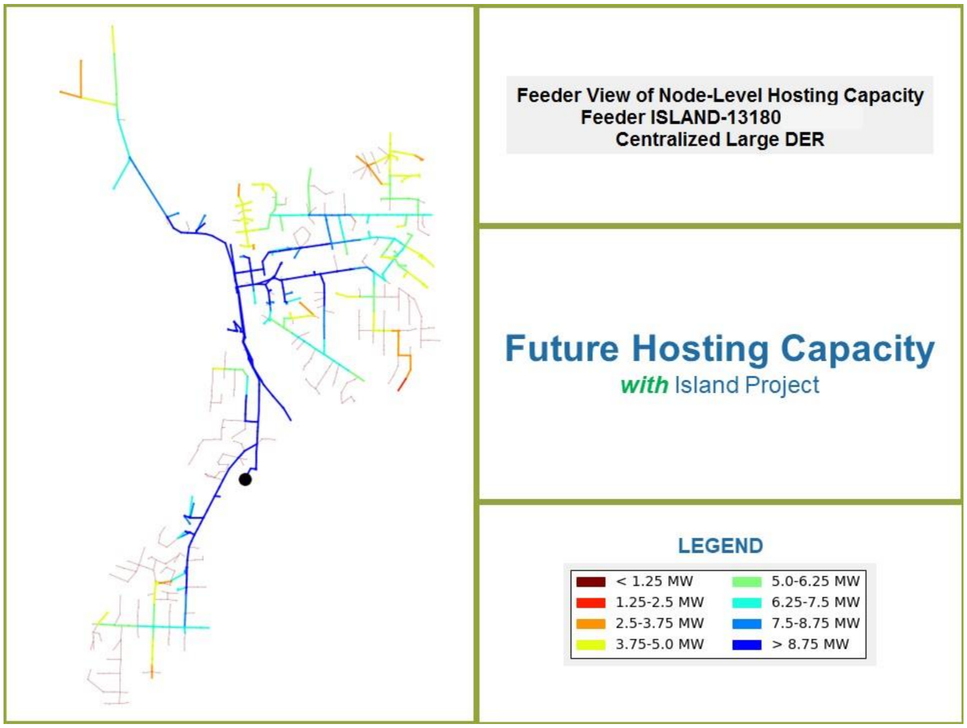
< 1.25 MW	5.0-6.25 MW
1.25-2.5 MW	6.25-7.5 MW
2.5-3.75 MW	7.5-8.75 MW
3.75-5.0 MW	> 8.75 MW

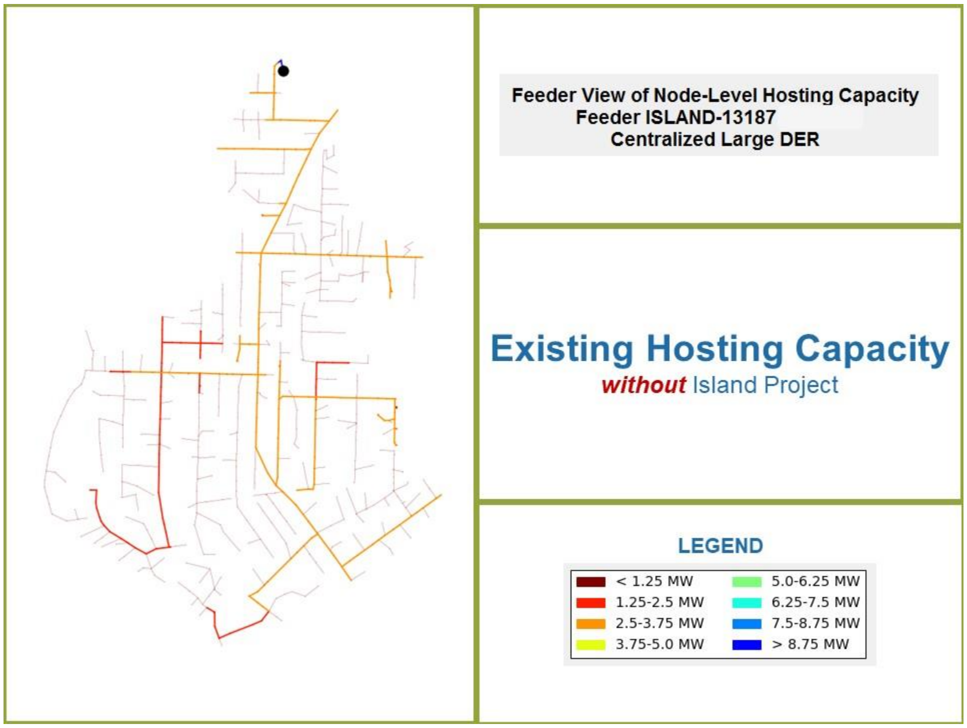
Island Substation

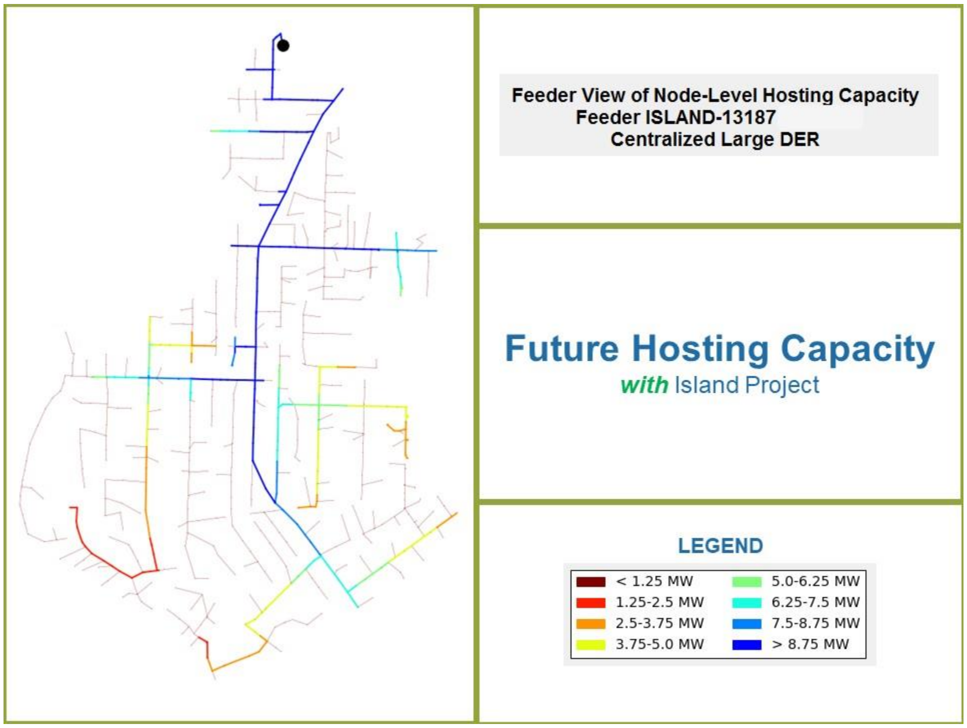
Hosting Capacity Study: DR Testbeds
T&D Planning

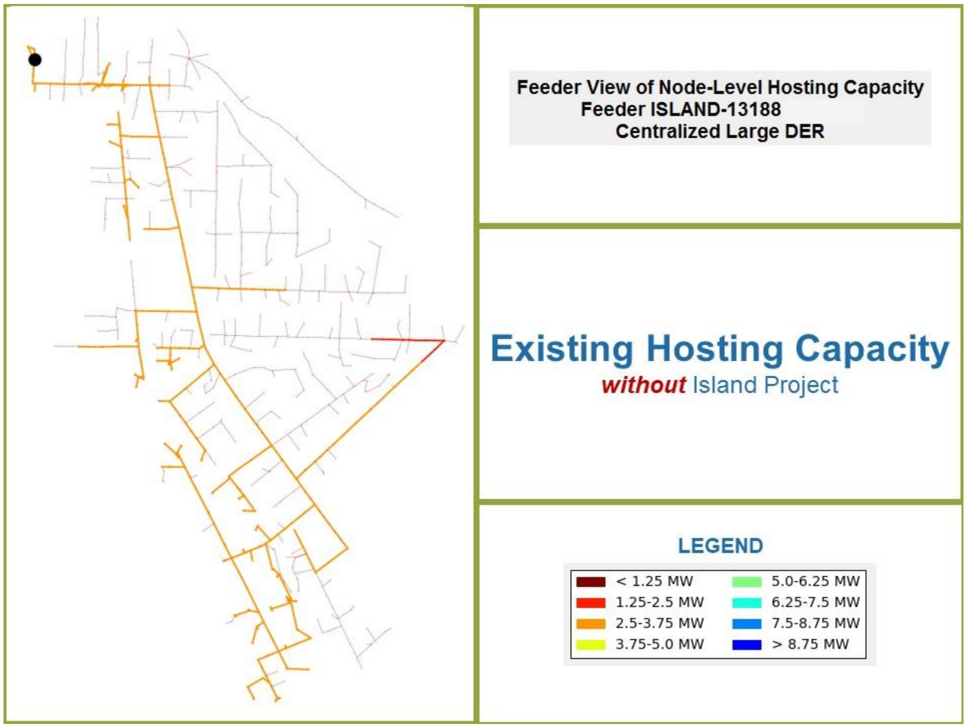
55

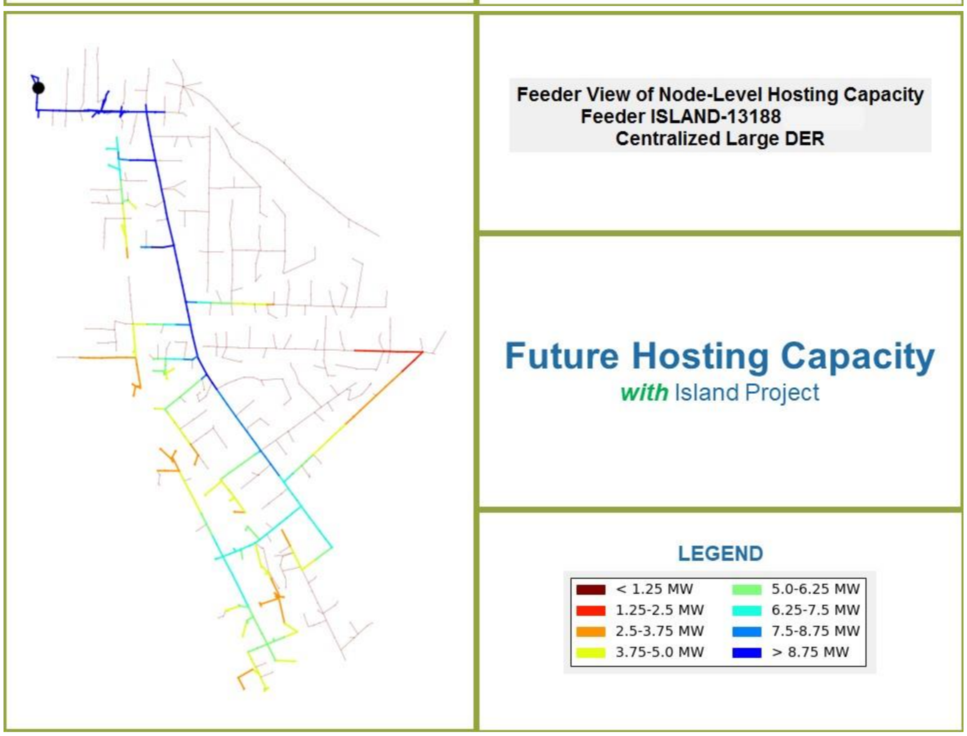

Feeder View of Node-Level Hosting Capacity
Feeder ISLAND-13180
Centralized Large DER
Existing Hosting Capacity
without Island Project
LEGEND
< 1.25 MW
1.25-2.5 MW
2.5-3.75 MW
3.75-5.0 MW
5.0-6.25 MW
6.25-7.5 MW
7.5-8.75 MW
> 8.75 MW


Feeder View of Node-Level Hosting Capacity
Feeder ISLAND-13180
Centralized Large DER
Future Hosting Capacity
with Island Project
LEGEND
< 1.25 MW
1.25-2.5 MW
2.5-3.75 MW
3.75-5.0 MW
5.0-6.25 MW
6.25-7.5 MW
7.5-8.75 MW
> 8.75 MW


Feeder View of Node-Level Hosting Capacity
Feeder ISLAND-13187
Centralized Large DER
Existing Hosting Capacity
without Island Project
LEGEND
< 1.25 MW
1.25-2.5 MW
2.5-3.75 MW
3.75-5.0 MW
5.0-6.25 MW
6.25-7.5 MW
7.5-8.75 MW
> 8.75 MW


Feeder View of Node-Level Hosting Capacity
Feeder ISLAND-13187
Centralized Large DER
Future Hosting Capacity
with Island Project
LEGEND
< 1.25 MW
1.25-2.5 MW
2.5-3.75 MW
3.75-5.0 MW
5.0-6.25 MW
6.25-7.5 MW
7.5-8.75 MW
> 8.75 MW


Feeder View of Node-Level Hosting Capacity
Feeder ISLAND-13188
Centralized Large DER
Existing Hosting Capacity
without Island Project
LEGEND
< 1.25 MW
1.25-2.5 MW
2.5-3.75 MW
3.75-5.0 MW
5.0-6.25 MW
6.25-7.5 MW
7.5-8.75 MW
> 8.75 MW


Feeder View of Node-Level Hosting Capacity
Feeder ISLAND-13188
Centralized Large DER
Future Hosting Capacity
with Island Project
LEGEND
< 1.25 MW
1.25-2.5 MW
2.5-3.75 MW
3.75-5.0 MW
5.0-6.25 MW
6.25-7.5 MW
7.5-8.75 MW
> 8.75 MW

Marketing as Recruitment for 25%,70%, & 90% Participation

Marketing Tactic	Cost %25	Cost %70*	Cost %90*
Digital advertising	$ 270,000	$ 756,000	$ 972,000
Search engine marketing			
Digital advertising/social advertising			
Direct mail/Email marketing	$ 80,000	$ 240,000	$ 320,000
Targeted direct mail and email combo sent to each neighborhood			
Door to door canvasing	$ 300,000	$ 900,000	$ 1,200,000
Canvasing to each neighborhood to educate about demand response, and schedule install/enrollment. This including payment to hired individuals and/or canvasing vendor.			
Community events/partnerships	$ 100,000	$ 300,000	$ 400,000
Tabling and sponsorships at fair/festivals			
Working with businesses on gamemifiction of outreach			
Work with Energy Partner business customers to engage their customers			
Influencer marketing	$ 150,000	$ 450,000	$ 600,000
Identify influential/ community leaders in each neighborhood, get them on board to talk about programs through social media or at events, community forums, etc.			
Model homes - in each neighborhood	$ 10,000	$ 10,000	$ 10,000
PGE employee or influencer home enrolled in all DR program - utilized to showcase, take pictures of home, create profile of home, and utilize in case studies, social media and for tours.			
TV, radio, print	$ 60,000	$ 180,000	$ 240,000
Local or community/neighborhood papers, local radio (OBP, NPR)			
This is for TV placement only and does not account for production costs			
Total	$ 970,000	$ 2,826,000	$ 3,732,000

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Marketing Budget

Marketing Tactic	
Digital advertising	$ 270,000
Search engine marketing	
Digital advertising/social advertising	
Direct mail/Email marketing	$ 80,000
Targeted direct mail and email combo sent to each neighborhood	
Community events/partnerships	$ 100,000
Tabling and sponsorships at fair/festivals	
Working with businesses on gamemifiction of outreach	
Work with Energy Partner business customers to engage their customers	
Influencer marketing	$ 150,000
Identify influential/ community leaders in each neighborhood, get them on board to talk about programs through social media or at events, community forums, etc.	
Model homes - in each neighborhood	$ 10,000
PGE employee or influencer home enrolled in all DR program - utilized to showcase, take pictures of home, create profile of home, and utilize in case studies, social media and for tours.	
TV, radio, print*	$ 60,000
Local or community/neighborhood papers, local radio (OBP, NPR)	
* This is for TV placement only and does not account for production costs	
Total	**$ 670,000**

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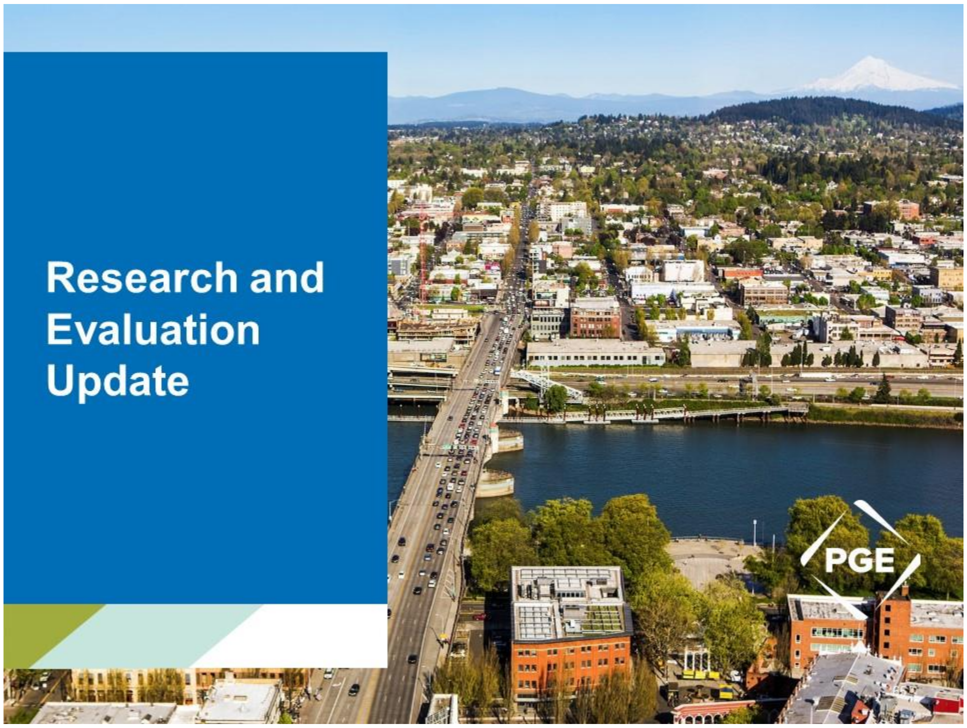

Objectives and Benefits

Objectives

- Understand customer awareness of demand response programs
  - This objective will be measured by presenting the respondents with clear program descriptions to account for the lack of customer knowledge about the concept of demand response.
- Gauge customer preference/interest for demand response program concepts
- Understand customer willingness to participate (consideration) in a demand response program based on the concepts they are presented with.
- Measure respondent reaction to proposed program messaging
- Measure the change in customer awareness, preference, and willingness to participate in demand response programs over the course of the evaluation period.

Benefits

- Providing an idea how widespread knowledge of demand response is with the customer base.
- Establish baseline data for awareness, preference and consideration of demand response programs.
- Measure improvements in awareness, preference and interest in demand response programs over time due to marketing and awareness efforts
- Provide message testing to improve the effectiveness of marketing and awareness efforts
- Measuring preference and willingness to participate in demand response programs will provide a rough idea of the size of the market

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Sample composition and methodology

Methodology:

- In order to achieve the stated objectives, PGE will conduct surveys of residential and business customers in geographies served by 3 PGE substations. The survey will require 2 survey strategies
- An online survey for residential customers
  - It may be necessary to add a phone survey component depending upon the characteristics of the residential customers present in each geography.
    - Certain customer segments are easier to contact via phone and necessity to do so will be determined after an analysis of the customer makeup of the sample in each substation geography.
- A phone survey for business customers
  - This is necessary due to the difficulty in recruiting business customers for online surveys
- It may also be necessary to stratify the sample and include recruiting quotas for customer segments that are over or under-represented. Additionally, post-hoc weighting may be required to account for customer segments that are not adequately represented by the results. .

Sample Composition:

- The respondent sample will be made up of all PGE residential and business customers in geographies served by 3 PGE substations.

Geography	Roseway	Island	Delaware	Total
Residential Sample*	4390	7915	7794	20,099
Business Sample*	535	1208	664	2407

* Sample counts are estimated. Actual counts will vary slightly from the above

- Reporting for the results will be available for the following segments
  - Business and residential
  - By PGE's residential segmentation profiles
  - Any PGE database variables that do not personally identify the respondents (e.g. HH income, age, usage, etc.)

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Timeline and Cost: 3-survey option

The market research effort for this phase of the project will consist of 3 survey efforts over the course of two years.

- The initial survey research will be launched in Q4, 2018 prior to any marketing efforts. It
  - will be used to establish the baseline awareness, preference, and consideration measurements.
  - This research can also be used to test initial marketing messages.
- The research will include follow-up surveys at the end of year 1 and year 2
  - These surveys will provide data to compare against the baseline awareness, preference, and consideration measurements
  - They will also provide opportunities to test additional marketing messages.

Baseline Survey	End of Year 1 Follow-up Survey	End of Year 2 Follow-up Survey	Phase 1 Final Assessment
Q4-2018	Q4-2019	Q4-2020	

The 3-survey option is the best in terms of outcomes. It provides a mid-phase opportunity to ascertain how well the testbed is running and allows for the flexibility to respond to problems or opportunities that arise.

Cost:

The estimated cost for conducting three surveys during phase 1 of the program is $150,000-$180,000

- Note that there really are not any significant cost-savings for conducting surveys on only 1 or 2 of the targeted geographies.

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Timeline and Cost: 2-survey option

The market research effort for this phase of the project will consist of 2 survey efforts over the course of two years.

- The initial survey research will be launched in Q4, 2018 prior to any marketing efforts. It
  - will be used to establish the baseline awareness, preference, and consideration measurements.
  - This research can also be used to test initial marketing messages.
- The research will include follow-up surveys at the end of year 1 and year 2
  - These surveys will provide data to compare against the baseline awareness, preference, and consideration measurements
  - They will also provide opportunities to test additional marketing messages.

Baseline Survey	End of Year 2 Follow-up Survey	Phase 1 Final Assessment
Q4-2018	Q4-2020	

The 2-survey option is the least expensive, but it only provides the opportunity to assess how well the testbed is running at the end of the first phase and thus allows for less flexibility in responding to opportunities or problems that might arise

Cost:

The estimated cost for conducting three surveys during phase 1 of the program is $120,000-$140,000

- Note that there really are not any significant cost-savings for conducting surveys on only 1 or 2 of the targeted geographies.

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Proposal for Sub-Workgroups

Is there an interest and need to have small groups to dive deeper into the following work areas? Marketing, Research and Evaluation, Programs, Implementation and Other?

Next Steps

Coordination of next meeting and subgroups (if approved and needed).

PGE will deliver a draft filing for comment and review to the DRRC by the end of July

Presentation to the Commission (individually and/or formally) Filing late August

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Appendix E Cost Effectiveness Memo

Memorandum

Portland General Electric

To: File

From: Tess Jordan

Date: October 4, 2018

Re: Demand Response Testbed Cost Effectiveness

The Testbed project is comprised of three substation geographies in which a portfolio of demand response programs will be promoted. The project's primary purpose is to accelerate the development and acquisition of demand response and to explore approaches towards this end. This analysis considers six demand response (DR) programs that will be promoted, with a 66% target residential participation rate. The DR programs included are: Rush Hour Rewards, Thermostat Installation, Water Heater, Time of Use Pricing, Peak Time Rebate (opt out), and Business & Government/Energy Partner.

The Testbed will facilitate a portfolio level investigation of the following issues:

- Most effective participant acquisition strategies
- The extent to which DR participation rates may cannibalize one another
- Alignment of incentives to move participants to PGE's priority, direct load control programs
- Verification of load impacts and financial performance of DR programs

PGE's cost effectiveness modeling includes four distinct tests and is based on PGE's 'A Proposed Cost-Effectiveness Approach for Demand Response,' submitted to the OPUC in 2016 and based upon California protocols. Benefit:cost ratio estimates for each test are reported below under two Testbed enrollment scenarios. All tests compare the net present value of costs and benefits over a 10-year horizon. Additional test detail is included at the end of this memo.

Because NPV is based on a discounted estimate of expenditures and participation/load impacts over time, cost effectiveness modeling is sensitive to the timing of each. The more near-term the spend (and benefits realized), the greater the impact on NPV. Cost effectiveness results reflect current assumptions on program launch and ramp up, as well as costs and participation levels.

	Aggressive	Moderate	Costs Included	Benefits Included
Total Resource Cost Test: *'all parties' perspective*	0.58	0.48	Administrative + soft costs	Avoided costs of electricity + environmental
Program Administrator Test: *utility perspective*	0.44	0.36	Administrative + incentives paid	Avoided costs of electricity
Rate Impact Measure Test: *ratepayer perspective*	0.43	0.35	Administrative + incentives paid + sales revenue lost	Avoided costs of electricity
Participant Cost Test: *participant perspective*	3.16	2.90	Soft costs	Incentives paid
Annualized MW load impact	6.17	4.88		

Cost effectiveness decreases under the moderate enrollment scenario, in which relatively more participants are enrolled in Peak Time Rebate (opt out) rather than Direct Load Control programs. The lower benefit cost ratio results from a lower load impact over which to spread fixed portfolio-level costs.

Each of the programs modeled within the Testbed have undergone independent cost effectiveness analyses that supported each program's initial filing. The consolidation of inputs from these separate analyses into the Testbed model is described in the remainder of this memo.

Residential Participation Targets

Testbed participation is considered incremental to the participation targets previously established for each of the DR programs included. Participation drives both costs and benefits of the Testbed effort.

For the five residential programs combined, enrollment was capped at 66% of Testbed households, the share of residential accounts for which PGE has an associated email address.

1. The Testbed geographies encompass 19,883 households. The number of households eligible to participate in each of the four programs was estimated according to the following criteria, by household type:
    - Thermostat programs require air conditioning or electric heat, plus a low voltage thermostat
    - The water heater program requires an electric water heater
    - Peak Time Rebate requires contact information (email or cell phone)
    - Time of Use requires contact information (email or cell phone)
2. Testbed program design assumes all households with email contact are enrolled in Peak Time Rebate (PTR), a total of 13,123 households. This will be an opt out program: households not wishing to participate will have to take action. The model assumes that 3% of enrollees exit the program each year, either due to lack of fit or move out.
3. The aggressive scenario targets 50% of PTR-enrolled households to transition to a direct load control program (DLC, e.g. thermostat or water heater), and 5% to enroll in Time of Use (TOU) pricing while remaining in the PTR program.
4. The moderate scenario targets 25% of PTR-enrolled households for transition to a DLC program, and 5% enroll for Time of Use pricing. In the moderate scenario, total

participation across all programs remains unchanged, but more participants remain in PTR rather than being transitioned to a higher value (greater load impact) program.

Across all three Testbed geographies, target enrollment is as follows:

Aggressive Enrollment Target (Residential)

	(Direct Load Control Programs)			(Voluntary)	*(no events)*	
Meter Type	Thermostat: RHR	Thermostat: Direct Install	Water Heaters	Peak Time Rebate	*Time of Use**	Total
SFR	2,146	536	1,073	5,687	*472*	9,442
MFR	104	26	2,469	832	*172*	3,430
Mobile Home		150	75	25	-	251
Total	2,250	713	3,617	6,534	*644*	13,123

Moderate Enrollment Target (Residential)

	(Direct Load Control Programs)			(Voluntary)	*(no events)*	
Meter Type	Thermostat: RHR	Thermostat: Direct Install	Water Heaters	Peak Time Rebate	*Time of Use**	Total
SFR	1,073	268	536	7,564	*472*	9,442
MFR	52	13	1,234	2,131	*172*	3,430
Mobile Home	-	75	38	138	-	251
Total	1,125	356	1,808	9,833	*644*	13,123

**TOU participants are a subset of PTR participants. They are excluded from the total column.*

Commercial Participation Targets

A target of 577 business participants across the three geographies was established by CLEAResult, the administrator of PGE's commercial DR program. This equates to 25% of both small and medium sized businesses located within the Testbeds, and 40% of large businesses.

Business Size	Customers within Testbed	Existing Program Participation Target	Testbed Target Rate	Incremental Testbed Rate	Target Participation: Testbed Effort
Small	2,105	0.3%	25%	24.7%	520
Med	225	1.1%	25%	23.9%	54
Large	17	22.7%	40%	17.3%	3
Total	2,347	13	589		577

Cost Details

Programmatic Costs: component of Administrative Costs (50%). Included cost in the Total Resource Cost, Program Administrator, and Rate Impact Measure tests.

- Testbed modeling assumes program targets are reached over two years and, with the exception of 3% annual PTR attrition, this initial Testbed model assumes steady enrollment over the remainder of the 10-year horizon. This simplifies the modeling undertaken for individual DR programs, which for some programs involves ongoing attrition, re-engagement, and early termination penalties/equipment return.
- Variable program costs: includes all per-participant costs such as data aggregation, thermostat or water heater purchase and installation, software licensing, equipment maintenance, and commercial equipment installation.
- Fixed program costs: Testbed modeling excludes the fixed costs associated with those DR programs that include fixed costs. Examples include program management, vendor implementation costs, and marketing associated with unique DR programs. Fixed costs have already been represented in the programs' independent cost effectiveness analyses; the assumption is that Testbed participation will not drive increases in fixed costs.
- Business and Government DR costs were modeled by CLEAResult, PGE's commercial DR implementor. These include marketing, sales/outreach, provisioning, equipment, and project management.

Portfolio Level Costs: component of Administrative Costs (50%). Included cost in the Total Resource Cost, Program Administrator, and Rate Impact Measure tests.

The Testbed assigns more resources to education, outreach, and marketing than is true for the individual DR programs. Portfolio level costs include marketing, program FTE, contingency, and evaluation and research. Portfolio level costs are detailed in the Testbed Filing.

Incentives: included as a cost in Program Administrator and Rate Impact Measure tests, and as a benefit in the Participant test. This is excluded from the Total Resource Cost Test, which considers the perspective of all parties. As a cost to the utility and a benefit to the participant, it is net neutral in that test only.

Incentive levels are modeled consistent with initial program design. Final design for Peak Time Rebate and Time of Use programs is still underway; this analysis utilizes program assumptions as of September 2018. Incentives comprise 36% of total costs under the Program Administrator test.

Transaction Costs to Participants and Value of Service Lost (Soft Costs): included as a cost in the Total Resource Cost and Participant tests.

Transaction Costs to Participants and Value of Service Lost attempt to quantify the non-monetary burden of participation and are defined as a percentage of each program's incentive. This percentage varies by DR program and was held constant with each program's original cost effectiveness analysis.

Lost Revenue: included as a cost in the Rate Impact Measure test and a benefit in the Participant test.

Lost revenue corresponds to energy savings, which are minimal. Energy savings were valued at the Schedule 7 variable charge of $0.11 per kWh (2018). Lost revenue comprises 3% of total costs under the Rate Impact Measure Test and 8% of benefits under the Participant Cost Test.

Benefit Details

Avoided Cost of Capacity: component of the Avoided Cost of Supplying Electricity. Included in all tests but the Participant Cost Test.

The value of DR is defined in terms of avoided cost. At 96%, avoided cost of capacity is the bulk of DR benefit. This analysis uses the 2016 IRP Update value of the avoided capacity proxy resource ($128.96 kw-yr for a SCCT), and de-rates that value separately for each program, to reflect program availability and event notification requirements. Each program was assigned a unique discount rate at the time of analysis, reflecting both the program's design and PGE's capacity needs at that time. Both inputs may have shifted over time, as has PGE's understanding of the most effective ways to model the value of DR to our system. PGE has not yet established an internally vetted and externally approved methodology for de-rating DR capacity; efforts are currently underway. The Testbed cost-effectiveness model reflects the assumptions that supported each individual program's pilot launch. The exception is Rush Hour Rewards DLC; for the Testbed analysis, this program's de-rate was updated to match that of Thermostat Install DR, due to an expansion in the program's availability since its initial filing. Each program will be re-evaluated at the end of its pilot phase, to compare actual performance with initial estimates.

Avoided Cost of Energy: component of the Avoided Cost of Supplying Electricity. Included in all tests but the Participant Cost Test.

This is a second component of the Avoided Cost of Supplying Electricity. Most DR programs involve de minimus energy savings, as the bulk of energy conserved during an event is expended before and after the event (e.g., water heater pre-heating). The value of energy savings is based on Aurora energy price models, and total 1% of the Testbed's Avoided Cost of Supplying Electricity.

Avoided Cost of Transmission and Distribution: component of the Avoided Cost of Supplying Electricity. Included in all tests but the Participant Cost Test.

This describes the benefits to the T&D system from shaving peak capacity events and (minimally) reducing energy demand. PGE has explored various approaches to modeling this benefit. For Testbed modeling an energy-based methodology is employed, which applies the Schedule 7 tariffed charge per MWh for transmission and for distribution. Avoided T&D benefits comprise 3% of the Testbed's Avoided Cost of Supplying Electricity.

Environmental Benefits: included as a benefit in the Total Resource Cost Test only.

The Testbed analysis calculates the cost of carbon via Aurora energy price forecasts with and without carbon pricing and applies this delta to the anticipated reduction in energy usage. Environmental benefits are included in the TRC test only and comprise 0.7% of total program benefits. This small amount stems from the minimal overall energy reduction associated with DR programs.

Lost Revenue: See Cost Details above.

Test Bed Two-Year Budget

Budget Category	Launch	Year 1	Year 2	Total
Establishment Costs				
Marketing	$335,000	$335,000	$111,000	$781,000
Research and Evaluation	$130,000	$110,000	$240,000	$480,000
Staffing	$148,000	$607,000	$607,000	$1,362,000
Subtotal	$613,000	$1,052,000	$958,000	$2,623,000
Programmatic Costs				
Materials and Equipment	-	$1,076,000	$1,162,000	$2,238,000
Program incentives	-	$446,000	$558,000	$1,004,000
Subtotal	$0	$1,522,000	$1,720,000	$3,242,000
Testbed Total Costs	$613,000	$2,574,000	$2,678,000	$5,865,000

Aggressive Enrollment Scenario

Total Resource Cost Test: 'All Parties' perspective

Cost/Benefit Category	Costs	Benefit
Administrative costs	$5,897,000	
Avoided costs of supplying electricity		$4,083,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		$28,000
Incentives paid		
Revenue loss from reduced sales		
Transaction costs to participant	$446,000	
Value of service lost	$708,000	
	$7,051,000	$4,111,000
Benefit Cost Ratio		**0.58**

Program Administrator Cost Test

Cost/Benefit Category	Cost	Benefit
Administrative costs	$5,897,000	
Avoided costs of supplying electricity		$4,083,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		
Incentives paid	$3,364,000	
Revenue loss from reduced sales		
Transaction costs to participant		
Value of service lost		
	$9,261,000	$4,083,000
Benefit Cost Ratio		**0.44**

Rate Impact Measure Test

Cost/Benefit Category	Cost	Benefit
Administrative costs	$5,897,000	
Avoided costs of supplying electricity		$4,083,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		
Incentives paid	$3,364,000	
Revenue loss from reduced sales	$281,000	
Transaction costs to participant		
Value of service lost		
	$9,542,000	$4,083,000
Benefit Cost Ratio		**0.43**

Participant Cost Test

Cost/Benefit Category	Costs	Benefit
Administrative costs		
Avoided costs of supplying electricity		
Bill Reductions		$281,000
Capital costs to utility		
Environmental benefits		
Incentives paid		$3,364,000
Revenue loss from reduced sales		
Transaction costs to participant	$446,000	
Value of service lost	$708,000	
	$1,154,000	$3,645,000
Benefit Cost Ratio		**3.16**

Moderate Enrollment Scenario

Total Resource Cost Test: 'All Parties' perspective

Cost/Benefit Category	Costs	Benefit
Administrative costs	$4,882,000	
Avoided costs of supplying electricity		$2,889,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		$20,000
Incentives paid		
Revenue loss from reduced sales		
Transaction costs to participant	$463,000	
Value of service lost	$689,000	
	$6,034,000	$2,909,000
Benefit Cost Ratio		**0.48**

Program Administrator Cost Test

Cost/Benefit Category	Cost	Benefit
Administrative costs	$4,882,000	
Avoided costs of supplying electricity		$2,889,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		
Incentives paid	$3,138,000	
Revenue loss from reduced sales		
Transaction costs to participant		
Value of service lost		
	$8,020,000	$2,889,000
Benefit Cost Ratio		**0.36**

Rate Impact Measure Test

Cost/Benefit Category	Cost	Benefit
Administrative costs	$4,882,000	
Avoided costs of supplying electricity		$2,889,000
Bill Reductions		
Capital costs to utility	$0	
Environmental benefits		
Incentives paid	$3,138,000	
Revenue loss from reduced sales	$201,000	
Transaction costs to participant		
Value of service lost		
	$8,221,000	$2,889,000
Benefit Cost Ratio		**0.35**

Participant Cost Test

Cost/Benefit Category	Costs	Benefit
Administrative costs		
Avoided costs of supplying electricity		
Bill Reductions		$201,000
Capital costs to utility		
Environmental benefits		
Incentives paid		$3,138,000
Revenue loss from reduced sales		
Transaction costs to participant	$463,000	
Value of service lost	$689,000	
	$1,152,000	$3,339,000
Benefit Cost Ratio		**2.90**

Appendix F Evaluation Report for PGE's Residential Pricing Pilot (2018)

Portland General Electric
121 SW Salmon Street • Portland, Ore. 97204
PortlandGeneral.com

July 10, 2018

Email
puc.filingcenter@state.or.us

Public Utility Commission of Oregon
201 High Street, S.E., Suite 100
P.O. Box 1088
Salem, OR 97308-1088

Attn: Commission Filing Center

Re: UM 1708 Cadmus Evaluation of PGE's Residential Pricing Pilot

Enclosed is Cadmus' evaluation of PGE's Residential Pricing Pilot (also known as Flex). PGE contracted with Cadmus to evaluate the load impacts and customer satisfaction associated with different pricing and behavioral demand response program designs for Flex. Flex is intended to test the load impacts and residential customer acceptance of various demand response approaches. The Cadmus evaluation reviewed two winter seasons (2016/2017 and 2017/2018) and two summer seasons (2016 and 2017) and involved analysis of randomized control trials for twelve demand response (DR) treatments including peak-time rebates (PTR), time-of-use (TOU) pricing, behavioral demand response (BDR), and combinations of these treatments. Cadmus performed the research design, peak demand impact analysis, program staff interviews, and customer surveys. Cadmus' evaluation report is provided as Attachment A.

The Cadmus evaluation confirms that PGE can obtain customer demand savings through pricing and behavior-based DR programs to manage its system peak demand while delivering a positive customer experience. Based on the Cadmus findings and recommendations for increasing demand savings and customer satisfaction, PGE will propose a combination of offerings that achieve high customer satisfaction and will support PGE's goal of at least 77 megawatts of DR by end-of-year 2020. The offerings will likely include the following:

- Opt-in PTR – Customers receive notifications asking them to shift energy use during peak-time events (16-20 events per year). As a reward, they receive an on-bill credit based on the difference between actual versus expected usage.

- Opt-in TOU and PTR Hybrid – Customers can save on their daily energy costs by shifting usage to off-peak times when rates are lower. They also receive notifications asking them to shift energy use during peak-time events (16- 20 events per year). As a reward, they receive an on-bill credit based on the difference between actual versus expected usage.

- BDR Public Alert Strategy – Residential customers learn of *critical* PTR events via public alerts (e.g., radio, television, web) and are encouraged to shift energy use during critical peak events (one or two times per year). Customers will be informed of, and encouraged to enroll in, the higher-frequency PTR program to support ongoing DR goals.

Opt-in PTR

Of the twelve scenarios tested, Opt-in PTR produced the second highest demand savings during events and had the highest customer satisfaction rating. Opt-in PTR customers also had the lowest un-enrollment rates of the opt-in scenarios, which is promising for customer retention moving forward.

PGE tested three incentive "tiers" for Opt-in PTR customers:

- PTR1 $0.80C/kWh;
- PTR2 $1.55/kWh; and
- PTR3 $2.25 kWh.

PGE's proposal for the Pricing Program will likely include Opt-in PTR as one of the core offerings with revisions to the tested incentive tiers.

Opt-in TOU/PTR Hybrid

Hybrid treatments, which combined TOU pricing with PTR incentives, resulted in the highest demand savings of those scenarios tested. Satisfaction was also high for those customers who saved on the hybrid plan. TOU/PTR hybrid customers had lower satisfaction in winter, as demand saving or shifting proved challenging for them in this season and they voiced concern about winter bill increases. Satisfaction was lowest and opt-out was highest for those customers who faced a negative financial impact. PGE is currently conducting detailed analysis of the TOU structures to see where revisions could potentially be made to mitigate issues in winter while maintaining resource value.

Using the Cadmus findings and recommendations, to inform our target participants, PGE is conducting further segmentation to profile those customers who could benefit most from the rate plan, those with a neutral impact, and those who could be negatively impacted.

Opt-Out Behavioral Demand Response (BDR)

Customers in this group received a subset of PTR event notifications but were not incented for their participation. Opt-out BDR achieved the lowest demand shift and satisfaction ratings of the scenarios tested. Many participants did not understand DR program goals or the value of their participation. However, the size of this potential population (400,000 to over 700,000) provides opportunity for limited engagement that could yield significant load shift.

Demand Response Education

As Cadmus reported, PGE's opt-in rates were significantly lower than those achieved by other utilities such as Sacramento Municipal Utility District (SMUD). It's likely that PGE customers are less familiar with the concept of DR and time varying rates, and customer feedback from the pilot supports that theory.

If you have any questions or require further information, please call me at (503) 464-7805 or Kalia Savage at (503) 464-7432.

Please direct all formal correspondence and requests to the following e-mail address pge.opuc.filings@pgn.com.

Sincerely,

Stefan Brown
Manager, Regulatory Affairs

Encls

cc: UM 1708 Service List

Flex Pricing and Behavioral Demand Response Pilot Program

EVALUATION REPORT

June 25, 2018

Prepared for:
Portland General Electric
121 SW Salmon St.
Portland, OR 97204

CADMUS

Prepared by:
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Acronyms, Terms, and Definitions

Acronym/Term	Definition
AMI	Advanced Metering Infrastructure
BDR	Behavioral Demand Response
CI	Confidence Interval
Conversion rate	Measures a given marketing channel's effectiveness in spurring enrollment, calculated by taking the number of customers who enrolled from a given channel and dividing this by the total number of customers that the channel reached.
CDH	Cooling Degree Hours
Flex	Pricing and Behavioral Demand Response Pilot Program
HDH	Heating Degree Hours
OLS	Ordinary Least Squares
OO	Opt-Out – Opt-out customers are automatically enrolled in the pilot and given the opportunity to opt out of the pilot; an alternative to opt-in program design format.
Opt-in rate	The ratio of the number of customers who enrolled in a treatment to the total number of customers invited to participate.
Opt-out rate	The ratio of the number of enrolled customers who opted out of treatment to the total number enrolled.
PGE	Portland General Electric
PTR	Peak-Time Rebate
QC	Quality Control
RCT	Randomized Control Trial
TOU	Time-of-Use

Abstract

Through its residential Pricing and Behavioral Demand Response Pilot program (Flex), Portland General Electric (PGE) sought to assess the load impacts from and customer satisfaction with different pricing and behavior-based demand response treatments. Findings from the pilot would be used to inform offerings for a future, large-scale rollout of a PGE demand response program.

In 2015, PGE contracted with Cadmus to evaluate Flex. The evaluation covered two winter seasons (2016/2017 and 2017/2018) and two summer seasons (2016 and 2017) and involved analysis of randomized control trials (RCT) for 12 demand response treatments including peak time rebates (PTR), time-of-use (TOU) pricing, behavioral demand response (BDR), and combinations of these treatments. Cadmus performed the research design, peak demand impact analysis, program staff interviews, and customer surveys.

Opt-in PTR produced demand savings during Flex events ranging from 17%–21% in summer and 7%–12% in winter. Opt-out PTR and BDR yielded event demand savings of 7% and 2% in summer, and 5% and 1% in winter, respectively. Two of three TOU rates delivered demand savings during peak periods of 5%–8% in summer. In winter, none of the TOU rates produced statistically significant savings. Hybrid treatments combining TOU and either PTR or BDR achieved peak period demand savings of 8%–23% in summer and 1%–5% in winter. During summer and winter Flex events, TOUxPTR treatments tended to produce less demand savings than opt-in PTR-only customers. For many treatments, the estimated load impacts equaled or surpassed PGE planning estimates.

In general, Flex customers were satisfied with the pilot. Opt-in PTR customers consistently had the highest satisfaction (79%–92%). TOU and opt-out customer automatically enrolled in the pilot tended to have lower satisfaction (51%–82%). TOU and TOU-hybrid customers had lower satisfaction in winter, as demand saving or shifting proved challenging for them in this season.

These findings demonstrate that PGE can deploy pricing and behavior-based demand response to manage its system peak demand while delivering a positive customer experience. This report makes recommendations for increasing Flex demand savings and improving the customer experience.

Executive Summary

In 2016, Portland General Electric (PGE) launched Flex, a pricing and behavioral demand response pilot program. PGE launched the program to test the load impacts and customer acceptance of various demand response strategies. The program enrolled 14,000 customers and tested 12 pricing and behavior-based program design options (referred to as “treatments” in this report) aimed at reducing residential peak demand during summer and winter months. The treatments featured three time-of-use (TOU) rates, three peak-time rebates (PTR), behavioral demand response (BDR), four hybrid demand response treatments (TOU pricing in combination with PTR or BDR), and opt-out (OO) BDR and PTR demand response that automatically enrolled customers.

PGE called upon customers enrolled in PTR or BDR treatments to reduce loads during a limited number of Flex events in summer and winter. PGE paid rebates of $0.80/kWh, $1.55/kWh, or $2.25/kWh to PTR customers for reducing consumption during Flex events below individual-customer baselines, and PGE provided encouragement to BDR customers to save during Flex events, but did not compensate them for saving or shifting their demand. In contrast to event-based PTR and BDR, TOU pricing always was in effect. PGE moved participating customers on a standard flat rate to rate schedules that varied the cost of electricity as a function of the day of the week and hour of the day. Table 1 shows the three rate schedules (TOU1, TOU2, and TOU3) that PGE tested for the Flex pilot.

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Table 1. Flex Pilot Summer and Winter TOU Rate Schedules

Summer	TOU1	TOU2	TOU3
Off Peak	7.5¢/kWh	8.3¢/kWh	6.9¢/kWh
	10:00 pm–6:00 am	8:00 pm–3:00 pm	10:00 pm–11:00 am
Mid Peak			11.9¢/kWh
			11:00 am–3:00 pm 8:00 pm–10:00 pm
On Peak	13.6¢/kWh	17.6¢/kWh	18.0¢/kWh
	6:00 am–10:00 pm	3:00 pm–8:00 pm	3:00 pm–8:00 pm
Winter	**TOU1**	**TOU2**	**TOU3**
Off Peak	8.0¢/kWh	8.8¢/kWh	7.4¢/kWh
	10:00 pm–6:00 am	8:00 pm–7:00 am; 11:00 am–3:00 pm	10:00 pm–7:00 am
Mid Peak			12.4¢/kWh
			11:00 am–3:00 pm; 8:00 pm–10:00 pm
On Peak	14.1¢/kWh	18.1¢/kWh	18.5¢/kWh
	6:00 am–10:00 pm	7:00 am–11:00 am; 3:00 pm–8:00 pm	7:00 am–11:00 am; 3:00 pm–8:00 pm

*TOU rates in effect as of August 1, 2016.

TOU customers paid a higher unit price to consume electricity during peak periods (e.g., weekday afternoon hours) when electricity was most costly to supply and a lower unit price during off-peak periods (weekday morning, weekend, and evening hours). The TOU3 rate also included a mid-peak period, when the retail electricity price was about midway between the off-peak and on-peak prices.

Evaluation Context

As presented in its 2016 Integrated Resource Plan, in the next several years, PGE expects to face a shortfall in generating capacity from the planned closure of its Boardman facility in 2020 and the expiration of wholesale power contracts.[1] At the same time, PGE plans to increase its production of electricity from intermittent renewable energy resources to comply with the requirements of Oregon Senate Bill 1547. In consideration of these developments, PGE's Integrated Resource Plan (2016) calls for the use demand response to help manage system peak loads and to assist with integration of

[1] PGE's integrated resource plan for 2016 is available at https://www.portlandgeneral.com/our-company/energy-strategy/resource-planning/integrated-resource-planning/2016-irp

renewable energy resources. The IRP sets a goal of adding demand response capacity of 77 MW in winter and 69 MW in summer.

An important source of future demand response capacity for PGE will come from residential customers. These customers contribute to PGE's system peak demand through weather-driven increases in demand for air conditioning in summer and demand for space heating in winter. By deploying demand response programs to residential customers, PGE can manage its peak system loads and reduce its costs of electricity supply. Between 2010 and 2013, PGE ran a critical peak pricing (CPP) pilot and obtained demand savings between 10%–12%. To lay the groundwork for a full-scale launch of residential pricing and behavior-based demand response offerings, PGE implemented the Flex pilot and hired Cadmus to conduct an evaluation. The evaluation sought to assess a range of program design options, including different peak rebates, time-of-use rate schedules, behavioral demand response, and customer opt-in and opt-out designs.

This evaluation report presents findings addressing the Flex pilot's design and delivery, load impacts, and customer experience, and provides recommendations to help PGE optimize its future demand response program offerings. Cadmus evaluated four seasons of the Flex pilot (Summer 2016, Winter 2016/2017, Summer 2017, and Winter 2017/2018), but this report focuses on Summer 2017 and Winter 2017/2018 as PGE did not reach its customer recruitment targets until summer 2017, and PGE changed some aspects of the program's delivery during the first two seasons.

Key Findings

Table 2 presents findings from the Flex pilot evaluation regarding peak demand savings, customer satisfaction, and customer opt-out rates across treatments for Summer 2017 and Winter 2017/2018. The table shows demand savings during Flex events for all treatments and on-peak period demand savings for all TOU and Hybrid treatments. Although PGE did not notify TOU-only customers of Flex events, Cadmus estimated Flex event savings for these customers to assess the peak capacity impacts of TOU pricing.

The most significant findings follow:

- Opt-in PTR treatments produced demand savings during Flex events ranging from 17%–21% in summer and 7%–12% in winter.
- Opt-out PTR and BDR treatments reduced loads during Flex events by 7% and 2% in summer and 5% and 1% in winter, respectively.
- The TOU1 rate, which defined on-peak periods as weekday hours between 6:00 a.m. and 10:00 p.m., did not result in shifting of loads from on-peak periods to off-peak periods or demand savings during Flex events. The TOU1 load impacts were not statistically different from zero.
- In summer, the TOU2 and TOU3 rates, which defined a shorter on-peak period on weekdays from 3:00 p.m. to 8:00 p.m., resulted in demand savings from 5%–8% during on-peak periods and Flex event hours. In winter, neither TOU2 nor TOU3 resulted in statistically significant Flex event demand savings or shifting of loads from peak to off-peak hours.

- During on-peak TOU periods, Hybrid treatments, which combined PTR or BDR with TOU pricing, resulted in demand savings from 8%–23% in summer and 1%–5% in winter. During summer Flex events, Hybrid treatments saved 10%–20% of peak demand. During winter Flex events, TOU2 and TOU3 hybrid treatments saved about 13%.
- None of the TOU-only or Hybrid treatments led to changes in total energy consumption. Estimates of changes in total energy consumption were close to zero and not statistically significant.
- Opt-in PTR customers were those most satisfied with the pilot. In summer and winter, 80% or more of PTR customers reported a satisfaction rating of 6 or higher on a 10-point scale.
- TOU-only customers and opt-out customers were the least satisfied with Flex. Among TOU-only customers, 76% were satisfied with Flex in summer and 61% were satisfied in winter. For opt-out customers, 56% were satisfied in summer and 61% were satisfied in winter. Some TOU customers reported less-than-expected bill savings, and some opt-out customers were not interested in participating.
- TOU customer satisfaction with the pilot depended on perceived bill savings. Satisfied customers (those giving 6–10 ratings on a 10-point scale) most often noted that the program delivered bill savings. Unsatisfied customers (those giving 0–5 ratings a 10-point scale) most often noted seeing little to no difference in their bills.
- Customers opting into the pilot exhibited high engagement with Flex events. Depending on the season, 93% to 96% of opt-in PTR-only respondents and 94% to 97% of opt-in Hybrid respondents remembered receiving event notifications. Also, 76% to 86% of opt-in respondents reported conserving electricity during events in both seasons.
- Opt-out customers automatically enrolled in the pilot exhibited lower awareness of Flex events compared to opt-in customers. Depending on the season, 77% to 89% of opt-out respondents remembered receiving event notifications, and 48% to 63% reported conserving electricity during events in both seasons.
- TOU customers did not have strong awareness of their rate schedules. Only about one-half of TOU and Hybrid respondents (52%) correctly identified their rate schedules from a list of three rate schedule images, a result only slightly better than customers guessing at random.
- During the first season, PGE experienced challenges in providing accurate and timely feedback to participants about savings during Flex events. However, with improvements in the baseline calculation methodology and data QC procedures, PGE increased the feedback's accuracy and shortened the time required to send customers feedback to less than 24 to 48 hours after the event.
- Around one-half of customers (48%) did not know they could change their event notification channel preferences on the Flex website. PGE received complaints from BDR-OO customers that they received too many event notifications.

- TOU and Hybrid customers, who faced financial risks from participating in the pilot, opted out of the pilot at higher rates (8%–11%) than opt-in PTR, opt-out PTR, and BDR customers (2%–6%), who did not face such risks.
- PGE experimented with three marketing channels (email, postcard, and business letter) and three messaging themes (economics, control, and community) to determine which marketing strategies converted to higher customer enrollment. The two paper-based channels (business letter 4.5% and postcard 2.5%) had a higher conversion rate than email (1.5%).
- PGE found that financial-focused messaging resonated more with customers as PGE enrolled a higher percentage of customers when it emphasized the opportunity to earn bill credits or savings. In surveys, customers reported that saving money on electric bills was the top reason for enrollment (78%).

Table 2. Flex Evaluation Findings by Treatment and Season*

Category	Treatment		Summer Savings** Planning	Summer Savings** Evaluation	Summer Satisfaction*** Satisfied (6-10)	Summer Satisfaction*** Delighted (9-10)	Winter Savings** Planning	Winter Savings** Evaluation AM	Winter Savings** Evaluation PM	Winter Satisfaction*** Satisfied (6-10)	Winter Satisfaction*** Delighted (9-10)	Program Opt-Out Rate****
PTR-Only	PTR1		13%	18%	79%	46%	14%	13%	7%	80%	44%	4%
	PTR2			22%	92%	42%		0%	8%	89%	55%	6%
	PTR3			17%	84%	52%		3%	12%	89%	58%	5%
Opt-Out	PTR2-OO		6%	7%	73%	40%	7%	0%	6%	79%	35%	2%
	BDR-OO		3%	2.3%	51%	23%	3%	-0.7%	1%	57%	25%	3%
TOU-Only	TOU1	On-Peak	5%	2%	57%	23%	6%	-1%		54%	23%	8%
		Flex Event		-1%				2%	0%			
	TOU2	On-Peak		8%	82%	45%		3%		62%	23%	9%
		Flex Event		5%				2%	2%			
	TOU3	On-Peak		5%	82%	42%		0%		68%	23%	9%
		Flex Event		6%				3%	-1%			
Hybrids	TOU1xPTR2	On-Peak	5.2% TOU;	3%	72%	34%	5.8% TOU;	1%		69%	38%	11%
		Flex Event	12.9% PTR	10%			14.2% PTR	10%	5%			
	TOU2xPTR2	On-Peak	5.2% TOU;	24%	70%	27%	5.8% TOU;	5%		73%	18%	10%
		Flex Event	12.9% PTR	20%			14.2% PTR	12%	13%			
	TOU2xBDR	On-Peak	5.2% TOU;	8%	81%	37%	5.8% TOU;	1%		71%	36%	8%
		Flex Event	3.0% BDR	11%			3.3% BDR	-1%	1%			
	TOU3xPTR2	On-Peak	5.2% TOU;	9%	88%	50%	5.8% TOU;	4%		72%	46%	10%
		Flex Event	12.9% PTR	8%			14.2% PTR	4%	13%			

* Seasonal results presented only for Summer 2017 and Winter 2017/2018.

**Impact values reflect percentage demand reduction during Flex peak-time events (and on-peak periods for TOU rates); green font indicates significance at 90%.

*** Satisfaction values represent participant survey respondents' satisfaction with Flex on a 0-10 rating scale.

**** Opt-out rates show the percentage of customers enrolled in a specific treatment who have unenrolled through February 2018.

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Conclusions and Recommendations

Key takeaways from the Flex pilot evaluation include the following:

Peak-Time Rebates

Larger rebates did not yield more Flex event savings.
Opt-In PTR customers saved about 20% of consumption during summer Flex events and between 7% and 12% of consumption during winter Flex events. No statistically significant differences in savings appeared by rebate amount. In summer, customers receiving a $0.80/kWh rebate achieved the same savings as customers receiving a $2.25/kWh rebate.

Of 12 treatments, Opt-In PTR-only customers were most satisfied with the Flex pilot.
In both seasons, Opt-In PTR-only respondents had the highest satisfaction rates with Flex (83% reported a program satisfaction score of 6 or higher on a 10-point scale in winter; 86% in summer) compared to Hybrids (71% in winter; 79% in summer) and TOU-only (61% in winter; 76% in summer).[2] Opt-In PTR2 treatment achieved the highest satisfaction rate of 92% in the summer survey. Opt-In PTR2 (89%) and PTR3 (89%) treatments also achieved high satisfaction rates in the winter survey. PTR customers may have been most satisfied as they faced no financial risk from participation. Customers could earn rebates for saving energy during Flex events, but were not penalized if their consumption increased.

Larger rebates (greater than $1.55/kWh) increased customer satisfaction with the Flex pilot.
PTR1 customers, who received the smallest rebate ($0.80/kWh), had lower satisfaction with Flex for both winter and summer seasons than PTR2 ($1.55/kWh) or PTR3 ($2.25/kWh) customers. In summer, 79% of PTR1 customers expressed satisfaction with the program, while 92% of PTR2 customers and 84% of PTR3 customers expressed satisfaction. In winter, PTR1 had a satisfaction rate of 80%, about 10 percentage points lower than that of PTR2 (89%) and PTR3 (89%).

Flex event savings from peak-time rebates did not depend on outside temperatures.
A statistical relationship was not found between PTR savings and outside temperatures during Flex events in winter or summer. Outside temperatures during Flex events ranged between 82°F and 96°F in summer and 28°F and 45°F in winter.

PTR Recommendation

- When setting rebates for future PTR programs, PGE should consider the tradeoff arising from offering a higher rebate: over the lower range of rebates tested ($0.80/kWh to $1.55/kWh), there were positive effects on customer satisfaction but no impacts on Flex event savings

[2] Respondents rated their overall satisfaction with the program on a 0–10 scale, where 0 meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defined a 6–10 rating as *satisfied*.

from increasing the rebate. This suggests that larger rebates may raise customer satisfaction, but lower program cost-effectiveness.

TOU Rates

Customers under the TOU1 rate schedule encountered difficulties in shifting consumption from peak to off-peak hours.

The TOU1 rate used "day/night" off-peak and on-peak period definitions. As the on-peak period was set from 6:00 a.m. to 10:00 p.m., many customers were awake only during peak hours and asleep during off-peak hours, making load shifting inconvenient or difficult. Shifting loads would require many customers to adjust their sleep schedules or to have appliances programmed to run at night. Among TOU customers, those on the TOU1 rate had the lowest program satisfaction rates (57% in summer and 54% in winter) and did not achieve peak savings in either season. TOU1 respondents dissatisfied with Flex most often mentioned the rate schedule being difficult for their households; these respondents said it was not convenient or worth changing one's sleep time to do chores during off-peak periods.

TOU rate schedules with short peak-period definitions yielded peak savings and high satisfaction in summer.

In summer, TOU2 and TOU3 customers achieved significant savings during peak periods (8% and5%, respectively). They also saved 5%–6% during Flex event hours, which Cadmus used as a proxy for the peak capacity impact of TOU, even though TOU customers did not receive Flex event notifications or incentives. In summer, the TOU2 and TOU3 schedules had relatively short peak periods, from 3:00 p.m. to 8:00 p.m., which coincided with PGE's summer system peak and enabled customers to shift loads to off-peak periods. In summer, TOU2 and TOU3 customers had relatively high customer satisfaction ratings of 82%.

The simpler TOU rate schedule achieved the same peak period savings and satisfaction as the more complex one.

In summer, the TOU3 rate, with peak (3:00 p.m.–8:00 p.m.), mid-peak (11:00 a.m.–3:00 p.m.), and off-peak periods, reduced loads by 5% during the mid-peak period. However, no differences emerged in peak period savings between the simpler TOU2 rate, which only had peak (3:00 p.m.–8:00 p.m.) and off-peak periods, and the more complex TOU3 rate. TOU2 and TOU3 showed statistically similar program satisfaction rates in summer (TOU2 82%; TOU3 82%) and winter (TOU2 62%; TOU3 68%).

In winter, TOU customers experienced difficulties in shifting loads from peak to off-peak periods and achieving bill savings.

During winter, none of the TOU-only treatments produced statistically significant reductions in or shifts in peak-period loads. Either TOU did not affect customer loads, or the load impacts were too small to detect with the existing sample sizes. TOU customers also reported relatively low satisfaction with Flex (54%–68%) because of adverse bill impacts and the rate schedule being difficult for their households. TOU schedules had morning *and* evening peak periods. Notably in the survey's open-ended comments, TOU-only and Hybrid customers mentioned the program was more difficult to participate in during winter than summer. Moreover, TOU-only and Hybrid treatments showed significantly lower program satisfaction rates in winter (61%–71%) than in summer (76%–79%).[3] This seasonal pattern in program satisfaction for TOU-only and Hybrid treatments suggests that the TOU aspect may be more challenging for customers in winter than in summer.

TOU Recommendations

- Unless an economic case justifies shifting customer loads from mid-peak to off-peak hours, PGE should implement the TOU2 rate schedule, which is simpler for customers to understand.
- PGE should consider redesigning the winter TOU rate schedules by removing the morning peak period. This would minimize the potential for adverse customer bill impacts and simplify the customer experience.
- PGE should redesign the TOU1 rate schedule or offer TOU1 customers enabling technology to facilitate load shifting from peak to off-peak periods.
- PGE did not test the impacts of pairing enabling technology with TOU pricing, but studies of other TOU pricing programs suggest that enabling technology such as price-responsive smart thermostats can increase load shifting. PGE should consider testing the load impacts of enabling technology in the future.
- PGE should consider enhancing customer screening during the enrollment process to determine whether a customer is a good fit for a TOU rate.
- Given TOU customers' challenges in achieving winter bill savings, PGE should offer them more education about how to save energy or shift loads from peak to off-peak periods.

Opt-Out Behavioral Demand Response

Behavior-based treatments caused PGE customers to save energy during Flex events.
BDR-OO customers saved an average of 2.3% of consumption in summer and 1.2% of consumption in winter. PGE sent opt-out BDR customers Flex event alerts, encouragement to reduce consumption, and individualized post-event feedback but did not charge them higher electricity prices or provide them with rebates during Flex events, demonstrating that residential customers responded to non-price interventions.

Opt-out BDR program design yielded capacity benefits, but resulted in relatively low customer satisfaction.
PGE automatically enrolled over 12,000 residential customers in the BDR-OO treatment. While average savings per treated customer were small (only 1%–2% of consumption), total program demand savings were large due to the size of the treated population. In the future, PGE can deploy the BDR program to help manage system peaks, but at the potential cost of lower customer satisfaction: only 51% of BDR-OO customers in winter and 57% in summer rated the program a 6 or higher on a 10-point scale.

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[3] Significant difference with 90% confidence ($p \leq .10$).

Satisfaction ratings were likely low due to the opt-out program design and the unfamiliarity of many customers with behavioral demand response and the costs of supplying energy during utility system peaks. The program sent event notifications to many customers who had little interest in receiving them or participating in a BDR program. PGE also mentioned in the interviews that it received feedback from some BDR customers that it dispatched too many events and that these customers had not been aware that they could change their event notification settings.

BDR Recommendations

- PGE should consider using opt-out BDR for achieving capacity savings targets, given its success with BDR in reducing loads during this pilot; but it should consider possible changes to program design to increase customer satisfaction, such as:
  - Limiting the frequency of future BDR events, which would also limit the number of event notifications customers received.
  - Shortening the duration of future BDR events to lessen the burden on customers.
  - Spacing out future BDR events to avoid calling back-to-back events or multiple events in the same week.
  - Sending BDR customers a handy reminder magnet or sticker about BDR events and how to save, akin to the clock sticker PGE sent to TOU customers.
- PGE should clearly inform opt-out BDR customers that they can opt out of treatment, and should make it relatively easy for customers to opt out if they do not want to participate.

Opt-Out Peak-Time Rebates

The opt-out participation program design significantly increased program participation.
PGE attained a much higher participation by presenting customers with a choice to opt out of the program rather than opt in. PGE automatically enrolled approximately 1,600 customers in the PTR2-OO program. By the end of the Winter 2017/2018 season, only 2.3% of customers had opted out. In comparison, at the end of the recruitment period for opt-in PTR treatments, less than 7% of PGE customers accepted offers to participate in a PTR1 (4.3%), PTR2 (2.8%), or PTR3 (6.2%) treatment.[4] Of customers opting in to PTR treatment, between 4.5% and 6.3% subsequently opted out. The opt-out design took advantage of customers who were expected to be "complacent": they would neither opt in nor opt out of a demand response program, if given the choice. Cadmus estimated that 92% of opt-out customers were complacent customers. By making participation the default choice, PGE obtained program participation and peak capacity that it would not have achieved otherwise.

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4 PGE experimented with different marketing strategies during the first two waves and obtained higher rates of acceptance during the third wave after improving its approach. Also, PGE stopped recruiting for the opt-in PTR2 treatment after the second wave.

The design of the pilot participation choice (opt-in vs. opt-out) presents a tradeoff between savings per customer and number of participants.

Depending on the rebate amount, opt-in PTR customers saved 17% to 21% of consumption during summer Flex events and from 7% to 12% of consumption during winter Flex events. Customers automatically enrolled in PTR2 saved an average of 7% during summer Flex events and 5% during winter Flex events.[5] Cadmus estimated that in Summer 2017, "complacent customers"—who would neither opt in nor opt out of a PTR program if given the choice—saved 6% during Flex events. While opt-in PTR customers saved more, the opt-out design enrolled many more customers. As noted above, fewer than 6% of PGE customers took up offers to participate in the PTR program. In contrast, more than 97% of customers defaulted onto PTR2-OO remained in treatment through the end of the Winter 2017/2018 season.

Adding a peak-time rebate to behavior-based demand response increased Flex event demand savings and customer satisfaction.

The opt-out BDR treatment and the opt-out PTR treatment only differed in the rebate paid to customers for saving energy during Flex events. PTR customers received the same notifications, tips for saving energy, and individualized feedback about savings as BDR-OO customers. Opt-out PTR customers, however, saved significantly more during Flex events than BDR-OO customers (5% in winter and 7% in summer vs. 1% and 2%, respectively), demonstrating that the rebate lifted savings and complemented the behavior-based treatment. The rebate also increased customer satisfaction. PTR2-OO customers reported 73% program satisfaction in summer and 79% in winter—high customer satisfaction rates for customers automatically enrolled in a program. In contrast, BDR-OO customers only reported program satisfaction rates of 51% in summer and 57% in winter.

Opt-Out PTR Recommendation

- Given the tradeoff between savings per customer and numbers of participants, PGE should analyze whether the opt-in or opt-out PTR design proved more cost-effective, and whether each design will generate the desired aggregate demand response capacity.

Hybrid Treatments

TOU pricing did not enhance (and possibly diminished) savings from PTR during Flex events and customer satisfaction (TOUxPTR vs. PTR).

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[5] The surveys also found that a higher percentage of opt-in (75% in summer, 89% in winter) than opt-out (37% in summer, 75% in winter) PTR2 customers reported participating in Flex events.

During Summer Flex events, opt-in PTR customers saved 17% to 21% of consumption, but TOUxPTR customers only saved 9% to 19%[6]. During Winter Flex events, opt-in PTR customers saved 7% to 12%, but TOUxPTR customers only saved 4% to 12%. TOU pricing may cause PTR customers to become inattentive to Flex event alerts, or TOUxPTR customers may have less incentive to save energy during Flex events because their consumption baseline used for calculating rebates is lower. In summer and winter, satisfaction with Flex was 10 to 20 percentage points lower for TOUxPTR customers than for PTR-only customers.

Adding peak-time rebates to TOU pricing increased customer satisfaction and Flex event savings (TOUxPTR and TOUxBDR vs. TOU-Only).

Peak-time rebates had positive impacts on customer satisfaction for TOU customers. Depending on the TOU rate, TOU-only customers reported program satisfaction ranging from 57% to 82% in summer and 54% to 68% in winter. In contrast, TOUxPTR customers reported satisfaction levels ranging from 70% to 88% in summer and from 69% to 73% in winter, suggesting that the PTR enhanced customer satisfaction with the program.

During Flex events (i.e., hours used in this report to approximate system capacity conditions), TOUxPTR customers also saved more than TOU-only customers. In summer, TOUxPTR or TOUxBDR customers saved from 8% to 19% of Flex event demand, while TOU-only customers saved from 2% to 8%. During Winter events, TOU2xPTR2 and TOU3xPTR2 customers saved 12% of consumption, while TOU-only customers did not save any demand.

Hybrid Treatment Recommendations

- If PGE's primary objective is to save demand during system peaks, it should consider enrolling more customers in PTR-only treatments than hybrid TOUxPTR treatments to maximize the impact on system peak.
- If PGE deploys TOU rates on a wide scale, it should consider pairing TOU rates with a peak-time rebate to raise customer satisfaction and Flex event savings.

Customer Experience

TOU and Hybrid customers reported higher satisfaction with the Flex pilot in summer than winter, primarily due to greater summer bill savings.

[6] The Flex event savings estimate for Hybrid customers indicates the combined effects of TOU and PTR during Flex events. The savings are estimated relative to customers who are treated with neither PTR nor TOU pricing.

Overall, participant respondents were more satisfied with the Flex pilot in Summer 2017 (74% *satisfied*) than Winter 2017/2018 (69% *satisfied*).[7] The seasonal satisfaction differences, however, were greatest for treatments involving TOU pricing, which typically produced annual bill savings, with most or all savings occurring in summer. For TOU-only and Hybrid treatments, respondents reported significantly higher program satisfaction in summer (76%–79% *satisfied*) than in the winter (61%–71% *satisfied*).[8] Summer and winter respondents giving the program satisfied ratings most often noted that the program delivered bill savings. Respondents giving a less-than-satisfied rating most often noted seeing little to no difference in their bill savings. In summer, 16% of TOU survey respondents said they saved on their electric bills, compared to 9% of TOU survey respondents in winter. These program satisfaction results align with demand savings estimates showing participants achieved higher peak-period load reductions in summer than winter.

Although PGE automatically enrolled them, opt-out PTR and BDR customers showed high event awareness and engagement with the pilot.

As expected, customers opting into the pilot exhibited high awareness of and engagement with Flex events. Depending on the season, 93% to 96% of opt-in PTR-only respondents and 94% to 97% of opt-in Hybrid respondents remembered receiving event notifications. Also, 76% to 86% of opt-in respondents reported conserving electricity during events in both seasons. These awareness and engagement levels were higher than for BDR-OO and PTR2-OO customers automatically enrolled in the pilots. and 89% of opt-out respondents remembered receiving event notifications. Also, 48% of opt-out respondents in summer and 63% of respondents in winter reported conserving energy during these events. This suggests that PGE can engage customers in achieving demand savings who are automatically enrolled in demand response programs.

PGE has an opportunity to increase peak period and Flex event demand savings from TOU rates through additional education with existing TOU customers.

TOU2 and TOU3-only and Hybrid treatments saved 5% to 8% of demand during peak periods and 8% to 20% of demand during Flex events, indicating that TOU treatments proved effective. TOU customers, however, did not have strong awareness of their rate schedules. Only about one-half of TOU and Hybrid respondents (52%) correctly identified their rate schedules from a list of three rate schedule images. That was only slightly better than results one would expect (33%) if all customers guessed at random. This suggests TOU customers could save more if they knew of their rate schedules. PGE might be able to increase TOU customer demand savings through doing additional education and outreach.

PGE identified several pilot implementation issues that negatively affected customer experiences and either corrected the issues or will correct them in future Flex deployments.

[7] Respondents rated their overall satisfaction with the program on a 0–10 scale, where a zero meant *extremely dissatisfied* and a 10 meant *extremely satisfied*. PGE defined a 6–10 rating as *satisfied*.

[8] Significant differences at the 90% level (p≤.10).

In interviews with Cadmus, PGE managers and implementation contractors described several program implementation issues:

- PTR and BDR customers received inaccurate and delayed feedback regarding their demand savings during Flex events. The inaccurate feedback may have discouraged some customers from saving, and the delay in providing feedback prevented PGE from calling additional events until these issues resolved. By the start of Winter 2016/2017, PGE had resolved the savings calculation issues and managed to deliver feedback to participants within 24 to 48 hours of events.
- Another issue concerned communication about event notification settings. Some customers complained that they received too many notifications or that the notifications did not arrive through their preferred delivery channels. Many customers reported being unaware that they could change their notification settings. In the future, PGE plans to communicate more proactively with participants about options for program communications and will simplify the process for changing the settings.

Pairing technology with Flex treatments may improve customer's ability to achieve load reduction. While the Flex pilot did not test the impacts of pairing enabling technologies, such as smart thermostats, advanced water heaters, or in-home displays, with the pricing or behavior-based treatments, other studies have found the pairing of these technologies enhances peak demand savings. The experience of TOU1 customers illustrates the potential benefits of enabling technology. TOU1 customers reported challenges in shifting loads from daytime on-peak periods to nighttime off-peak periods; programmable or price-responsive enabling technologies may facilitate shifting of loads and increase TOU1 on-peak demand savings.

Customer Experience Recommendations

- PGE should consider modifying the TOU design and delivery for the winter season to help customers save or shift more electricity consumption. This would improve customer satisfaction and increase load impacts. Modifications could include eliminating the morning on-peak period, shortening the length of the on-peak periods, or automatically enrolling TOU customers in the PTR program. A conjoint analysis of the TOU program offering could examine tradeoffs between different rate schedule designs, customer satisfaction, and load impacts.
- PGE should provide TOU customers with additional education about their rate schedules. This information should be simple and easy to understand. One idea is delivering educational information through alternative media, such as online video.
- PGE should consider opt-out demand response programs as a component of its demand response portfolio. The Flex pilot demonstrated that opt-out programs can reach large numbers of customers and that 50% or more of customers automatically enrolled in PTR or BDR remained engaged, as measured by self-reported rates of Flex event awareness and conservation.

- PGE should conduct test events before the start of each season to assess readiness of its customer communications and data analytics platforms. Testing will allow PGE to correct issues before the season starts, refamiliarize customers with the program, and give customers a chance to change their communications preferences.
- PGE should consider conducting pilots to test the impacts of pairing enabling technologies such as smart thermostats or advanced water heaters with time-based rates or behavior-based treatments if PGE expects the technologies would be cost effective.

Marketing

Paper-based marketing and bill-savings messaging resonated most with customers.
PGE experimented with email, postcard, and business letter marketing, and found business letters achieved the highest customer marketing conversion rate (4.5%), followed by postcards (2.5%), and then email (1.5%).[9]

Business letters emphasized financial messaging (i.e., rate comparison information and a bill savings pitch). PGE initially used economic, control, and community messaging in the emails and post cards, but those approaches proved unsuccessful in enrolling customers. The recruitment survey also found a large majority of participants enrolled to save money on their electric bills (78%); far fewer respondents indicated enrolling to save energy (46%) or help the environment (28%).

Marketing Recommendation

- PGE should consider employing business letter marketing approach for future demand response programs to increase the cost-effectiveness of its marketing. This approach would include leading with bill savings and rate comparisons rather than energy savings or community as primary messages in postcards, emails, or other marketing channels.

[9] A conversion rate measures a given marketing channel's effectiveness in spurring enrollment, calculated by taking the number of customers who enrolled from a channel and dividing this by the total number of customers that the channel reached.

Introduction

In the next several years, PGE will face a shortfall in generating capacity from the planned closure of its Boardman facility in 2020 and the expected expiration of wholesale power contracts. At the same time, PGE plans to increase its production of electricity from intermittent renewable energy resources to comply with the requirements of Oregon Senate Bill 1547. In consideration of these developments, PGE's Integrated Resource Plan (2016) calls for the use of dispatchable resources including demand response to help manage system peak loads and to assist with the integration of renewable energy resources. The IRP sets a goal of adding demand response capacity of 77 MW in winter and 69 MW in summer.

Residential customers participating in demand response programs will provide an important source of Portland General Electric's (PGE) future demand response capacity. These programs use price signals, direct load control, behavior-based treatments, or combinations of these to encourage customers to reduce demand during periods when it is costly for the utility to supply or distribute electricity.

Demand response represents a fundamental shift in the utility's relationship with its customers. Customers participating in demand response programs do not simply just consume utility-supplied electricity; they also provide peak capacity to utilities. To take full advantage of this evolving "prosumer" role, PGE will need to offer its customers new retail electricity rates or other incentives as well as compelling education, marketing, and program experience to encourage customers to participate.

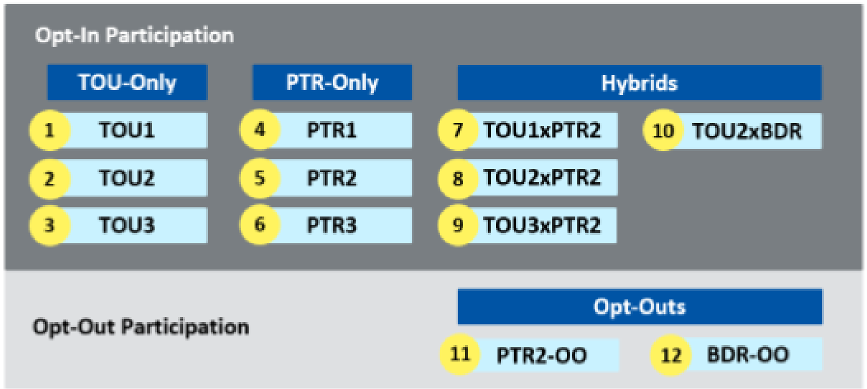
In 2015, PGE launched the Flex pilot program to test the effectiveness and customer acceptance of different demand response program offerings, including time-of-use (TOU) pricing, peak-time rebates (PTR), and behavioral demand response (BDR). By assessing a range of program treatment designs involving different incentive levels, rate structures, and recruitment approaches, PGE sought to understand its options and to lay the groundwork for a future where most of its residential customers participate in demand response programs.

This evaluation report assesses the design and delivery, load impacts, and customer experiences of 12 demand response treatments. PGE tested the demand response treatments as randomized control trials (RCTs), providing highly credible evidence about the treatment effects. The evaluation provides PGE with feedback about the pilot's performance in these areas, and presents insights that can be used to optimize PGE's future demand response program offerings.

Pilot Program Description

In 2016, PGE launched the Pricing and Behavioral Demand Response Pilot Program. The pilot enrolled approximately 14,000 residential customers and tested 12 pricing and behavior-based program design options (treatments), aimed at reducing residential peak demand during summer and winter months. The treatments featured TOU pricing, peak-time rebates (PTR), behavioral demand response (BDR), hybrid demand response (TOU in combination with PTR or BDR), and opt-out demand response (OO) that automatically enrolled customers. PGE offered the 12 treatments as the Flex Pilot Program. Figure 1 shows a diagram of the Flex Pilot Program's multi-treatment program design.

Figure 1. Twelve Treatments Tested in the Flex Pilot Program



PGE outlined the following Flex Pilot Program objectives:

- Implement the program over four seasons (e.g., Summer 2016, Winter 2016/2017, Summer 2017, and Winter 2017/2018), with six to 10 peak demand events per season
- Identify treatment(s) that could be cost-effective at scale, with 10% of customers participating
- Help customers achieve lower or cost-neutral rates
- Achieve positive customer experiences

To facilitate evaluation and planning for a future, full-scale rollout of Flex, PGE established planning estimates for expected demand reduction during Flex events (shown in Table 3). PGE developed the planning estimates based on load impacts reported by utilities operating similar demand response programs.

Table 3. Flex Pilot Program Demand Reduction Planning Estimates

Treatment	Summer	Winter
TOU-Only: TOU1, TOU2, TOU3	5.2%	5.8%
PTR-Only: PTR1, PTR2, PTR3	12.9%	14.2%
Hybrids (PTR): TOU1xPTR2, TOU2xPTR2, TOU3xPTR2	5.2%–12.9%	5.8%–14.2%
Hybrids (BDR): TOU2xBDR	3.0%–5.2%	3.3%–5.8%
PTR2-OO	6.4%	7.1%
BDR-OO	3.0%	3.3%

Note: Table shows PGE planning estimate of percentage demand savings during Flex events.

PGE also set total enrollment goals of approximately 3,850 customers for the 10 opt-in treatments and 13,610 customers for the two opt-out treatments. These enrollment goals ensured sufficient statistical power for testing the various treatments.

PGE designed and implemented the pilot program with assistance from CLEAResult and AutoGrid as the implementation contractors. CLEAResult co-managed day-to-day program implementation and executed program marketing, while subcontracting with AutoGrid to provide the program's technology platform software and data services. PGE selected Cadmus as the program evaluator, assisting PGE with research design, savings analyses, and customer surveys.

Treatments Tested

The Flex Pilot Program tested 12 treatments, consisting of TOU, PTR, BDR, Hybrids, and Opt-Out program designs. This section summarizes these five program designs and the 12 different treatments.

Time-of-Use Rates

Customers enrolled in a TOU treatment paid a different unit price for electricity depending on when the electricity was consumed. TOU rates encourage customers to shift electricity consumption from periods when the utility's cost of supplying electricity is high to periods when the cost is low.

PGE tested three TOU rate schedules: TOU1, TOU2, and TOU3. Table 4 shows TOU rate schedules for summer and winter seasons under Flex.[10] TOU1 and TOU2 only had off-peak and on-peak periods, with TOU1 charging lower on- and off-peak rates, but having a longer on-peak period than TOU2. TOU3 had off-peak, mid-peak, and on-peak periods, with the off-peak rate below and the on-peak rate above those of TOU1 and TOU2. The TOU rate schedules also varied by season. During winter, each TOU rate included morning and afternoon peak periods, while, during summer, the TOU rates only included an afternoon peak period.

[10] Summer TOU rates are in effect from May 1 to October 31. Winter TOU rates are in effect from November 1 to April 30. This evaluation estimated TOU pricing impacts in summer between June 1 and September 30 and in winter between December 1 and February 28.

In summer, the peak-to-off-peak price ratio equaled 1.8 for TOU1, 2.1 for TOU2, and 2.6 for TOU3. In winter, the peak-to-off-peak price ratios were essentially unchanged, equaling 1.8 for TOU1, 2.1 for TOU2, and 2.5 for TOU3. A higher peak-to-off-peak price ratio should encourage greater load shifting, all else equal.

During the first year of participation, TOU customers could request refund if their annual electricity bills exceeded what they would have paid under the standard PGE residential rate. After the first year of participation, the bill protection lapsed and customers could not request a refund.

Table 4. Flex Schedule: TOU Summer and Winter Rates*

Summer	TOU1	TOU2	TOU3
Off Peak	7.5₵/kWh	8.3₵/kWh	6.9₵/kWh
	10:00 pm–6:00 am	8:00 pm–3:00 pm	10:00 pm–11:00 am
Mid Peak			11.9₵/kWh
			11:00 am–3:00 pm 8:00 pm–10:00 pm
On Peak	13.6₵/kWh	17.6₵/kWh	18.0₵/kWh
	6:00 am–10:00 pm	3:00 pm–8:00 pm	3:00 pm–8:00 pm
Winter	**TOU1**	**TOU2**	**TOU3**
Off Peak	8.0₵/kWh	8.8₵/kWh	7.4₵/kWh
	10:00 pm–6:00 am	8:00 pm–7:00 am; 11:00 am–3:00 pm	10:00 pm–7:00 am
Mid Peak			12.4₵/kWh
			11:00 am–3:00 pm; 8:00 pm–10:00 pm
On Peak	14.1₵/kWh	18.1₵/kWh	18.5₵/kWh
	6:00 am–10:00 pm	7:00 am–11:00 am; 3:00 pm–8:00 pm	7:00 am–11:00 am; 3:00 pm–8:00 pm

* TOU rates in effect as of August 1, 2016.

TOU customers received a rate schedule (the Flex schedule), depicting these various costs and times. Each month during summer and winter seasons, PGE sent TOU customers a report on how much money they saved under the TOU rate, with comparisons to the previous month, and tips on how to conserve or shift energy. For the first year, PGE provided bill protection to customers on TOU rates. This insured that TOU customers would not pay more than they would have if they remained on the standard flat rate. Bill protection was applied to a customer's annual—not monthly—consumption.

Peak-Time Rebate

Customers enrolled in a PTR treatment received cash rebates for reducing electricity consumption during Flex time events. PGE tested three rebate amounts[11]:

- PTR1 customers received $0.80 per kWh of savings
- PTR2 customers received $1.55 per kWh
- PTR3 customers received $2.25 per kWh

A customer's PTR savings were calculated relative to his or her baseline consumption, which was an estimate of what normal consumption would have been during the event hours.

One day in advance, PGE dispatched event notifications via email, text, and voice mail to customers, with another notification on the day of the event. These event notifications came with tips on conserving or shifting energy.

Within two days after an event, PGE provided PTR customers with feedback regarding their performance, showed them how much electricity they saved and incentives earned. Within two weeks after the season's end, PGE mailed a report (along with a rebate check) to customers, addressing the total amount of electricity they saved during the season's events. The end-of-season report also showed energy savings for the customer and all Flex Program participants.

Behavioral Demand Response

The BDR treatment used behavior-based strategies to encourage customers to reduce electricity consumption during Flex events. PGE sent BDR customers event notifications, similar to those for PTR treatment, asking them to reduce electricity during specific hours of high demand. BDR customers, however, did not receive rebates or other financial incentives for reducing consumption during events. Rather, PGE provided BDR customers with social-normative peer comparisons and appeals to participate in collective actions to reduce electricity demand during peak periods. BDR customers received an end-of-season report similar to that provided for the PTR treatment, but they did not receive a rebate check.

Hybrids

Customers in Hybrid treatment received a combination of TOU and PTR treatments or a combination of TOU and BDR treatments:

- **TOUxPTR**: PGE tested three TOU rate treatments paired with the PTR2 treatment: TOU1xPTR2, TOU2xPTR2, and TOU3xPTR2. Customers in this Hybrid treatment paid different unit prices for electricity, depending on the day of week and time of day, *and* became eligible to receive a rebate for reducing consumption below baseline levels during Flex events.

[11] PTR incentives reflect pricing as of August 1, 2016.

- **TOU2xBDR:** PGE tested TOU2 paired with BDR. Customers in this Hybrid treatment paid the TOU2 rate *and* were asked to reduce consumption during Flex events, without financial incentive.

Opt-Out Participation

PGE tested BDR as an opt-out treatment, automatically enrolling customers but allowing them to opt out at any time. PGE also tested PTR2 as an opt-out and opt-in treatment to determine how the framing of the participation choice affected enrollments, demand savings, and customer satisfaction. PGE administered the PTR2 treatments identically to opt-out and opt-in customers.

Research Design and Program Set-Up

PGE implemented a large, randomized field experiment to test the Flex Pilot Program, using recruit-and-deny randomized controlled trials (RCT) to test the 10 opt-in treatments and a standard RCT to test the two opt-out treatments. Randomized field experiments serve as the gold standard for demand-side management program evaluation and are expected to produce unbiased estimates of treatment effects.

Customer Eligibility Requirements

PGE identified 246,000 residential customers eligible to participate in the pilot. To receive an invitation to participate or to be automatically enrolled in the pilot, customers had to meet the following criteria:

- Receive electricity service from PGE and the current service address for at least the previous 12 months
- Not be a solar energy customer (i.e., did not have solar panels installed on the premises and on a net metering rate)
- Not be a participant in the Rush Hour Rewards thermostat control demand response program
- Provide PGE with a valid email address
- Have a functioning interval consumption meter that records and communicates energy consumption to PGE

PGE did not impose eligibility requirements regarding minimum or maximum energy consumption or peak demand levels, allowing customers with low or high consumption levels to participate. However, PGE screened all eligible customers for expected bill savings from TOU treatments. Only customers expected to reduce their annual electricity bill payments with TOU pricing were given the opportunity to participate.[12]

[12] Only customers with positive bill savings under the assumption that they shifted 7% of load from peak period to off-peak period were invited to participate in a TOU or Hybrid treatment.

Random Assignment to Treatment

PGE randomly assigned eligible customers to a pricing treatment (e.g., TOU2 or PTR1) and to a test or control group, and then invited them to participate in the pilot. Customers who opted into the pilot and had been randomly assigned to a test group were placed into treatment, while customers who opted in and had been assigned to the control group were not enrolled. Customers assigned to an opt-out treatment test group were automatically enrolled and received the assigned treatment unless they opted out. Customers assigned to the control group of an opt-out pricing treatment did not receive that treatment or any program-related communications. None of the customers assigned to a control group could participate in the Flex pilot.

Marketing and Recruitment

Customer recruitment for 10 opt-in treatments began in mid-February 2016 and continued through Spring 2017. PGE recruited customers to the pilot in three waves: Spring 2016; Summer/Fall 2016; and Spring 2017.

PGE and CLEAResult developed marketing materials and messaging for the pilot. This messaging focused on economics (personal gains, including bill savings), control (taking charge of your consumption), and community (the greater good). For customers invited to participate in a TOU treatment, the marketing presented expected bill savings under the assumptions of 7% and 15% shifts in consumption from the peak to off-peak period. For TOUxPTR hybrid customers, the marketing also presented bill savings with expected PTR-earnings.

In marketing the program to customers, PGE employed the following communication channels:

- **Email.** PGE sent multiple emails to customers with valid email addresses.
- **Direct mail.** PGE first sent postcards and then later sent business letters.
- **Flex website:** PGE established a customer engagement web portal, where customers could enroll in the program, review their current pricing plan, view information on ways to save, and obtain information about their household's electricity consumption.

Opt-In Treatment Recruitment and Enrollment Process

As discussed, PGE and Cadmus randomly preassigned eligible customers to one of 10 opt-in treatments and to either a test group or a control group. All eligible customers received an email and postcard invitation to enroll in Flex. The email and postcard included rate comparison information pertaining to the customer's assigned pricing option. The email and postcard provided customers with an activation code to sign up through the Flex website. Customers received a reminder email to enroll a week after the initial email and were given up to 45 days to enroll.

After logging into the Flex website, a customer completed enrollment by accepting the assigned pricing treatment. Test group customers who accepted their assigned pricing treatment became program participants. Control customers who accepted their pricing treatment were not placed into treatment, but rather received a message saying they did not qualify to enroll currently, but may be able to do so in the future.

PGE initially offered test and control customers a reward for enrolling during the early 2016 recruitment period. Enrolled customers could choose between an Amazon gift card and a pair of zoo tickets. After seeing very little enrollment impact, however, PGE eliminated the enrollment reward.

Test group customers participating in the 10 opt-in pricing treatments could opt out at any time by contacting the pilot's call center.

Opt-Out Treatment Enrollment Process

PGE automatically enrolled randomly-chosen customers into one of two opt-out treatments: a peak-time rebate (PTR2-OO); or a behavioral demand response (BDR-OO). Customers randomly assigned to an opt-out treatment test group received a welcome email and postcard in mid-June 2016. The email and postcard included a link to access the Flex website.

Test-group customers participating in an opt-out treatment could opt out of the program in two ways: unsubscribing to the emails; or contacting the program's call center.

Recruitment Targets and Actual Enrollments

Table 5 shows PGE's enrollment targets, the number of customers enrolled in each Flex test group at the beginning of each season, and historical maximum enrollment as a percentage of the target. The enrollment targets were determined through statistical power analysis, with the objective of enrolling enough customers to detect the expected load impacts through statistical analysis. At first, recruitment proceeded slower than expected. In Summer 2016, only 50% of the targeted customers had enrolled, but, by Summer 2017, the program exceeded its targets, with many treatments reaching 150% or more of the sample size targets.[13] All treatments except for BDR-OO met their enrollment targets.

[13] Because PTR2 had recruitment priority to achieve a sample size large enough to support analysis for the Summer 2016 season, PGE stopped recruiting for PTR2 after Spring 2016.

Table 5. Flex Customer Recruitment Targets and Enrollments

Treatment	Number of Customers (N)				Target (N)	Percent of Target Achieved (Maximum)
	Summer 2016	Winter 2016/2017	Summer 2017	Winter 2017/2018		
PTR1	112	144	368	344	220	167%
PTR2	243	227	225	206	220	110%
PTR3	165	219	456	414	220	207%
TOU1	136	152	413	386	390	106%
TOU1xPTR2	132	146	346	329	220	157%
TOU2	480	564	1013	946	875	116%
TOU2xBDR	184	217	898	833	875	103%
TOU2xPTR2	251	234	220	202	220	114%
TOU3	130	158	432	401	390	111%
TOU3xPTR2	126	147	321	292	220	146%
PTR2_OO	375	703	631	564	430	163%
BDR_OO	6,233	11,215	10,089	9,095	13,180	85%
Total Opt-In	**1,959**	**2,208**	**4,692**	**4,353**	**3,850**	**122%**
Total Opt-Out	**6,608**	**11,918**	**10,720**	**9,659**	**13,610**	**88%**

Table 6 shows target and enrolled numbers of control group customers by treatment and season for the Flex pilot study. The control group sizes for individual treatments largely mirror those for the test groups. All treatments except BDR-OO achieved their targets by Summer 2017.

Table 6. Flex Control Group Sizes

Treatment	Number of Customers (N)				Target (N)	Percent of Target Achieved (Maximum)
	Summer 2016	Winter 2016/2017	Summer 2017	Winter 2017/2018		
PTR1	121	155	363	343	220	165%
PTR2	212	199	191	181	220	96%
PTR3	160	218	453	422	220	206%
TOU1	114	128	454	417	390	116%
TOU1xPTR2	118	123	326	302	220	148%
TOU2	388	453	554	513	390	142%
TOU2xPTR2	230	208	189	171	220	105%
TOU3	108	136	460	422	390	118%
TOU3xPTR2	126	159	309	287	220	140%
PTR2_OO	405	730	662	605	430	170%
BDR_OO	6,186	11,178	10,087	9,081	13,180	85%
Total Opt-In	**1,577**	**1,779**	**3,299**	**3,058**	**2,490**	**132%**
Total Opt-Out	**6,591**	**11,908**	**10,749**	**9,686**	**13,610**	**87%**

Event and Data Management

CLEAResult subcontracted with AutoGrid to operate the Flex Pilot Program's technology platform and to provide PGE with program management software and data management services. AutoGrid built and configured an online system to handle data from three different program designs (TOU, PTR, and BDR), employing a two-part system to manage the program's demand response events and data:

- The engagement portal (Flex website), which houses and tracks customer-facing program data and information
- The demand response management system, designed to schedule events and measure consumption at short time intervals

AutoGrid's system communicated with PGE's customer information system to gather up-to-date customer account information and, through PGE's advanced metering infrastructure (AMI), to gather customer interval consumption data at the meter level. PGE scheduled and dispatched events via the AutoGrid system, which sent event notifications to customers on the day before the scheduled event. On the day after the event, the AutoGrid system received and analyzed interval consumption data and estimated the load impacts. After reviewing the event performance results, PGE released them to customers, usually within 24-48 hours.

Table 7 shows Flex events that PGE called over the two summer and winter seasons.

Table 7. Flex Time Events by Season

Season	Date	Event Period	Notes
Summer 2016	7/27/2016	4:00 p.m.–7:00 p.m.	
	7/29/2016	4:00 p.m.–7:00 p.m.	
	8/11/2016	4:00 p.m.–7:00 p.m.	
	8/12/2016	4:00 p.m.–7:00 p.m.	
	8/18/2016	4:00 p.m.–7:00 p.m.	
	8/25/2016	4:00 p.m.–7:00 p.m.	
Winter 2016/2017	12/6/2016	4:00 p.m.–7:00 p.m.	
	12/8/2016 (snow day)	4:00 p.m.–7:00 p.m.	
	12/15/2016 (snow day)	4:00 p.m.–7:00 p.m.	BDR-OO not dispatched.
	1/3/2017	4:00 p.m.–7:00 p.m.	
	1/4/2017	4:00 p.m.–7:00 p.m.	
	1/11/2017	5:00 a.m.–8:00 a.m.	
	2/1/2017	7:00 a.m.–10:00 a.m.	
	2/3/2017 (snow day)	7:00 a.m.–10:00 a.m.	TOU2xBDR and BDR-OO not dispatched.
Summer 2017	7/25/2017	4:00 p.m.–7:00 p.m.	
	8/1/2017	5:00 p.m.–8:00 p.m.	
	8/3/2017	4:00 p.m.–8:00 p.m.	
	8/7/2017	4:00 p.m.–7:00 p.m.	TOU2xBDR and BDR-OO not dispatched.
	8/9/2017	3:00 p.m.–6:00 p.m.	
	8/28/2017	4:00 p.m.–8:00 p.m.	
	9/5/2017 (fire day)	4:30 p.m.–7:30 p.m.	Air quality issue from Eagle Creek fire.
Winter 2017/2018	1/3/2018	5:00 p.m.–8:00 p.m.	
	1/9/2018	5:00 p.m.–7:00 p.m.	TOU2xBDR and BDR-OO not dispatched.
	1/18/2018	5:00 p.m.–8:00 p.m.	
	1/25/2018	5:00 p.m.–8:00 p.m.	TOU2xBDR and BDR-OO not dispatched.
	1/31/2018	5:00 p.m.–8:00 p.m.	TOU2xBDR and BDR-OO not dispatched.
	2/20/2018	5:00 p.m.–8:00 p.m.	
	2/23/2018	7:00 a.m.–10:00 a.m.	

Evaluation Objectives

PGE specified the following evaluation objectives for the Flex pilot:

- Estimate the load impacts for each treatment and compare the estimated treatment effects.
- Assess customer enrollments in and satisfaction with the different treatments, including opt-in and opt-out treatments.
- Assess whether customer opt-in rates, satisfaction, and estimated load reductions depend on the PTR incentive amount or TOU pricing schedule.
- Determine whether behavior-based treatments result in significant and sustained reductions in customer demand.
- Assess whether Hybrid treatments result in larger peak demand reductions than single treatments.
- Identify implementation challenges, improvement opportunities, and potential for expanding the pilot.
- Assess program successes, challenges, and areas for improvement and scalability.

PGE's research objectives did not include cost-effectiveness analysis, as PGE planned to conduct the cost-effectiveness analysis using the study's results as inputs.

Evaluation Activities

Evaluation Background

In October 2015, PGE hired Cadmus to evaluate the Flex pilot. At the beginning, Cadmus assisted with the research design for the evaluation, which involved selecting demand response treatments, designing the randomized field experiments, and determining minimum sample sizes. After selecting the 12 treatments for testing, PGE began implementing the pilot. Cadmus assisted by randomly assigning eligible customers to one of the 12 treatments and to a test or control group. In March 2016, PGE began recruiting customers for enrollment; this was the first of three recruitment waves, with subsequent waves launching in summer/fall 2016 and spring 2017.

This Flex evaluation covers two summers and two winters, beginning in June 2016 and ending in February 2018. While Cadmus evaluated the pilot during all four seasons, this report focuses on Summer 2017 and Winter 2017/2018 seasons because the pilot did not reach its customer recruitment targets until summer 2017 and PGE changed some aspects of the program's delivery during the first two seasons.

To assess program delivery, design, and the customer experience, Cadmus performed a series of participant surveys (for treatment and control groups), including just after recruitment, during seasons after a peak-saving events, and at the end of a season, after all events had been completed. Cadmus also conducted multiple interviews with program and implementation staff at various points across the evaluation cycle.

Cadmus estimated pilot load impacts by analyzing hourly AMI customer consumption data. This involved performing separate regressions by season and treatment to assess differences in loads between test and control customers.

Table 8 summarizes the Flex pilot evaluation activities and how each relates to PGE's evaluation objectives. Below, we discuss each of these evaluation activities in greater detail, except for the research design, which was discussed already.

Table 8. Flex Pilot Evaluation Activities

Activity	Description	Outcomes	Relevance to Study Research Objectives
Research design	Designed recruit-and-deny RCT for opt-in treatments and RCT for opt-out treatments. Determined sample sizes for each treatment required to detect expected savings.	Randomized field experiment design and required sample sizes to obtain accurate and precise estimates of treatment effects.	1, 2, 3, 4, 5
Data collection and preparation	Collecting and preparing analysis of individual-customer AMI meter interval consumption data.	Final analysis sample for estimation of load impacts.	1
Load impact analysis	Regression analysis of individual-customer AMI meter interval consumption data.	Estimates of Flex event savings for 12 treatments and for peak and off-peak load impacts for TOU pricing.	1, 3, 4, 5, 6
PGE manager and implementation contractor interviews	Interviewed managers and contractors regarding program design, implementation, successes, and challenges.	Documentation of pilot implementation and lessons learned.	1, 6, 7
Customer surveys	Recruitment, event, and customer experience surveys.	Findings about customer satisfaction with the program and PGE, customer engagement, and event awareness.	2, 3, 6, 7

Data Collection and Preparation

Cadmus collected and prepared the following data for analysis:

- Individual-customer AMI meter electricity consumption data for all test and control group customers
- Weather data for each customer from the NOAA weather station closest to each customer's residence.
- Pilot enrollment, program participation, and account closure data for customers who received an invitation to participate in Flex, were automatically enrolled in the pilot (opt-out BDR or PTR), or assigned to the opt-out BDR control group or PTR control group.
- Dates and times of all Flex events and rate schedules for all Flex TOU pricing treatments

The AMI meter data recorded a customer's electricity consumption at 15 or 60-minute intervals and covered 12 months before the customer first received treatment (i.e., the customer's TOU rate became active) and all post-treatment months while the customer's account remained active. Cadmus aggregated all 15-minute interval consumption data to the customer-hour level. We performed standard data-cleaning steps to address duplicate observations, extreme outliers, and missing values. These data cleaning steps are discussed in Appendix A.

The weather data were high-frequency, asynchronous temperature and humidity readings from seven NOAA weather stations across PGE's service area. Cadmus aggregated the weather data to the hourly level and merged them with the hourly interval consumption data.

The pilot enrollment and program participation data included the following fields for each customer:

- Assignment to treatment (e.g., BDR, TOU1, etc.), assignment to test or control group, and indicator for recruiting wave (Wave 1, Wave 2, or Wave 3)
- For opt-in customers an indicator for whether the customer opted into the pilot and the date when the customer opted in.
- The official enrollment date if the customer opted into the pilot and had been assigned to the test group
- For customers assigned to receive an opt-out treatment, the date when the customer was automatically enrolled in the pilot.
- The account closure date if the customer's account closed during the pilot.
- The date the customer unenrolled from the pilot if the customer opted out of treatment.

Cadmus used the pilot enrollment and program participation data to identify customers in the test and control groups for each treatment, to define different variables for the load impact analysis, such as treatment and test-group indicator variables, to develop survey sample frames, and to calculate treatment opt-out rates.

In cleaning and preparing the AMI meter data, Cadmus encountered several issues that had to be addressed before the data could be analyzed. These issues included:

- Some AMI datasets were recorded on Coordinated Universal Time (UTC) instead of Pacific Time (UTC -8 or UTC -7).
- During the pre-treatment period, some customers' AMI meter data were recorded as integer kWh instead of as watt-hours.
- PGE did not provide pretreatment data for the same 12 months for all pilot customers

Appendix A discusses Cadmus' solutions to these issues. Robustness checks of the Flex treatment savings estimates indicate that the estimates were not sensitive to the specific solutions Cadmus developed.

Analysis Samples

Table 9 shows the initial and final analysis samples for each treatment in Summer 2017 and Winter 2017/2018 seasons. The initial analysis sample includes all customers who were randomly assigned to a test or control group and whose billing account remained active at the beginning of the Flex season.

Customers who opted out of treatment were included in both total enrollment and final analysis customer counts. Customers who moved or discontinued electricity service before the season began were excluded from samples.

Table 9. Flex Pilot Final Analysis Sample Sizes

Treatment	Summer 2017			Winter 2017/2018		
	Initial Analysis Sample (N)	Final Analysis Sample (N)	Analysis Sample Percentage	Initial Analysis Sample (N)	Final Analysis Sample (N)	Analysis Sample Percentage
PTR1	731	722	99%	687	678	99%
PTR2	416	408	98%	387	380	98%
PTR3	909	889	98%	836	823	98%
PTR2-OO	1,293	1,256	97%	1,169	1,149	98%
BDR-OO	20,176	19,587	97%	18,176	17,889	98%
TOU1	867	827	95%	803	787	98%
TOU2	1,567	1,510	96%	1,459	1,406	96%
TOU3	892	849	95%	823	805	98%
TOU1xPTR2	672	638	95%	631	612	97%
TOU2xPTR2	409	385	94%	373	354	95%
TOU2xBDR	1,452	1,398	96%	1,346	1,317	98%
TOU3xPTR2	630	598	95%	579	559	97%

The final analysis sample includes customers used in the impact estimation. The analysis sample excluded only a small number of test and control group customers in each treatment. For most treatments, the analysis included more than 97% of enrolled customers in the analysis. The main drivers of customer attrition from the analysis sample included lack of pre- or post-period AMI data.

Cadmus verified that there were not statistically significant differences in pre-treatment consumption between test and control group customers in the final analysis sample. For almost all treatments, the test and control groups were well balanced. Appendix C provides detailed balance test results.

Savings Estimation Approach

Cadmus estimated savings for each Flex treatment by collecting individual-customer AMI interval consumption data from before and after the customer enrolled in the Flex pilot and by comparing the peak demand of customers in the randomized test and control groups. This evaluation reports the following impacts:

- Flex event demand savings for all treatments, including TOU rates
- Peak period and off-peak period load impacts for TOU-based treatments, including TOU-only and hybrid treatments

We provide an overview of the estimation approach but a more detailed description is found in Appendix B.

Event-Based Treatments

Cadmus estimated the demand savings from event-based treatments (e.g., PTR1, opt-out BDR) by comparing demand during Flex events of customers in the randomized test and control groups. Using data for event hours during each winter or summer season, Cadmus estimated a multivariate panel regression of customer hourly energy demand on control variables for pretreatment hourly average demand, hour-of-sample fixed effects, and assignment to treatment. We estimated a separate model for each treatment.

The pretreatment demand variables controlled for average differences in electricity demand between customers during Flex event hours. Cadmus calculated separate mean pretreatment demand for morning and evening hours for each season, using AMI interval data for days before the beginning of the Flex season. Cadmus did not calculate mean pre-treatment demand using non-event days during the demand response season in consideration of evidence from other studies showing that event-based treatment can produce savings on non-event days. The hour-of-sample fixed effects controlled for weather and other unobserved factors specific to each event hour.

Cadmus estimated the models by ordinary least squares (OLS) and clustered the standard errors on customers to account for correlation over time in customer demand. Given the random assignment of customers to test and control groups, the regression was expected to produce an unbiased estimate of the treatment effect. Cadmus estimated alternative model specifications to test the estimates' robustness to specification changes, and found the results were very robust. Cadmus tested specifications that included indicator variables for a customer's recruitment wave (i.e., Wave 1, Wave 2, or Wave 3) as standalone variables and interacted with other explanatory variables and that dropped the pre-treatment consumption variables from the regression.

Time of Use Rate and Hybrid Treatments

Cadmus estimated treatment effects for TOU rate and hybrid-TOU rate treatments by comparing demand of customers in each treatment's randomized test and control groups. Using interval data on customer demand for each winter or summer season, Cadmus estimated a multivariate panel regression of customer hourly energy demand on control variables for pretreatment demand, peak and off-peak hours, day-of-the-week, weather, and assignment to treatment. We estimated treatment effects for Summer 2017 using data from June 1, 2017 to September 30, 2017 and for Winter 2017/2018 using data from December 1, 2017 to February 28, 2018. We estimated a separate model for each treatment.

Cadmus estimated the TOU and Hybrid models by OLS and clustered the standard errors on customers. Again, because of random assignment of customers to test and control groups, the regression was expected to produce unbiased savings estimates. Cadmus also estimated alternative model specifications to test the robustness of estimates to specification changes. For example, Cadmus tested specifications that included indicator variables for a customer's recruitment wave (i.e., Wave 1, Wave 2, or Wave 3) as standalone variables and interacted with other explanatory variables. The results proved robust to this and other specification changes. To estimate the treatment effect for the TOU3 rate, which included a mid-peak period, Cadmus added an indicator variable for the mid-peak period to the specification.

To estimate treatment effects for the Hybrid treatments such as TOU1xPTR2 or TOU2xBDR, Cadmus specified a model that allowed the effect of peak period hours to depend on whether the hour was a Flex event hour.

Adjusting the Treatment Effects for Customer Opt-Outs

Estimation of the average treatment effect using data for all customers who were randomly assigned to the test or control groups and whose account remained active provides an estimate of the intent-to-treat (ITT) effect. However, not all customers assigned to treatment received treatment or treatment for the duration of the study. Over the randomized field experiment's course, some customers opted out of the pilot, ending their participation. Including these opt-outs in the analysis yields a savings estimate across customers who remained in treatment and those who opted out.

To estimate the average treatment effects for customers randomly assigned to and remaining in treatment, Cadmus scaled the intent-to-treat (ITT) savings estimates by dividing them by one minus the percentage of customers assigned to treatment who opted out before or during the season.[14] This produces an estimate of savings for treated customers. Since, in general, the opt-out rates for individual treatments were small, scaling of the ITT savings estimates had little effect.

Staff Interviews

Over the course of two summer and winter Flex seasons, Cadmus conducted five interviews with PGE and CLEAResult managers of the Flex pilot. The first interview occurred prior to Summer 2016 and focused on documenting and understanding the program design, recruitment, marketing, and delivery plan for the individual treatments. After each subsequent summer and winter season, Cadmus conducted additional interviews, focused on implementation changes and new perspectives on program successes, challenges, and learnings. Cadmus also used information from the interviews to design and refine the customer surveys for each season.

[14] This scaling produces an unbiased estimate of the treatment's effect for treated customers (i.e., those not opting out) if customers who opt out do not continue to save demand. If opt-out customers continue to save, the treatment effect estimate will be biased upward. Although customers did not receive event notifications after opting out, they could continue to save demand if they had programmed thermostats or other household appliances to run during off-peak periods and do not adjust the settings after opting out.

Customer Surveys

Cadmus designed and administered the following six customer surveys online:

- Recruitment survey (fielded in May 2016)
- Summer 2016 event survey (fielded in August 2016)
- Summer 2016 experience survey (fielded in November/December 2016)
- Winter 2016/2017 experience survey (fielded in April 2017)
- Summer 2017 experience survey (fielded in January 2018)[15]
- Winter 2017/2018 experience survey (fielded in April 2018)

The recruitment survey asked test group customers in the 10 opt-in treatments about how they heard about Flex, their awareness of TOU pricing and Flex events, about their satisfaction with PGE, and questions designed to establish demographics.

The event surveys asked test group customers in PTR and BDR treatments about event notifications and participation, load-shifting and conservation behaviors, and satisfaction with Flex and PGE. Control group customers were surveyed at the same time to collect comparative data on satisfaction with PGE.

The experience surveys asked test group customers in all 12 treatments about program awareness and participation, load-shifting and conservation behaviors, satisfaction with Flex and PGE, and demographics. Control group customers were surveyed at the same time to collect comparative data on satisfaction with PGE and demographics.

Each survey took respondents, on average, five minutes to complete and were fielded for a two-week period. Respondents did not receive an incentive or reward for completing a survey. For more details on the customer survey design, see Appendix E.

Survey Sampling and Response Rates

The number of test and control customers available at the time of survey fielding in each of the 12 treatments determined the sampling method for customer surveys. For all treatments except BDR-OO, Cadmus surveyed the census of active customers. For BDR-OO, however, Cadmus surveyed a random sample of 3,333 customers due to the very large number of customers in this treatment. Table 10 shows the number of test group customers contacted for each survey and the response rates by opt-in and opt-out treatment type. Table 11 shows the number of control group customers contacted and the response rate by opt-in and opt-out treatment types. For sampling and response rate details on each of the 12 treatments, see Appendix E.

[15] Cadmus fielded the Summer 2017 experience survey late compared to the previous summer experience survey due to survey instrument revisions and coordination with PGE on customer contact approval.

Table 10. Customer Survey Samples and Response Rates: Test Group

	Recruitment Survey 2016	Summer 2016 Event Survey	Summer 2016 Experience Survey	Winter 2016/2017 Experience Survey	Summer 2017 Experience Survey	Winter 2017/2018 Experience Survey
Opt-In Treatments						
Number of Contacted	865	969	1,467	1,659	3,828	3,635
Number of Completes	458	348	319	328	817	833
Response Rate	53%	36%	22%	20%	21%	23%
Opt-Out Treatments						
Number of Contacted	–	3,610	3,551	3,679	3,895	3,840
Number of Completes	–	329	119	160	202	277
Response Rate	–	9%	3%	4%	5%	7%
Total (Opt-In and Opt-Out Treatments Combined)						
Number of Contacted	865	4,579	5,018	5,338	7,723	7,475
Number of Completes	458	677	438	488	1,019	1,110
Response Rate	53%	15%	9%	9%	13%	15%

Table 11. Customer Survey Samples and Response Rates: Control Group

	Summer 2016 Event Survey	Winter 2016/2017 Experience Survey	Winter 2017/2018 Experience Survey
Opt-In Treatments			
Number of Contacted	–	–	2,647
Number of Completes	–	–	599
Response Rate	–	–	23%
Opt-Out Treatments			
Number of Contacted	3,602	3,729	3,926
Number of Completes	389	345	362
Response Rate	11%	9%	9%
Total (Opt-In and Opt-Out Treatments Combined)			
Number of Contacted	3,602	3,729	6,573
Number of Completes	389	345	961
Response Rate	11%	9%	15%

Survey Data Analysis

Cadmus compiled frequency outputs, coded open-end survey responses, and ran statistical tests to determine whether survey responses differed significantly between treatments and groups. Cadmus also compared survey responses between seasons.

Detailed Findings

Customer Enrollment and Retention

Opt-In Rates

Table 12 provides the cumulative opt-in rates for each opt-in treatment through the Summer 2017 season when PGE stopped recruiting customers for Flex. These rates indicate the number of customer who opted into the pilot compared to the total number of customers invited to participate. Cadmus calculated opt-in rates across all three waves of recruitment that received enrollment offers via mail or email and included opt-in rates for customers who were assigned to the control group. Note that in Table 12 the TOU2 and TOU2xBDR treatments are combined, since PGE randomly assigned some customers who opted into the TOU2 treatment to receive the BDR treatment. Note also that the opt-in rates are identical in Winter 2017/2018 as they were for Summer 2017 because there were no new enrollments.

Table 12. Opt-In Rates by Treatment*

Treatment	Through Summer 2017	
	Invited Customers Who Opted In (%)	Count of Customers Who Opted In (N)
PTR Only		
PTR1	4.3%	790
PTR2	2.8%	481
PTR3	6.2%	986
TOU Only		
TOU1	3.5%	932
TOU2 and TOU2xBDR**	3.4%	2,656
TOU3	3.7%	937
Hybrids		
TOU1xPTR2	4.5%	720
TOU2xPTR2	2.4%	489
TOU3xPTR2	4.5%	675

* Results presented here include both test and control participants

** TOU2 and TOU2xBDR are presented together because PGE randomly assigned TOU2 customers to receive the BDR treatment.

The opt-in rates reflect customer enrollments over three waves of recruitment. These rates varied over time, as PGE experimented and experienced different degrees of success with various marketing and messaging strategies. In general, PGE experienced greatest success in recruiting in Wave 3, as it incorporated important marketing lessons learned during Waves 1 and 2. These lessons are discussed below in the *Implementation Challenges and Lessons Learned* section. Also, PGE prioritized recruiting of certain treatments and stopped recruiting for some treatments before others. This meant that PGE did not recruit customers to some treatments during Wave 3.

The opt-in rates ranged between 2.4% and 6.2%. Overall, opt-in rates were higher for treatments that included peak-time rebates. The highest opt-in rate was for PTR3, which offered the most generous rebate of $2.25 per kWh of savings. The PTR2 and TOU2xPTR2 treatments experienced the lowest opt-in rates because PGE had stopped recruiting for these treatments after completing Wave 2. PGE customer opt-in rates were lower than those achieved by SMUD, which obtained opt-in rates ranging between 16% and 19% for a TOU and CPP program.[16] A likely explanation for the difference is that PGE customers are less familiar with the concepts of demand response and time varying rates than SMUD customers. As PGE educates its residential customer population more about peak demand and its demand response program offerings, it is expected that a higher percentage of PGE customers will opt into future pricing programs.

Opt-Out Rates

Table 13 provides the cumulative opt-out rates by treatment and season. These rates pertain to enrolled customers who opted-out of each treatment between June 1, 2016 and the last day of the summer or winter season (September 30, 2017 and February 28, 2018, respectively). Customers could opt out of the program by contacting PGE customer service and asking to be un-enrolled. Customers who moved residences were removed from the program but were not counted as opt-outs.[17]

Table 13. Cumulative Opt-Out Rates by Treatment and Season

Treatment	Summer 2017		Winter 2017/2018	
	%	Count of Customers	%	Count of Customers
PTR Only				
PTR1	4.2%	15	4.5%	16
PTR2	4.6%	11	6.3%	15
PTR3	5.1%	21	5.4%	22
Opt-Outs				
PTR2-OO	1.7%	13	2.3%	18
BDR-OO	1.9%	241	3.2%	398
TOU Only				
TOU1	7.0%	28	8.0%	32

16 Potter, Jennifer, Stephen George, and Lupe R. Jimenez. 2014. *SmartPricing Options Final Evaluation, Sacramento Municipal Utility District*, p. 106. Available at https://www.smartgrid.gov/files/SMUD-CBS_Final_Evaluation_Submitted_DOE_9_9_2014.pdf

17 Due to limitations in the availability of accurate opt-out dates across the entire evaluation period, these rates constitute an upper bound on the true opt-out rate. The true opt-out rates may be lower.

Treatment	Summer 2017		Winter 2017/2018	
	%	Count of Customers	%	Count of Customers
TOU2	7.3%	68	8.6%	80
TOU3	8.1%	33	8.6%	35
Hybrids				
TOU1xPTR2	9.9%	32	10.6%	34
TOU2xPTR2	9.4%	22	9.9%	23
TOU2xBDR	7.2%	63	8.3%	72
TOU3xPTR2	8.7%	26	9.7%	29

Cumulative opt-out rates through Winter 2017/2018 ranged between 2.3% and 10.6%. The most important differences in opt-out rates were between treatments of different types: opt-in vs. opt-out treatments and PTR vs. TOU or Hybrid treatments. In general, only small differences existed between treatments of a given type. For example, opt-rates ranged between 7.0% and 8.1% for TOU-only customers and 4.6% and 5.1% for PTR-only customers. Most differences in opt-out rates between treatments of a given type were random and not statistically significant.

Opt-out rates for opt-in treatments were higher than those for opt-out treatments. For opt-in treatments, opt-out rates through the end of W2017/2018 season ranged from 4.5% (PTR1) to 10.6% (TOU1xPTR2). For the opt-out PTR2 and BDR treatments, opt-out rates were 2% and 3%, respectively. The opt-out rates were lower for opt-out treatments than opt-in treatments because many customers automatically enrolled in the program are complacent: they will neither opt in nor opt out of a program if given the opportunity. Also, opt-out customers may be less likely to know how to opt-out of treatment.

Among opt-in treatments, opt-out rates were higher for TOU and Hybrid treatments than for PTR treatments. The opt-rates for TOU and Hybrid treatments ranged between 8% and 11% through W17/18, almost twice as high as those for PTR customers. The higher opt-out rates for TOU and Hybrid customers aligns with the lower rates of customer satisfaction with these treatments as documented below in the *Customer* Experience section.

Load Impacts

The following section provides load impact estimates by Flex treatment for the Summer 2017 and Winter 2017/2018 events seasons. Table 14 summarizes the average load reductions during Flex events and on-peak TOU periods. Reporting is focused on the most current Flex event seasons due to two factors:

- The final wave of Flex recruitment occurred in March 2017. PGE did not achieve its recruitment targets until summer 2017, and previous seasons had participation levels significantly below the targets.
- During the first two pilot seasons, PGE implemented major improvements in the program delivery (e.g., in deploying events, messaging customers, and providing participants with feedback); by summer 2017, PGE had these refinements in place, and the pilot better reflected how a full-scale program will be implemented.

Load impacts from two initial Flex seasons are provided in the Appendix D. PGE plans additional research to estimate load impacts as a function of customer demographic and housing characteristics. PGE will use research about the relationships between demand savings and customer characteristics will inform future demand response program design, marketing, and delivery.

Prior to the Flex pilot, PGE ran a critical peak pricing (CPP) pilot between 2011 and 2013, which achieved demand savings during summer and winter afternoon events of 10% and 12%, respectively. In comparison to the Flex PTR-only treatments, the CPP pilot achieved lower savings in summer, but higher savings in winter.

Table 14. Flex Demand Savings by Treatment and Season*

Category	Treatment		Summer Demand Savings**				Winter Demand Savings**						
			Planning (%)	Evaluation (%)	Abs. Precision at 90% Conf.	Evaluation (kW)	Planning (%)	Evaluation (%)		Abs. Precision at 90% Conf.		Evaluation (kW)	
								AM	PM	AM	PM	AM	PM
PTR-Only	PTR1		13%	18%	±4%	0.41	14%	13%	7%	±7%	±4%	0.23	0.13
	PTR2			22%	±6%	0.48		0%	8%	±8%	±5%	-0.01	0.14
	PTR3			17%	±4%	0.39		3%	12%	±7%	±3%	0.05	0.22
Opt-Out	PTR2-OO		6%	7%	±3%	0.16	7%	0%	6%	±5%	±3%	0.00	0.10
	BDR-OO		3%	2.30%	±1%	0.05	3%	-0.7%	1%	±1%	±1%	-0.01	0.02
TOU-Only	TOU1	On-Peak	5%	2%	±3%	0.02	6%	-1%		±4%		-0.02	
		Flex Event		-1%	±6%	-0.02		2%	0%	±7%	±5%	0.03	0.00
	TOU2	On-Peak		8%	±3%	0.12		3%		±3%		0.04	
		Flex Event		5%	±5%	0.10		2%	2%	±6%	±4%	0.04	0.04
	TOU3	On-Peak		5%	±4%	0.07		0%		±3%		0.00	
		Flex Event		6%	±6%	0.13		3%	-1%	±9%	±5%	0.05	-0.01
Hybrids	TOU1xPTR2	On-Peak	5.2% TOU; 12.9% PTR	3%	±4%	0.04	5.8% TOU; 14.2% PTR	1%		±5%		0.01	
		Flex Event		10%	±7%	0.21		10%	5%	±11%	±6%	0.17	0.08
	TOU2xPTR2	On-Peak	5.2% TOU; 12.9% PTR	24%	±5%	0.33	5.8% TOU; 14.2% PTR	5%		±5%		0.08	
		Flex Event		20%	±8%	0.43		12%	13%	±13%	±6%	0.22	0.25
	TOU2xBDR	On-Peak	5.2% TOU; 3.0% BDR	8%	±3%	0.12	5.8% TOU; 3.3% BDR	1%		±4%		0.02	
		Flex Event		11%	±5%	0.23		-1%	1%	±7%	±5%	-0.02	0.02
	TOU3xPTR2	On-Peak	5.2% TOU; 12.9% PTR	9%	±5%	0.12	5.8% TOU; 14.2% PTR	4%		±4%		0.06	
		Flex Event		8%	±7%	0.17		4%	13%	±10%	±6%	0.08	0.25

* Seasonal results presented only for Summer 2017 and Winter 2017/2018. Percentage demand savings estimated as kW demand savings estimate divided by average control customer demand.

**Impact estimates are percentage demand savings during Flex peak-time events and on-peak savings for TOU rates; green indicates significance at 90%.

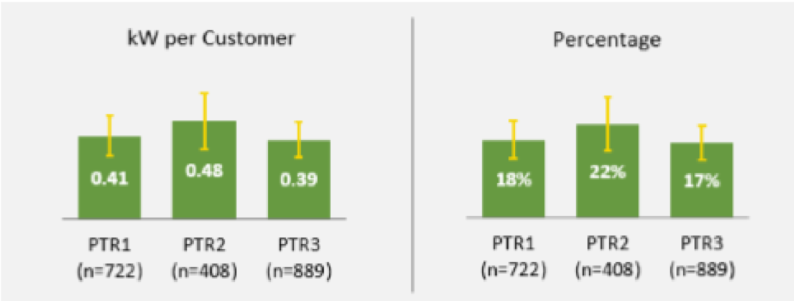
Peak-Time Rebates—Summer

Figure 2 shows the kW and percentage demand savings during Flex events for opt-in PTR treatments during summer 2017. PGE tested the load impacts of three peak rebates ($0.80/kWh, $1.55/kWh, and $2.25/kWh) during seven Flex events. The PTR treatments saved between an average of 0.39 kW per customer and an average of 0.48 kW per customer, or about 20% of demand. All PTR load impacts surpassed PGE's planning estimate of 13% for summer seasons.

Despite large differences in rebate levels, significant differences did not emerge between PTR treatments in the estimated demand savings. The $0.80/kWh and the $2.25/kWh rebates produced approximately the same demand savings. This demonstrates that PGE customers reduced consumption in response to the higher opportunity cost of consuming electricity during Flex events, but the rebate amount did not determine the magnitude of the response. In a recent study of a California critical peak-pricing program, Gillan (2017) made a similar finding, showing that customers were not sensitive to marginal changes in critical peak prices.[18]

Although the rebate did not influence the estimated demand savings, it affected customer satisfaction, as discussed demonstrate in the Customer Satisfaction with Flex section.

Figure 2. PTR-Only Demand Savings During Flex Events—Summer 2017



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during Flex events. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

Figure 3 shows estimated PTR demand savings and ambient outdoor temperature in °F for each of seven events during summer 2017. Peak-time rebates produced similar average demand savings per customer across events, between 0.3 kW and 0.5 kW. No correlation occurred between outdoor temperatures and demand savings during events.

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[18] Gillan, James, 2017. Dynamic Pricing, Attention, and Automation: Evidence from a Field Experiment in Electricity Consumption. Energy Institute at Haas Working Paper 284. Available at: https://ei.haas.berkeley.edu/research/papers/WP%20284.pdf

Figure 3. PTR-Only Demand Savings by Flex Event—Summer 2017

Notes: Figure shows by Flex event the average outdoor temperature during event hours and estimates of average kW savings per customer. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

Peak-Time Rebates—Winter

Figure 4 shows demand savings during Winter 2017/2018 Flex events for the opt-in PTR treatments. Six afternoon PTR events and one morning event occurred. The figure presents separate savings estimates for the morning (AM) and afternoon (PM) events. Unlike the summer season, all PTR treatments during the winter season produced point estimates of savings lower than PGE's planning estimates (14%). The PTR savings estimates may have been lower than PGE expected because the Winter 2017/2018 season was milder than normal.[19]

During the morning event, opt-in PTR customers saved between 0% (PTR2) and 13% (PTR1) of demand. During the six afternoon events, opt-in PTR customers saved between 7% (PTR1) and 12% (PTR3). As in summer, no relationship between savings and the rebate amount became evident. While PTR3 customers, who received the largest rebate, saved the most during evening events, PTR1 customers, who received the smallest rebate, saved the most during the morning event.

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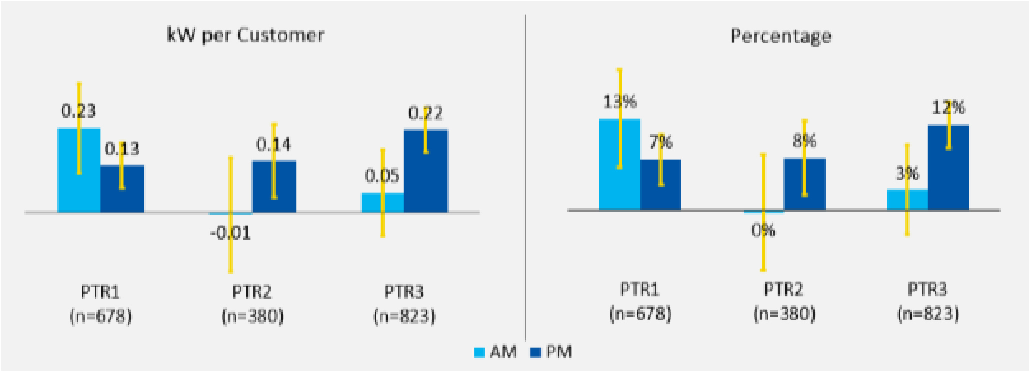
[19] See *Mean Temperature Departures from Average* in NOAA National Climate Report for December 2017, January 2018, and February 2018. Available at: https://www.ncdc.noaa.gov/sotc/national/.

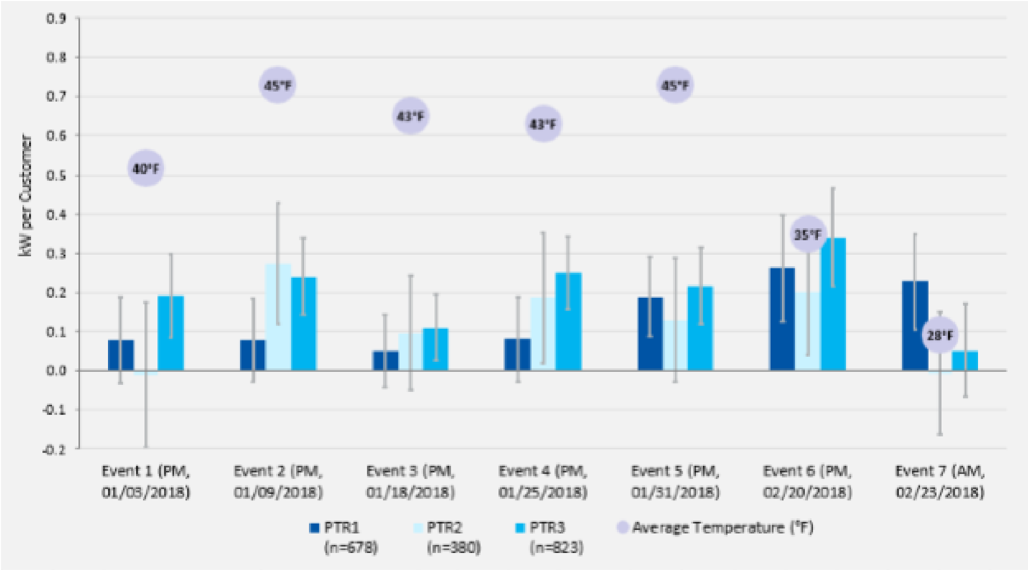
Figure 4. PTR-Only Demand Savings During Flex Events—Winter 2017/2018



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during Flex events. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

Figure 5 shows demand savings for opt-in PTR customers and outdoor ambient temperatures (°F) during each of the seven events in winter 2017/2018. There was more variation in average demand savings per customer between PTR treatments and across events in winter than summer. PTR3 customers tended to save the most and PTR1 customers the least, but this relationship did not hold for all events. As in summer, no relationship emerged between outdoor temperature and demand savings.

Figure 5. PTR-Only Demand Savings by Flex Event—Winter 2017/2018



Notes: Figure shows by Flex event the average outdoor temperature during event hours and estimates of average kW savings per customer during Flex events. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

Opt-Out Treatments—Summer

PGE also tested opt-out BDR and PTR2 treatments. PGE automatically enrolled customers in these treatments but gave them opportunity to opt-out, which less than 3% of customers did. Though not all PTR-OO customers who remained in the pilot attempted to save during PTR events, as discussed below, many customers did save, including those who would not have enrolled if given the choice. Except for the rebate, the BDR and PTR treatments were similar: opt-out customers received event notifications, encouragement to reduce demand, and personalized feedback about their savings. By comparing the BDR and PTR treatments, Cadmus could isolate the incremental effect of providing a rebate on peak demand savings.

Figure 6 shows the estimated demand savings for opt-out treatments during summer 2017 Flex events. Opt-out PTR2 customers saved an average of 0.16 kW per customer (or 7% of demand); and BDR saved an average of 0.05 kW per customer (or 2% of demand). While load impacts for PTR2-OO slightly surpassed PGE's 6% planning estimate, the load impacts for BDR-OO savings fell short of PGE's planning estimate (3%).The rebate's incremental effect was about 0.12 kW per customer or 5% of demand. In addition to increasing Flex event demand savings, the rebate increased customer satisfaction with the Flex pilot. As shown in Figure 20 below, PTR2-OO participants reported being more satisfied (6 to 10 ratings) and delighted (9 to 10 ratings) than BDR-OO participants by significant margins.

Opt-out PTR2 customers saved substantially less during Flex events than opt-in PTR2 customers, who, as Figure 2 shows, saved about 20% of demand; however, the group of treated opt-out customers included a large percentage of customers who would not have opted into treatment if given the choice. These customers included *complacent* customers, who stayed in treatment after PGE automatically enrolled them, and *never-takers*, who opted out after enrollment. A back-of-the envelope calculation suggests that the average *complacent* PTR customer saved about 6% of demand during Flex events.[20]

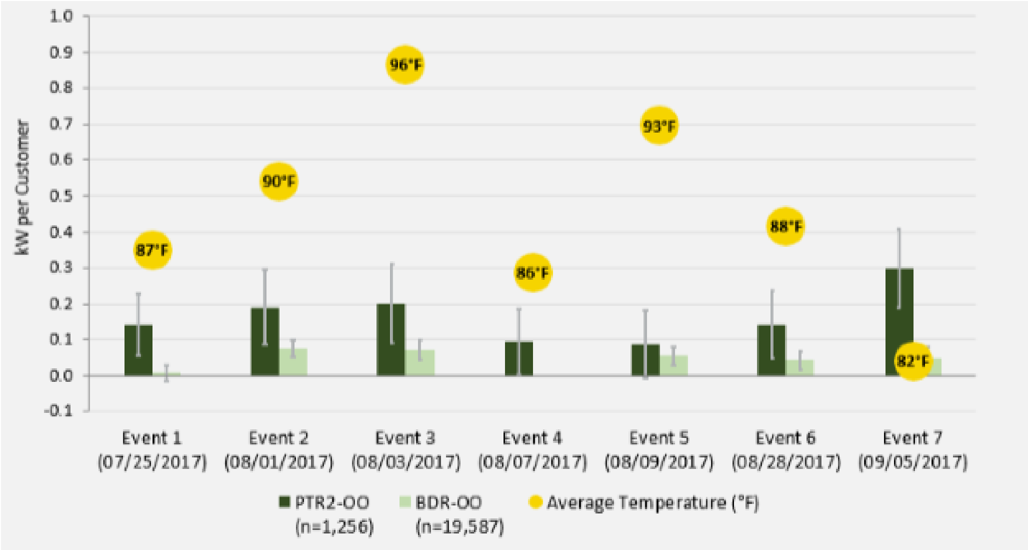
Figure 6. Opt-Out Treatments Demand Savings During Flex Events—Summer 2017

Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during Flex events. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

Figure 7 shows PTR2-OO and BDR-OO demand savings and ambient outdoor temperatures during Flex events for each of the seven events during summer 2017. PGE did not dispatch BDR-OO for Event 4 (August 7, 2017). Across the events, PTR2-OO produced average demand savings per treated customer between 0.1 kW per customer and 0.3 kW per customer; BDR-OO produced savings between 0.01 kW per customer and 0.08 per customer. No relationships between outdoor temperatures and savings became evident in the event impact estimates.

[20] The 7% savings estimate for the opt-out PTR2 treatment represented an average of savings across the following customer types: (1) *always-takers*—customers who would opt into the pilot if given the opportunity; (2) *complacents*—customers who would neither opt-in nor opt-out of treatment if given the choice, but who nevertheless might save when enrolled; and (3) *never-takers*—customers who would never enroll and always opted out given the choice. Our estimate assumed never-takers would not save and the 22% savings estimate for opt-in PTR2 customers was a reasonable estimate of PTR2 savings for always-takers. Additionally, from Table 11 and Table 12, *always-takers* constituted about 5% of the population (i.e., average opt-in rates for PTR1, PTR2, and PTR3 treatments), and *never-takers* constituted about 3% of the population (i.e., opt-out rate for opt-out PTR2). This implies that *complacent* customers constituted 92% of the customers defaulted into PTR2 treatment; and that *complacent* customers saved an average of 6.4% of demand.

Figure 7. Opt-Out Treatments Demand Savings by Flex Event—Summer 2017



Notes: Figure shows estimates of average kW savings per customer. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. During event 4, PGE did not dispatch BDR-OO customers.

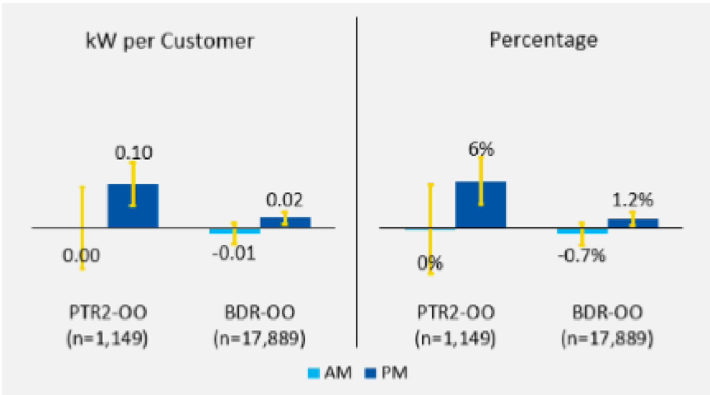
Opt-Out Treatments—Winter

Figure 8 shows demand savings estimates during winter 2017/2018 Flex events, which included six afternoon events and one morning event, for PTR2-OO and BDR-OO treatments.

During morning events, neither opt-out treatment achieved demand savings. The savings point estimates were small and statistically indistinguishable from zero. During evening events, PTR2-OO customers saved 6% of demand and BDR-OO customers saved 1% of demand, with both estimates statistically significant. For both opt-out treatments, demand savings were slightly less than PGE planning estimates for winter (7% for PTR-OO and 3% for BDR-OO). Based on a comparison of PTR2-OO and BDR-OO impacts, the rebate increased Flex events savings by about 4%. As in summer, the rebate enhanced customer satisfaction with Flex, lifting the percentage of satisfied customers by about 10%.

The opt-out PTR and BDR treatments saved less in winter than summer. One hypothesis explaining the smaller winter savings is that PGE customers had a lower tolerance for cold than heat and therefore were less willing to adjust their thermostat settings in winter. Another hypothesis holds that PGE customers had fewer opportunities to save. Many PGE customers heat with natural gas, eliminating the potential for demand savings from the largest home energy end use.

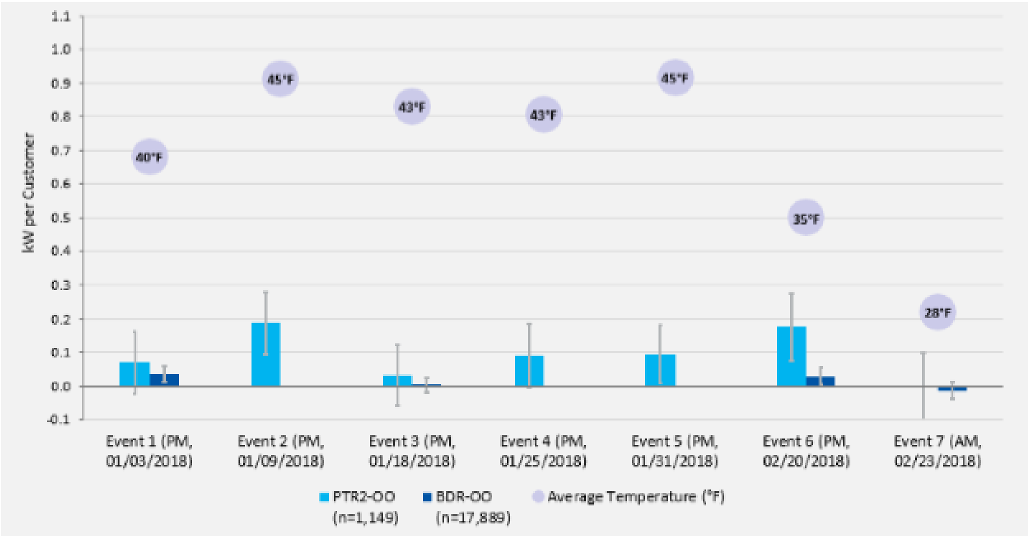
Figure 8. Opt-Out Treatments Demand Savings During Flex Event—Winter 2017/2018



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during Flex events. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers.

Figure 9 shows PTR2-OO and BDR-OO demand savings and ambient outdoor temperatures for each winter 2017–2018 event. PGE did not dispatch BDR-OO for events 2, 4, and 5 (January 1, 2018, January 25, 2018, and January 31, 2018). PTR2-OO demand savings ranged from zero kW per customer (Event 7) to 0.2 kW per customer (Event 2). As with opt-in PTR, no relationship emerged between outdoor temperatures and demand savings.

Figure 9. Opt-Out Treatments Demand Savings by Flex Event—Winter 2017/2018



Notes: Figure shows estimates by event of average kW savings per customer. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. During events 2, 4, and 5, PGE did not dispatch BDR-OO customers.

PGE Payments for Savings Caused by Peak Time Rebates

PTR customers earned rebates for saving energy relative to a customer-specific baseline but were not penalized for exceeding the baseline.[21] PGE paid customers for savings whether the savings were caused by the rebate, naturally-occurring, or from random variation in the customer's consumption. Since PGE pays for some savings that are not caused by the rebate and there is no corresponding financial penalty for increasing consumption above the baseline, PGE will overpay for savings at the program level.

As Table 15 reports, in Summer 2017, PGE paid an average of between $10 and $30 in rebates per PTR customer, depending on the rebate amount. In Winter 2017/2018, PGE paid an average of $6 and $20 in rebates per PTR customer. To estimate how much of the savings that PGE paid for represented savings caused by the program, Cadmus compared the evaluation's estimate of PTR savings per customer with PGE's estimate of average PTR savings per customer from its performance calculations.

Table 15 compares the savings estimates from PGE's performance calculation and the evaluation. For PTR-only treatments, the ratio of evaluated average PTR savings per customer to performance-calculated average savings per customer ranged between 67% and 83% in summer and 25% and 44% in

[21] The PTR is an asymmetric incentive. Customers face a higher effective marginal price for electricity equal to the sum of the rebate and the standard rate when their consumption is below the baseline and a lower effective marginal price for electricity equal to the standard rate when consumption is above the baseline.

winter. For the PTR hybrid treatments, the ratio ranged from 37% to 108% in summer and from 27% to 74% in winter.

Table 15. Evaluated Demand Savings vs. PGE Performance-Calculated Savings – Opt-In PTR

Treatment	Summer 2017			Winter 2017/2018		
	Performance-Calculated (kWh)	Evaluated Savings (kWh)	Ratio	Performance-Calculated (kWh)	Evaluated Savings (kWh)	Ratio
PTR1	12.59	9.38	75%	7.97	2.82	35%
PTR2	13.36	11.04	83%	9.20	2.33	25%
PTR3	13.27	8.91	67%	8.98	3.95	44%
TOU1xPTR2	10.20	4.73	46%	7.11	1.95	27%
TOU2xPTR2	9.27	9.96	108%	6.69	4.95	74%
TOU3xPTR2	10.33	3.85	37%	7.15	4.47	63%

Notes: Performance-calculated savings are average savings per customer per season verified by PGE for calculating customer rebates. Evaluated savings are the average savings per customer per season estimated by Cadmus.

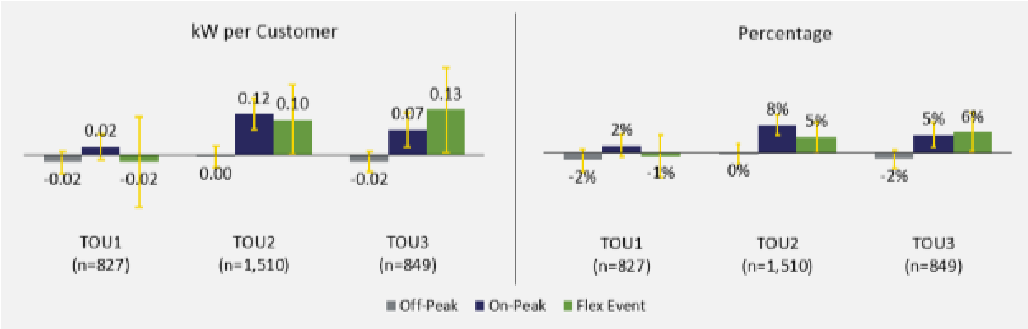
These results confirm that at least some savings for which PGE paid customers were naturally occurring and not caused by the rebates. For PTR-only customers, between one-third and one-fifth of performance-calculated savings in summer and one-half and three-quarters of performance-calculated savings in winter were not attributable to the program. Note, these overestimates of savings apply only to the performance-calculated figures used to pay customers, not to the evaluated savings shown in this report.

PGE may have overpaid for savings more in winter than summer for two reasons. First, as comparison of Figure 2 and Figure 4 show, PTR customers tended to save less in winter than summer, suggesting that a higher percentage of customers who PGE estimated to have saved did not in fact save. Second, customer demand during Flex events tended to be more variable in winter than summer, which could also increase PGE's payments for savings not caused by the pilot.

TOU-Only Treatments—Summer

Figure 10 shows kW and percentage load impacts for TOU-only treatments in summer 2017. The figures show estimated average load impacts per treated customer during off-peak hours, on-peak hours, and Flex event hours. Although TOU-only customers did not receive notification of Flex events, Cadmus measured load impacts during Flex hours to estimate impacts of TOU pricing on reducing system peak demand. The figures show reductions in demand or savings as positive impacts, and show load increases as negative impacts.

Figure 10. TOU-Only Demand Savings—Summer 2017



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during TOU off-peak, TOU on-peak, and Flex event hours (i.e., a proxy for system-peak demand hours). Reductions in demand (savings) are shown as positive values and increases in demand are shown as negative values. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. The TOU3 rate also had a mid-peak period. During the mid-peak period, TOU3 customers demanded 0.05 kW or 5% less on average, with a 90% confidence interval of [0.01 kW, 0.09 kW] or [1%, 8%].

Estimated load impacts for TOU1 customers were small and not statistically significant. In summer 2017, TOU1 customers reduced their consumption during on-peak hours by 2% and increased their consumption by 2% during off peak hours, but neither impact proved statistically significant, as shown by the 90% confidence intervals (CI), which were tightly estimated and included zero. TOU1 customers also did not save demand during Flex events, which proxy for hours of PGE system-peak demand.

The TOU1 rate schedule's design likely explained the small estimated impacts. The on-peak period occurred on non-holiday weekdays, from 6:00 a.m. to 10:00 p.m., covering waking hours for many customers, and making it difficult for them to shift loads from on-peak to off-peak periods. Many customers would need to adjust their routines to accommodate the TOU1 schedule or to schedule their household appliances (e.g., dishwashers, washing machines) to run at night. It remains unclear, however, how many Flex customers could schedule when their appliances would operate. In surveys, many TOU1 customers reported dissatisfaction with Flex due to the rate schedule being difficult for their households to adopt; these customers said it was not convenient or worth changing sleep schedules to do chores during off-peak periods.

While TOU1 did not yield the desired load shifting, the TOU2 and TOU3 rates, having shorter on-peak periods, did so. Both rates defined on-peak periods as hours during non-holiday weekdays, from 3:00 p.m. to 8:00 p.m. In addition, the TOU3 rate defined the mid-peak period as non-holiday weekday hours from 11:00 a.m. to 3:00 p.m. and 8:00 p.m. to 10:00 p.m. During the mid-peak period, customers faced a lower retail rate for electricity than the on-peak period rate, but had a rate higher than the off-peak period rate.

The TOU2 and TOU3 rates produced similar off-peak and on-peak load impacts. During on-peak hours, TOU2 customers reduced demand by about 0.12 kW per customer (or 8%), and TOU3 customers reduced demand by about 0.07 kW per customer (or 5%). The difference in these estimates was not statistically significant. Only weak evidence emerged of load shifting. TOU2 customers increased off-peak consumption by less than 0.5%, and TOU3 customers increased consumption by about 2%, but neither estimate proved statistically different from zero. This suggests customers tended to reduce demand during peak periods by, for example, adjusting their thermostat settings or turning off lights, rather than shifting consumption from peak to off-peak periods by, say, delaying dishwashing and laundry. As Figure 18 shows, approximately 50% of TOU participants reported having turned off lights or adjusted thermostat settings during peak periods.

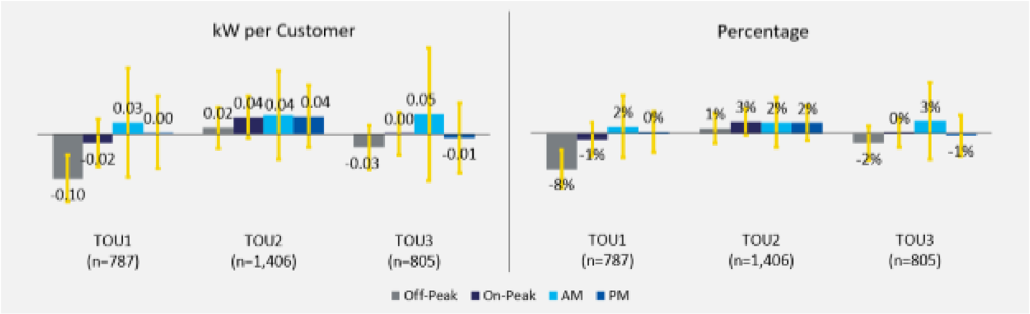
Estimated load impacts during Flex event hours (i.e., a proxy for system-peak demand hours) were about the same as those during on-peak hours. TOU2 and TOU3 customers saved about 5% and 6% of demand. Again, PGE did not notify TOU-only customers of Flex events; so it was expected that demand savings during event hours would not be significantly greater. For TOU2 and TOU3, load impacts for on-peak and Flex event periods met or surpassed the 5% PGE planning estimate.

TOU-Only Treatments—Winter

Figure 11 shows load impacts during peak, off-peak, and Flex event hours (again, a proxy for system-peak demand hours) for TOU1, TOU2, and TOU3 treatments. In winter, PGE scheduled morning and afternoon on-peak periods. Although TOU-only customers were not notified of Flex events, Cadmus estimated the average TOU savings per customer during seven Flex events to assess the impacts of TOU pricing during periods approximating system peak demand.

TOU pricing produced smaller reductions in demand in winter than summer. Except for TOU1 during off-peak hours, none of the TOU-only treatments reduced loads during on-peak hours or shifted loads to off-peak hours. In general, impact estimates were small, and confidence intervals for all estimated impacts included zero. None of the TOU-only treatments saved demand during Flex events, or the savings were too small to detect with the available sample sizes. The savings estimates were small and statistically insignificant. Peak period and Flex event saving for all TOU treatments were lower than PGE's planning estimate of 6% reduction for winter. Based on the estimated confidence intervals, it is possible to reject the hypothesis that demand savings during on-peak and Flex hours were greater than or equal to 6% for each TOU rate.

Figure 11. TOU-Only Demand Savings—Winter 2017/2018



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during TOU off-peak, TOU on-peak, and a.m. and p.m. Flex event hours. Reductions in demand (savings) are shown as positive values and increases in demand are shown as negative values. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. The TOU3 rate also had a mid-peak period. During the mid-peak period, TOU3 customers demanded 0.03 kW or 2% less on average, with a 90% confidence interval of [-0.02 kW, 0.07 kW] or [-2%, 5%].

Why did TOU2 and TOU3 customers reduce demand during peak hours and Flex events in summer but not winter? Two explanations seem possible. First, according to surveys completed with TOU customers, a significant source of peak savings comes through adjustments to thermostat settings. In winter, savings could have been achieved by setting thermostats at a lower temperature during peak periods. PGE customers, however, may have had less tolerance for cold than for heat, and therefore been less willing to make such adjustments. Second, many TOU customers heated their homes with gas (approximately 60% of TOU-only and 53% of Hybrid customers, per the Winter 2017/2018 survey), eliminating a large, potential source of savings from home heating.

TOU Conservation Impacts

TOU pricing encourages customers to shift demand from on-peak, high-price periods to off-peak, low-price periods. However, the expected effect of TOU pricing on total energy consumption is ambiguous. Depending on the customer's elasticity of demand and the changes in relative and absolute prices, total energy consumption could increase, decrease, or stay the same. In Summer 2017, the TOU2 and TOU3 treatments reduced demand during on-peak periods, but there were not statistically significant demand increases during the off-peak periods. This suggests that TOU pricing may have led to a small decrease in overall electricity consumption for the average customer.

Table 16 presents estimates of the total electricity consumptions impacts of TOU pricing in summer and winter. Cadmus estimated the impacts by regressing customer daily electricity consumption on an indicator for assignment to the test group, day-of-sample fixed effects, recruitment-wave fixed effects, customer pre-treatment average daily consumption, and daily cooling degrees. We tested the sensitivity of the estimates to different model specifications and found that the estimates were robust. The impacts shown in the table are adjusted for opt-outs.

Table 16. TOU-Only Energy Conservation Impacts

Treatment	Daily Energy Savings, Summer 2017		Daily Energy Savings, Winter 2017-2018	
	kWh	Abs. Precision at 90% Conf.	kWh	Abs. Precision at 90% Conf.
TOU1	0.08	±0.82	-1.27	±1.35
TOU2	0.02	±0.83	0.38	±1.21
TOU3	0.37	±0.86	-0.39	±1.14

Notes: The table reports the average daily energy savings per treated customer. Positive values indicate energy savings. The precision was estimated based on standard errors clustered on customers.

TOU pricing did not result in statistically significant changes in energy consumption. In summer, the impacts for TOU1 and TOU2 were small and not statistically significant, as the estimated confidence intervals included zero. TOU3 customers saved an average of 0.37 kWh per customer per day, but, as with the other TOU-only treatments, the estimate was not statistically significant. In winter, none of the energy savings estimated was statistically different from zero. The point estimates show that relative to control group customers, TOU1 and TOU3 customers increased energy consumption, while TOU2 customers reduced their consumption.

When Cadmus calculated the average daily energy savings per TOU customer using the on-peak period and off-peak period demand impact estimates in Figure 10 and Figure 11, we also obtained small and statistically insignificant savings.

Hybrid Treatments—Summer

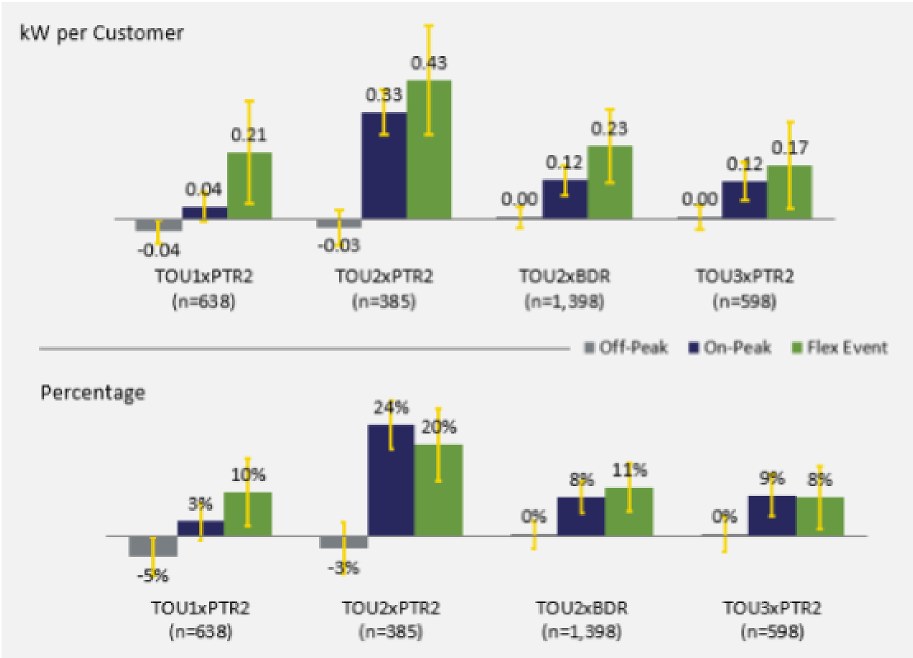
Figure 12 shows load impacts for Hybrid treatments in summer 2017, including TOU pricing with PTR and TOU pricing with BDR.

In general, the Hybrid treatments produced load reductions during on-peak periods similar to those for TOU-only treatments. The TOU1xPTR2 treatment did not produce statistically significant peak savings. Customers on TOU2xPTR2, TOU2xBDR, and TOU3xPTR2 saved, respectively, 0.33 kW per customer (24%), 0.12 kW per customer (8%), and 0.12 kW per customer (9%). The TOU2xBDR and TOU3xPTR2 impacts during on-peak hours were similar to those for TOU2 and TOU3 treatments. Customers on TOU2xPTR2, however, saved more than TOU2 (8%) customers. These peak savings estimates exceeded PGE's planning estimate of 5% for TOU rates in summer. None of the Hybrid treatments produced statistically significant load shifting from peak to off-peak hours. The load impact estimates for off-peak hours were close to zero and statistically insignificant. While generating approximately the same peak-period demand savings as the TOU-only treatments, the TOUxPTR2 treatments tended to produce higher customer satisfaction Table 34.

During Flex events, the Hybrid treatments produced savings between 8% and 20% of demand. TOU1xPTR2, TOU2xBDR, and TOU3xPTR3 yielded Flex event savings of approximately 10%, results close to and not statistically different from demand savings estimates during on-peak periods. TOU2xPTR2 saved about 20% of demand—about twice as large as Flex event savings estimates for other Hybrid treatments and four times as large as the Flex event savings for TOU2-only treatment. Except for

TOU2xPTR2, the Hybrid PTR treatments did not exceed PGE's planning estimate of 13% savings for opt-in PTR treatments in summer.

Figure 12. Hybrid Demand Savings—Summer 2017



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during TOU off-peak, TOU on-peak, and a.m. and p.m. Flex event hours. Reductions in demand (savings) are shown as positive values and increases in demand are shown as negative values. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. The TOU3 rate also had a mid-peak period. During the mid-peak period, TOU3xPTR2 customers demanded 0.10 kW or 9% less on average, with a 90% confidence interval of [0.05, 0.15 kW] or [4%, 13%].

In comparison to PTR2-only treatment, TOU-PTR hybrid treatments tended to generate smaller savings during Flex events (i.e., a proxy for system-peak demand hours). TOU2xPTR2 yielded approximately the same Flex event savings (20%) as PTR2 (22%), but TOU1xPTR2 and TOU3xPTR2 treatments produced much smaller savings than PTR2 only (10% and 8% vs. 22%). TOU1xPTR2 and TOU3xPTR2 treatments also produced smaller Flex event savings than PTR1 (18%), which offered customers a smaller rebate per kWh of savings than PTR2.

Hybrid treatments may have produced smaller Flex event savings than PTR-only for two reasons:

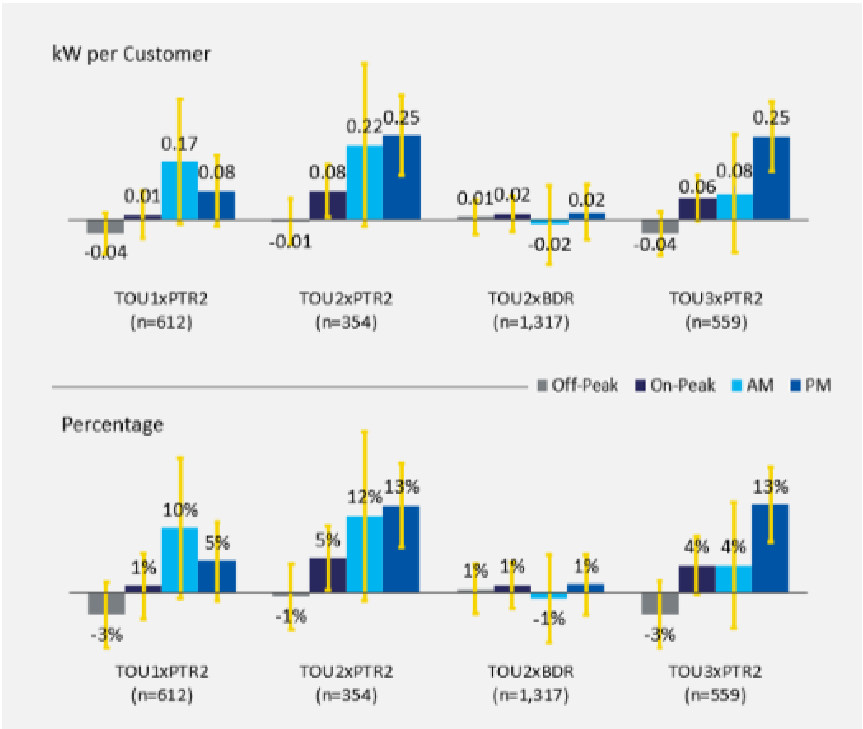
- Hybrid customers who reduced peak period consumption or shifted consumption to off-peak periods would have had lower baselines than PTR-only customers for calculating PTR savings, decreasing rebate payments and reducing the incentives for saving during Flex events. PGE used non-event days during Summer 2017 to establish the consumption baseline for calculating a customer's PTR savings, which would tend to result in lower baselines for TOU customers who saved during peak periods.

- Hybrid customers may have become inattentive to Flex events, having formed energy consumption habits (e.g., programming thermostats) to save demand during TOU on-peak periods that would have been costly from a time, effort, or psychic perspective to change during Flex events. For example, customers may have adjusted their thermostat settings to save during TOU on-peak periods, and it may have been easier for TOU customers simply to ignore event notifications than to make further adjustments to their settings. As discussed below, many TOUxPTR customers' surveys reported that they already conserved regularly and did not feel they needed to do more during events.

Hybrid Treatments—Winter

Figure 13 shows load impacts for TOU Hybrid treatments in Winter 2017/2018. In many ways, the results mirrored those for summer 2017, though load impacts tended to be smaller. As with TOU1-only treatment, TOU1xPTR2 treatment proved difficult for PGE customers; TOU1xPTR2 treatment did not result in peak savings or load shifting from peak to off-peak periods in winter. As discussed below, however, TOU1xPTR2 customers experienced higher satisfaction than TOU1-only customers, suggesting PTR lifted customer satisfaction. TOU2xPTR2 and TOU3xPTR2 customers reduced demand during peak periods by 0.08 kW per customer (5%) and 0.06 kW per customer (4%), but TOU2xBDR treatment did not produce statistically significant demand savings. TOU2xBDR was the only hybrid treatment that did not provide rebates to customers for reducing demand during Flex events, and it produced demand savings during on-peak periods and Flex events very similar to the savings from TOU2-only. None of the Hybrid treatments resulted in statistically significant increases in demand during off-peak hours.

Figure 13. Hybrid Demand Savings—Winter 2017/2018



Notes: Figure shows estimates of average kW savings per customer and percentage kW savings relative to control group customer demand during TOU off-peak, TOU on-peak, and a.m. and p.m. Flex event hours. Reductions in demand (savings) are shown as positive values and increases in demand are shown as negative values. Numbers (n) indicate the total number of test and control group customers used in the impact estimation. Errors bars show 90% confidence intervals estimated with standard errors clustered on customers. The TOU3 rate also had a mid-peak period. During the mid-peak period, TOU3xPTR2 customers demanded 0.05 kW or 2% less on average, with a 90% confidence interval [-0.02, 0.12 kW] or [-1%, 8%].

During Flex events, all Hybrid treatments except TOU2xBDR produced significant demand savings. During the morning Flex event, TOU1xPTR2 saved an average of 0.17 kW per customer (10%), TOU2xPTR2 saved an average of 0.22 kW per customer (12%), and TOU3xPTR2 saved an average of 0.08 (4%), though only the savings estimates for TOU2xPTR2 and TOU3xPTR2 were close to being statistically significant at the 10% level. During afternoon Flex events, TOU1xPTR2 treatment saved 0.08 kW per customer (5%) and TOU2xPTR2 and TOU3xPTR2 treatments saved 0.25 kW per customer (13%). These estimated impacts were close to those for PTR-only treatments in winter.

Hybrid Conservation Impacts

Table 17 presents estimates of the energy conservation impacts in Summer 2017 and Winter 2017/2018 for the Hybrid treatments.

Table 17. Hybrid Treatment Energy Conservation Impacts

Treatment	Daily Energy Savings, Summer 2017		Daily Energy Savings, Winter 2017-2018	
	kWh	Abs. Precision at 90% Conf.	kWh	Abs. Precision at 90% Conf.
TOU1xPTR2	0.14	±1.14	0.22	±1.67
TOU2xPTR2	0.35	±1.47	0.75	±1.82
TOU2xBDR	0.36	±0.87	0.20	±1.29
TOU3xPTR2	0.70	±1.06	0.57	±1.62

Notes: The table reports the average daily energy savings per treated customer. Positive values indicate energy savings. The precision was estimated based on standard errors clustered on customers.

The point estimates suggest that in summer and winter Hybrid treatments may have reduced energy consumption by less than an average of 0.7 kWh per customer day, but none of the estimates were statistically significant. For example, it was estimated TOU2xPTR2 treatment reduced consumption by an average of 0.35 kWh per customer per day, but the estimated confidence interval [-1.12, 1.82] is wide and includes zero. The confidence intervals for the other treatments are similarly wide and include zero.

When Cadmus calculated the average daily energy savings per TOU customer using the on-peak period and off-peak period demand impact estimates in Figure 12 and Figure 13 and, we also obtained small and statistically insignificant savings.

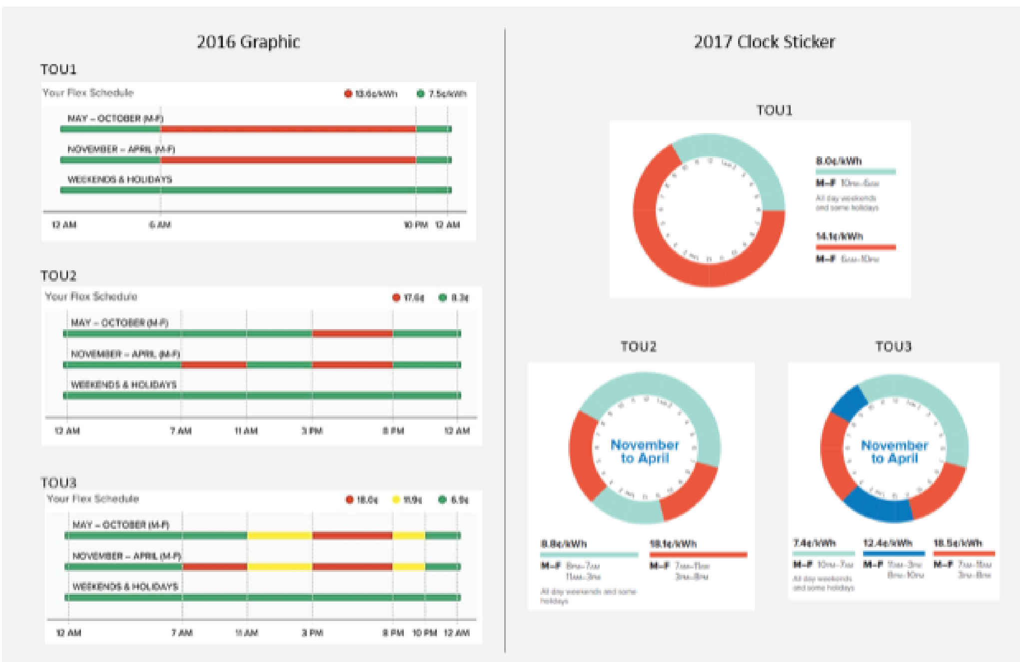
Customer Experience

The summer and winter experience surveys asked Flex customers about their awareness of rates and event notifications, efforts to reduce or shift loads, participation challenges, satisfaction with Flex, and satisfaction with PGE. Respondents rated their satisfaction on a 0–10 scale, where zero meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defined a 6-10 rating as *satisfied* and a 9-10 rating as *delighted*. The following section describes the major findings from the surveys.

Pricing Awareness

TOU customers could manage electricity costs by either: (1) reducing consumption during high-cost periods; or (2) shifting consumption from high-cost periods to lower-cost periods. Therefore, educating TOU customers about the Flex schedule (i.e., the rates and times) would prove crucial for program success. PGE educated TOU customers in two ways. First, PGE posted rate schedules online, allowing customers to review them on the Flex website. Also, in 2016, PGE distributed a rate schedule diagram to customers and, in 2017, a rate schedule clock sticker (see Figure 14).

Figure 14. Flex Schedule Educational Materials Distributed to TOU Customers

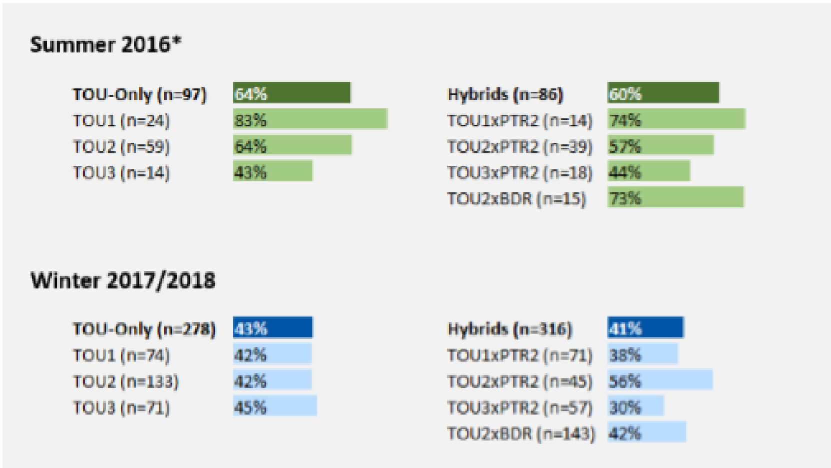


The summer and winter experience surveys asked customers in TOU-only and Hybrid treatments to identify their rate schedule from a list of three schedule images (i.e., the 2016 graphic shown in Figure 14). The surveys, administered online, displayed the 2016 rate schedule images and did not use the 2017 clock sticker images.

Figure 15 shows the percentage of respondents who correctly identified their rate schedules by season and TOU treatment. Due to the small number of respondents per treatment in the summer survey, caution should be exercised in making comparisons between treatments and seasons.

Across treatments and seasons, only 52% of respondents correctly identified their rate schedules. The relatively low rate of correct identification suggests that PGE could do more to educate customers about their TOU rates.

Figure 15. Percentage of Correct Rate Schedule Identification



Survey Question: Which image describes the rates you pay for electricity on the Flex Program?
*The Summer 2017 experience survey did not ask the rate schedule identification question. Results from the Summer 2016 experience survey are reported here instead. Appendix F contains the survey results for Winter 2016/2017.

No significant differences emerged between TOU-only and Hybrid respondents, but in general survey respondents more successfully identified their rate schedule correctly in summer than winter: average correct identification rates were 64% for TOU-only and 60% for Hybrids in summer, while 43% for TOU-only and 41% for Hybrids in winter. Across TOU treatments (except TOU3), a significantly higher percentage of summer respondents correctly identified their rate schedules than winter respondents.[22] The summer and winter surveys used the same rate schedule images from 2016. The rate schedule clock sticker that PGE distributed to customers in 2017 did not look like the images found in the survey and may have confused respondents who were used to seeing a clock graphic.

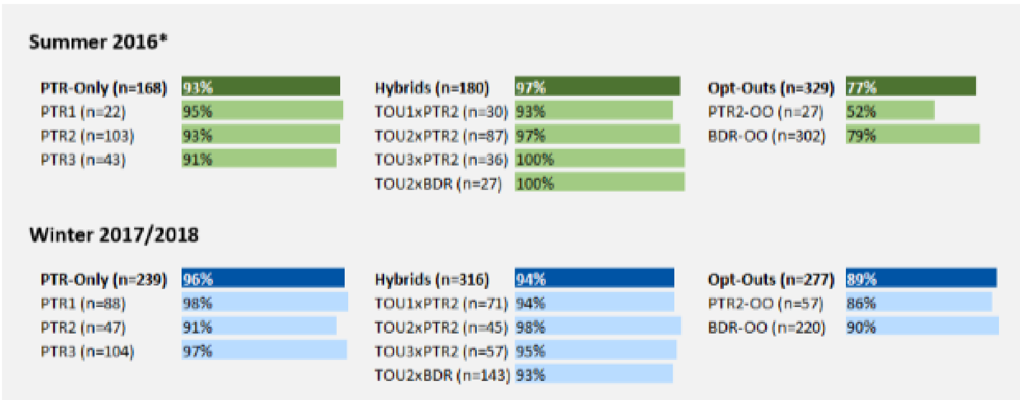
Flex Event Notifications

PGE called approximately seven Flex events per season (see Table 7 for further details). PTR, Hybrid, and BDR customers received an event notification on the day before and day of the event through their

[22] Significant difference with 90% confidence (p≤.10).

preferred communication channels (i.e., email, text, or voice message). The surveys asked customers in PTR and BDR treatments whether they remembered receiving event notifications. Figure 16 shows the percentage of respondents who recalled receiving event notifications by season and treatment.

Figure 16. Percentage of Event Notification Recall



Survey Question: Do you remember being notified of Flex Time events prior to their occurrence?

*As the Summer 2017 experience survey did not ask the event notification question, results from the Summer 2016 event survey are reported here instead.

Most respondents, especially PTR-only and Hybrids, remembered being notified of events. Recall was close to 100% for Hybrid (94%–97%) and PTR-only (93%–96%) respondents, but was significantly less (though still high) for Opt-Out respondents (77%–89%), suggesting those voluntarily enrolling in the program were more likely to look for notifications.[23]

The winter survey asked respondents to rate their satisfaction with their chosen event notification channels (email, text message, and/or voice mail) on a 0–10 scale, where zero meant *extremely dissatisfied* and 10 meant *extremely satisfied*. The survey question before this rating question asked respondents how they received notifications about Flex events; the response to this question determined which notification channels respondents rated on. As shown in Table 18, respondents were most satisfied with text message notifications, followed by email notifications, and voice mail notifications.

[23] The difference in recall rates between PTR or Hybrid respondents and Opt-Out respondents was significant, with 90% confidence (p≤.10).

Table 18. Satisfaction with Flex Event Notifications by Channel Type

Notification Channel	Satisfied (6-10 rating)	Delighted (9-10 rating)	n
Text Message	95%	77%	253
Email	88%	62%	685
Voice Mail	64%	48%	103

Survey Question: How satisfied were you with Flex Time event notifications? Please use a 0 to 10 scale where 0 means "extremely dissatisfied" and 10 means "extremely satisfied." A) Satisfaction with email notification, B) Satisfaction with text notification, C) Satisfaction with voice notification.

In open-ended comments about customer satisfaction with the Flex Program, several recurring themes pertaining to event notifications emerged in the summer and winter surveys:

- ***Awareness of Changing Notification Preferences***: Several respondents did not know they could change their notification channel preferences on the Flex website and suggested that PGE allow customers to select their preferred channels. The Summer 2016 event survey also found that 48% (n= 822) of respondents did not know they could change their notification preferences on the Flex website.
- ***Notification Reminders***: Several respondents wanted more notification reminders and/or earlier notifications, varying from a few days' notice to a few weeks' notice.
- ***Accidental Changes to Notification Settings***: Twenty-four respondents said they received notifications in summer but not in winter, or their notification preference settings changed without their knowledge. PGE confirmed that it reset Wave 3 customers' notification settings after realizing it set Wave 3 customers to receive all three types of notifications (e.g., email, text, and voice); PGE reset settings to email notifications for these customers.

Efforts to Reduce or Shift Loads

PTR or BDR customers were asked to reduce loads during Flex events, while TOU customers were encouraged to reduce loads and/or shift loads from peak to off-peak hours. To facilitate these efforts, PGE provided PTR and BDR customers with energy conservation one-liner tips in event email notifications as well as event performance results addressing how their household performed; tips focused on cooling, heating, and hot water – the high energy-consuming end-uses for the residential sector. PGE provided TOU customers with load-shifting and energy conservation tips, and provided household consumption performance in monthly reports.

Flex Event Participation and Behaviors

The Summer 2016 and Winter 2017/2018 experience surveys asked PTR, Hybrid, and BDR customers whether their household did anything to conserve energy during Flex events. Overall, the majority of respondents said "yes" to participating in Flex event conservation in both seasons (68% summer, 81% winter). A significantly higher percentage of winter respondents (78%, n=832) participated in Flex event conservation than summer respondents (63%, n=677).[24] The higher participation rate in winter can be explained by the surveys used to draw the comparison and customer habituation to the program. Cadmus did not ask the Flex event participation question in the Summer 2017 experience survey and used the Summer 2016 survey data instead. This created a one-and-a-half year gap between the Summer 2016 and Winter 2017/2018 surveys in which customers from Summer 2016 had fewer event feedback, tips, encouragement, and time to act on the tips compared to customers from Winter 2017/2018.

These self-reported Flex event participation results contradict the demand savings results whereby customers saved more during summer events than winter events. Although customers reported taking more actions in winter, it may be that customers took more of the low-saving actions and less of the high-saving actions struggling to manage the high-saving actions. In open-ended comments from the Summer 2017 and Winter 2017/2018 experience surveys, 40 respondents (a mix of PTR-Only, Hybrids, and Opt-Outs) mentioned that the Flex events were more difficult to participate in during winter than summer. The following quotes from these respondents demonstrate customers' difficulty in winter compared to summer:

- "It is much harder to reduce use during winter Flex hours. Unless we dine out, there is no way to reduce during Flex time because I routinely aim for lower demand hours for laundry, dishwasher, etc. Driving to a restaurant or fast food place would negate the energy reduction at the house and, unlike during summer, we don't want a cold dinner."
- "Works for me in the summer. Managing AC is doable. Managing heat and light in the winter is not as workable. I think my bills are higher in the winter due to Flex."
- "We are very conscientious about shifting our energy use, and our warm weather savings reflect that. However, a household member is disabled, home most of the day, and needs the thermostat kept at 68 degrees. During the winter, that heating requirement just kills our savings."

A significantly higher percentage of Opt-In respondents (76%) than Opt-Out respondents (48%) participated in summer events and winter events (89% Opt-In, 63% Opt-Out).[25] The Opt-In customers' participation rate was higher than that of Opt-Out customers because opt-in programs typically attract the most engaged customers.

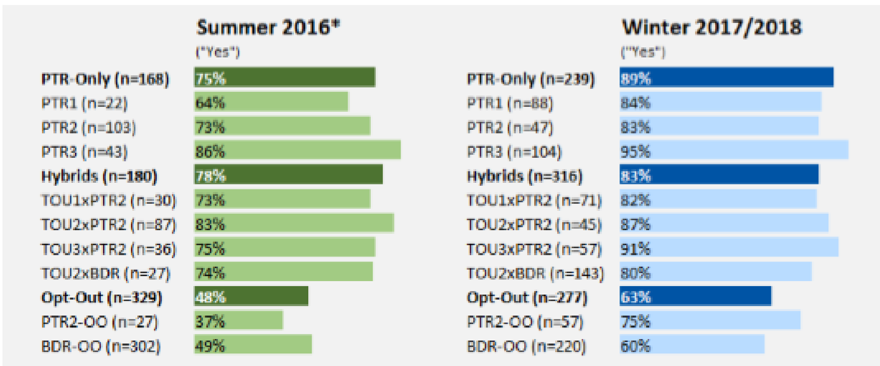
As shown in Figure 17, PTR-only respondents (75%) did not differ from Hybrid respondents (78%) in summer, but significantly differed in winter, when more PTR-only respondents (89%) than Hybrid respondents (83%) reported conserving during events.[26] In both seasons, PTR3 respondents showed the highest event participation rates.

[24] Significant difference with 90% confidence (p≤.10).

[25] Significant difference with 90% confidence (p≤.10).

[26] Significant difference with 90% confidence (p≤.10).

Figure 17. Flex Event Energy Conservation Participation Rates



Survey Question: Did you and your household do anything to conserve energy during the Flex Time event?

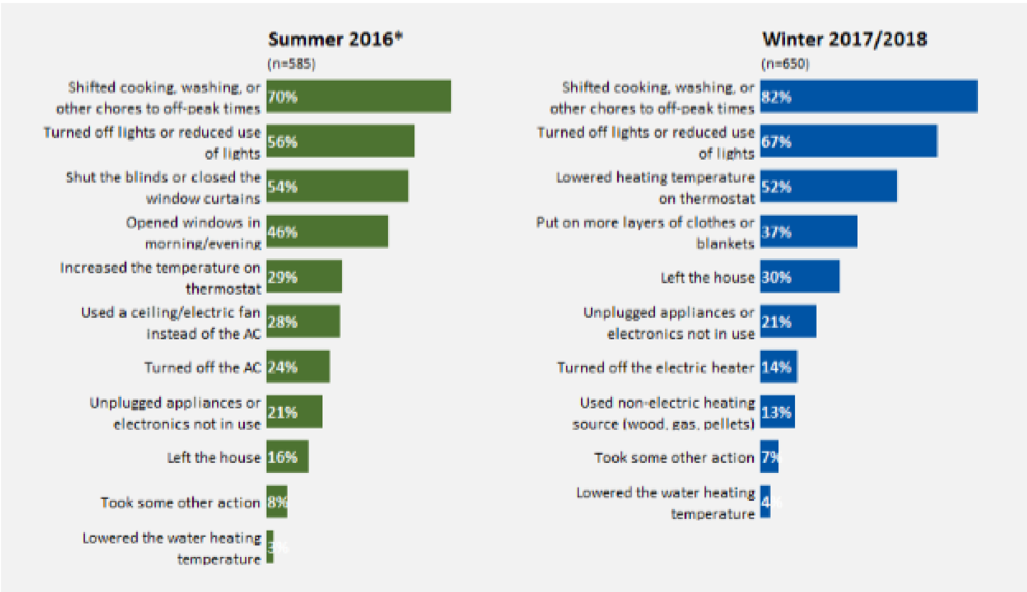
* The Summer 2017 experience survey did not ask the event participation question. Results from the Summer 2016 event survey are reported here instead. Appendix F contains the survey results for Winter 2016/2017.

The surveys also asked respondents answering "yes" to participating in event energy conservation how their household conserved. Figure 18 shows self-reported customer conservation actions by season.

In both seasons, respondents most frequently reported using one of two strategies: shifting chores to off-peak times; or turning off or reducing use of lights. In summer, 70% of respondents reported shifting their chores to off-peak times, and 56% reported reducing lighting. In winter, 82% of respondents reported shifting their chores to off-peak times, and 67% reported reducing lighting. In both seasons, large percentages of respondents reported reducing use of lighting, even though savings from such behaviors will be low due to the prevalence of efficient CFLs and LEDs in residential customer homes. This presents PGE with an opportunity to educate customers about strategies for producing larger demand savings or shifting such as managing space conditioning and water heating loads. The differences between summer and winter in proportions of respondents employing these strategies were statistically significant.[27] Higher activity rates in winter aligned with findings in Figure 17, indicating event participation was higher in winter than summer. Other actions tended to differ by season, such as adjusting a thermostat's temperature up or down.

[27] Significant difference with 90% confidence ($p \leq .10$).

Figure 18. How Customers Conserved During Events



Survey Question: How did you and your household conserve energy during Flex Time events? (Select all that apply)

*The Summer 2017 experience survey did not ask the event participation question. Results from the Summer 2016 event survey are reported here instead. Appendix F contains the survey results for Winter 2016/2017.

Note: This survey question was asked to customers in the event-based treatments (PTR-only, Hybrids, and Opt-Outs).

In summer, respondents saying they did not conserve during events (n=134) most often cited the following three reasons:

1. Did not know there was an event. (36%)
2. It was too hot or feeling cool was of high priority. (29%)
3. Forgot there was an event. (18%)

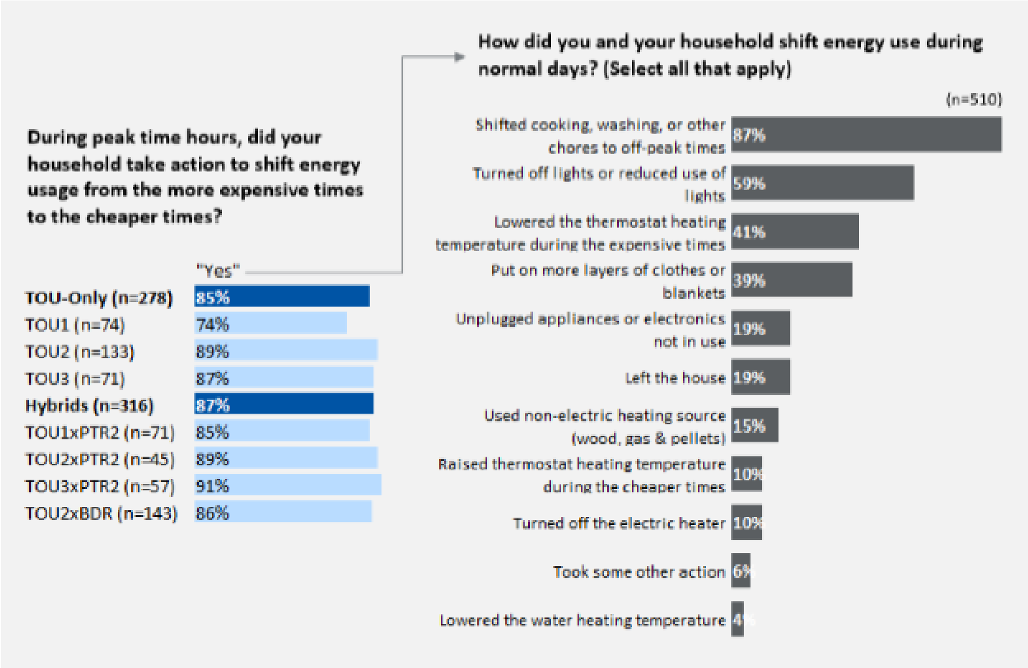
In winter, respondents saying they did not conserve during events (n=86) most often cited the following three reasons:

1. The event timing did not work for them. (26%)
2. Already conserving on a regular basis, so did not feel the need to do more on event days. (24%)
3. Forgot there was an event. (17%)

Time of Use Participation and Behaviors

The Winter 2017/2018 experience survey asked TOU customers whether their households took actions to shift energy consumption from more expensive to less expensive times. This question was not asked in the summer surveys. As shown in Figure 19, a similarly high percentage of TOU-only respondents (85%) and Hybrid respondents (87%) reported shifting their energy consumption. For TOU-only and Hybrid treatments, TOU2 and TOU3 respondents showed a significantly higher percentage of shifting energy consumption than TOU1 respondents.[28] The relatively low percentage of TOU1 customers who reported shifting consumption might reflect the TOU1 rate's day/night schedule, which made load shifting challenging for customers. Among Hybrid treatments, participation rates for shifting energy consumption (87%) were not significantly different from winter event participation rates (83%).

Figure 19. Customer Efforts to Reduce Load During Normal Days – Winter 2017/2018



Note: A comparison to summer is not available. The Summer 2016 and 2017 experience surveys did not ask the two load-shifting questions; these two questions were added to the winter 2017/2018 experience survey.

The winter survey also asked respondents who said "yes" to shifting energy consumption how their households took action. As shown in Figure 19, respondents most frequently shifted their chores to off-peak times and turned off or reduced use of lights—the same top two actions for events. TOU respondents showed one notable behavioral difference from event-based respondents: a significantly lower percentage of TOU respondents reported leaving the house (19% vs. 30%).[29] The TOU program design encourages customers to shift or reduce energy consumption on a regular basis, making leaving the home an impractical strategy. In contrast, PTR and BDR program designs asked customers to shift or reduce demand on event days only, making it easier for them to leave during periods of high demand.

[28] Significant difference with 90% confidence (p≤.10).

[29] Significant difference with 90% confidence (p≤.10).

In winter, respondents saying they did not participate in shifting energy consumption (n=65) most often cited the following three reasons:

1. Particular members in my household make it difficult to shift energy use. (20%)
2. Feeling comfortably warm is a high priority. (14%)
3. Inconvenient/hard to remember to do every day. (14%)

Customer Satisfaction with Flex

The summer and winter experience surveys asked Flex customers to rate their overall satisfaction with the program on a 0–10 scale, where zero meant *extremely dissatisfied* and 10 meant *extremely satisfied*. Figure 20 shows the percentage of satisfied (6–10 rating) and delighted (9 –10 rating) participants across treatments for Summer 2017 and Winter 2017/2018. Appendix F contains survey results for Summer 2016 and Winter 2016/2017.

In assessing Flex satisfaction, the results from PGE's CPP pilot (2011-2013) are a useful point of reference. Using a similar 0–10 rating scale as the Flex evaluation, PGE reported that 68% of customers were satisfied (6–10 rating) and 40% of customers were delighted (9 –10 rating) with CPP. As evident below, overall, PGE customers gave the Flex pilot higher satisfaction ratings. Perhaps because of risk of or actual energy bill increases from CPP and the absence of such risk for PTR, satisfaction proved significantly lower for CPP.

Over 50% of respondents in each Flex treatment expressed satisfaction, with the highest program satisfaction observed for PTR-only (83%–86%),[30] followed by Hybrids (71%–79%), TOU-only (61%–76%), and Opt-Outs (56%–61%). Opt-In PTR2 treatment achieved the highest program satisfaction rate at 92% in the summer survey. Opt-In PTR2 (89%) and PTR3 (89%) treatments also achieved high program satisfaction rates in the winter survey. On the other hand, BDR-OO and TOU1 treatments showed the lowest satisfaction rates in the summer survey (BDR-OO 51%; TOU1 57%) and in the winter survey (TOU1 54%; BDR-OO 57%). The higher program satisfaction rates among PTR-only treatments suggest that providing financial incentives without risk of penalty boosts customer satisfaction with the program.

Opt-In treatments showed significantly higher program satisfaction rates than Opt-Out treatments. In the summer survey, a significantly higher percentage of Opt-In treatment respondents (79%) than Opt-Out treatment (56%) respondents expressed satisfaction. [31] In the winter survey also, a significantly higher percentage of Opt-In treatment respondents (72%) than Opt-Out treatment respondents (61%) expressed satisfaction. [32] Opt-In treatments showing higher satisfaction with the program was expected

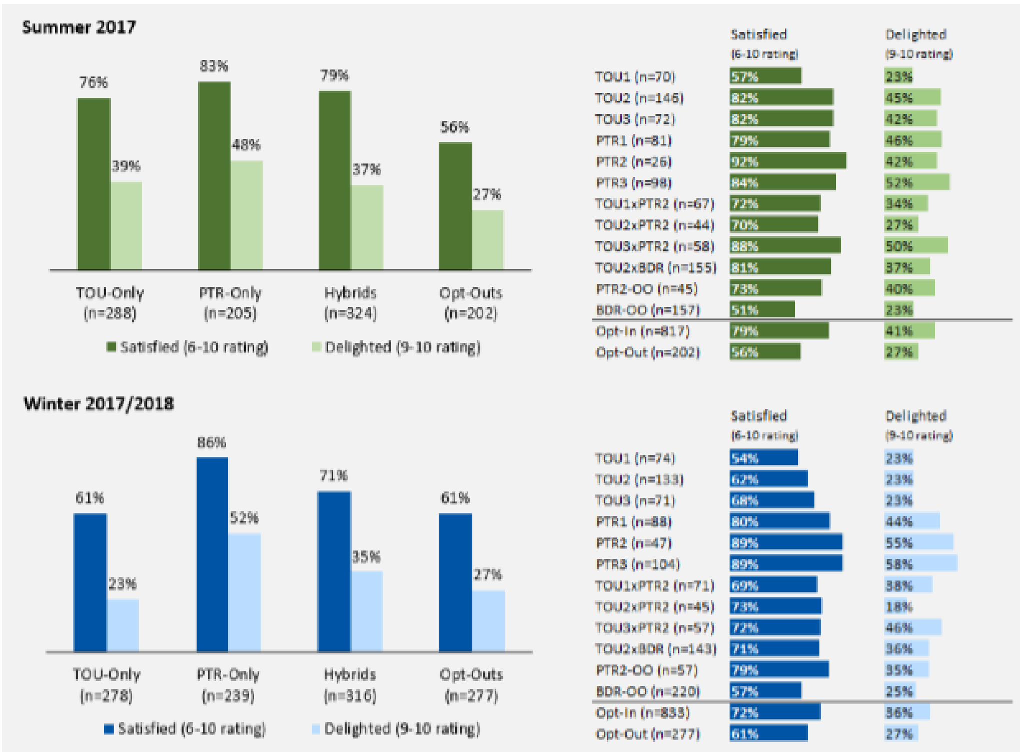
[30] In comparison to the 2013-2015 PGE CPP pilot, PGE reported that 68% of customers were satisfied (6–10 rating) and 40% of customers were delighted (9 –10 rating) with CPP

[31] Significant difference with 90% confidence (p≤.10).

[32] Significant difference with 90% confidence (p≤.10).

as customers who opt in to a program are more engaged than customers who are automatically enrolled in a program (opt-out program design).

Figure 20. Overall Satisfaction with Flex



Survey Question: Please rate your overall satisfaction with the Flex Program using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Program satisfaction tended to be higher in summer than in winter. As shown in Figure 20, seven of the 12 treatments exhibited higher satisfaction rates in summer than winter. In particular, TOU-only and Hybrid treatments showed significantly higher satisfaction rates in summer (76%–79%) than in winter (61%–71%).[33] This seasonal pattern for TOU-only and Hybrid treatments suggests that the TOU pricing may have been more challenging for customers in winter than in summer.

Additionally, the summer and winter experience surveys asked respondents to explain their program satisfaction ratings. Satisfied respondents most often said the program delivered bill savings, helped their household manage energy use, brought education and awareness about energy conservation, and helped the environment. Respondents not satisfied most often said they saw little to no difference in

[33] Significant difference with 90% confidence (p≤.10).

their bill savings, and found the Flex schedule or events difficult for their households. In particular, BDR-OO respondents most often mentioned the Flex events being difficult and TOU-only respondents (especially TOU1) most often mentioned the Flex schedule being difficult for their households.

Notably, respondents found the program more difficult to participate in during winter than summer, especially TOU-only and Hybrid respondents: 16% of respondents in the summer survey said the program helped them save on their electric bills, compared to 9% of respondents in the winter survey. Specifically, respondents said winter on-peak hours and event times occurred when household members were often home and needed to heat the home to stay warm. No respondents found the program more difficult in summer than in winter. PGE could lessen customer concerns about the seasonality of bill savings by encouraging them to enroll in *Equal Pay*, a payment option that allows customers to smooth their payments over months of the year. Another strategy, which PGE has already implemented, is to present cumulative, rather than monthly, bill savings to customers. Even if customers do not reduce their bills in winter, most do so over 12 months.

Among open-ended responses to the satisfaction rating question, 6% of respondents from the summer survey and 5% of respondents from the winter survey offered the following suggestions to improve the program:

- Provide a bill credit for savings instead of sending a check
- Provide more advanced Flex time event notifications
- Adjust the Flex schedule hours and/or Flex event times
- Provide more personalized information on tips and consumption data

Customer Satisfaction with PGE

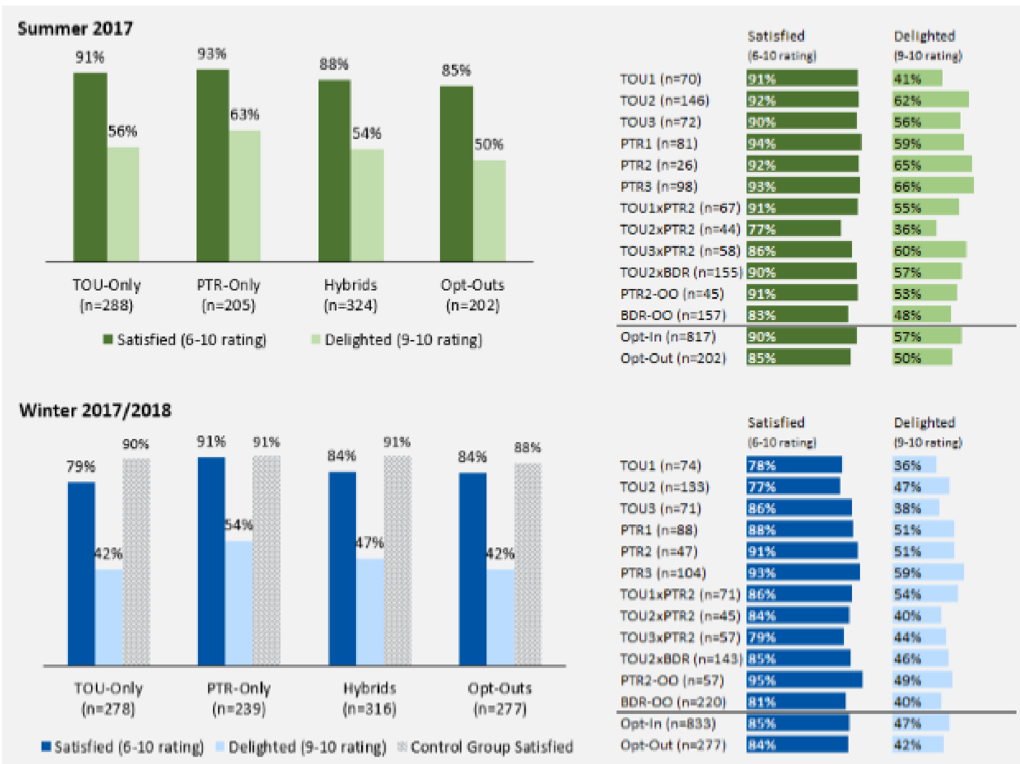
The surveys asked test and control group customers to rate their overall satisfaction with PGE on a 0–10 scale, where zero meant *extremely dissatisfied* and 10 meant *extremely satisfied*. Figure 21 shows the percentage of *satisfied* (6–10 rating) and *delighted* (9–10 rating) customers across treatments and groups for Summer 2017 and Winter 2017/2018. Appendix F contains survey results for Summer 2016 and Winter 2016/2017.

Among test group treatments, PTR-only had the highest PGE satisfaction rates. As shown in Figure 21, PTR-only had a PGE satisfaction rate of 93% in summer and 91% in winter. Opt-Outs had the lowest PGE satisfaction rates (85% in summer and 84% in winter). PGE satisfaction rates significantly differed between PTR-only and Opt-Outs in both seasons.[34] However, when combined, Opt-In customers showed no significant differences from Opt-Out customers in PGE satisfaction rates. In summer, Opt-Ins had a satisfaction rate of 90% and Opt-Outs had a satisfaction rate of 85%. In winter, Opt-Ins had a satisfaction rate of 85% and Opt-Outs had a satisfaction rate of 84%.

[34] Significant difference with 90% confidence (p≤.10).

Customer satisfaction with PGE was lower in winter than summer. Most treatments showed a decrease in PGE satisfaction in winter, with TOU-only showing a significant decrease. TOU-only respondents significantly rated their satisfaction with PGE as lower in winter (79%) than in summer (91%).[35] Hybrid respondents also rated their satisfaction with PGE as lower in winter (84%) than in summer (88%), though this was not a statistically significant difference. The lower PGE satisfaction ratings in winter possibly reflected challenges in saving energy during winter. As discussed in the previous section, TOU-only and Hybrid customers reported the program as more difficult to participate in during winter than summer.

Figure 21. Overall Satisfaction with PGE



Survey Question: Please rate your overall satisfaction with PGE using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

*Note: Cadmus did not survey the control group customers in the Summer 2017 experience survey. Appendix F contains the satisfaction results for Summer 2016 and Winter 2016/2017 as well as the control group's Winter 2017/2018 satisfaction results for all 12 treatments.

[35] Significant difference with 90% confidence (p≤.10).

PGE satisfaction ratings are compared between test and control groups only for winter (see the gray, hatched bars); control customers were not included in the summer survey. As shown in Figure 21, PTR-only had no impact on customer satisfaction with PGE, but other treatments had a negative impact on customer satisfaction with PGE. PTR-only test group and control group both had a PGE satisfaction rate of 91%. TOU-only test group had a significantly lower PGE satisfaction rate (79%) than control group (90%).[36] Hybrid test group also showed a significantly lower PGE satisfaction rate (84%) than control group (91%).[37] Opt-Out test group showed a lower PGE satisfaction rate (84%) than control group (88%), though not a statistically significant difference.

Implementation Challenges and Lessons Learned

PGE enrolled approximately 14,000 residential customers in the Flex pilot, which involved a complex RCT design using multiple treatments. Never having implemented a pilot of this scale or complexity, PGE encountered several implementation challenges, including marketing and providing feedback about demand savings to customers after events. This section documents these challenges and lessons learned, as communicated by PGE and implementation contractor program staff in interviews.

Marketing

Recruitment proceeded more slowly than expected, but still met its overall enrollment target by Summer 2017 (see Marketing and Recruitment and Table 5 for marketing and enrollment details). PGE and CLEAResult struggled at first with finding a marketing and messaging approach that resonated with customers. PGE experimented with marketing through emails, gift card rewards, postcards, and business letters as well as with messaging that emphasized economics (personal gains, including bill savings), control (taking charge of your consumption), and community (the greater good).

PGE reported the following customer conversion rates for Flex marketing channels over the course of the pilot:[38]

- 1.5% enrolled from email
- 2.5% enrolled from postcard
- 4.5% enrolled from business letter

Over the course of the pilot, PGE improved the effectiveness of its marketing through experimentation. PGE learned the types of messaging that resonated most with customers and the most effective marketing channels. It also found that offering a gift card as a reward did not increase the likelihood of

36 Significant difference with 90% confidence (p≤.10).

37 Significant difference with 90% confidence (p≤.10).

38 A conversion rate measures a given marketing channel's effectiveness in spurring enrollment, calculated by taking the number of customers who enrolled from a channel and dividing this by the total number of customers that the channel reached.

enrollment. PGE reported that during the third and final recruitment wave it had enrolled 4.5% of customers receiving one well-designed email or business letter who had not received a previous Flex solicitation. According to PGE, it enrolled a high percentage of customers in the pilot after "a single touch" because of critical lessons about marketing it had learned during the previous two recruitment waves.

PGE's experiments with marketing approaches revealed two critical lessons:

1. **Customers respond to paper (even after many emails).** Business letters and postcards enrolled customers more effectively than emails. Initially, PGE recruited customers with valid email addresses and only later opened recruitment to customers without email. Recruiting both customer sets helped the pilot program meet its enrollment targets. PGE also reported that it switched to business letters after having emailed customers as much as nine times; notably, when customers not responding by email received the business letter, they responded as if they had seen the program marketing for the first time.
2. **Customers respond to messaging about bill savings.** Business letters more successfully enrolled customers due to comparisons of standard flat rates vs. TOU rates and financial messaging about bill savings. Initially, PGE used control and community messaging in emails and postcards, which proved unsuccessful in converting customers. PGE realized that financial-focused messaging resonated more with customers as the primary participation benefit arose from the opportunity to earn bill credits or savings. Recruitment survey results (n=458) further supported this contention, indicating that saving money on electric bills was the top reason for enrollment (78%), followed by saving energy (46%), and helping the environment (28%).

Event Management

PGE encountered challenges in providing accurate and timely feedback to customers about their success in reducing or shifting loads during Flex events and in dispatching the appropriate number of events. A summary of challenges follows, along with PGE's efforts to address them:

- **PGE delivered inaccurate event savings feedback to some customers during the initial part of the Summer 2016 season.** To provide individualized feedback on event savings to participants, AutoGrid's data management platform performed consumption baseline calculations for each participating customer. During the initial Summer 2016 events, some customers received inaccurate or no feedback about their savings due to misaligned baseline calculation inputs. Inaccurate feedback or absence of feedback may have discouraged some customers from participating in future Flex events. To address these data errors, PGE and AutoGrid worked to refine the baseline calculation methodology and developed a quality control (QC) process to review event data before delivering them to customers. They began implementing the QC process in late Summer 2016.
- **PGE did not deliver event savings feedback to customers within the ideal 24-hour time frame.** PGE intended to send customers their event savings feedback within 24-hours of events, believing that each passing day could diminish the value customers gained from the feedback. PGE reported that, for the first few Summer 2016 events, it took a few days to a week to provide

feedback due to the baseline calculation difficulties and inaccuracies described previously. The delay in feedback also prevented PGE from calling additional events until these issues were resolved. However, by the end of Winter 2016/2017, PGE refined its process flow and managed to achieve 48-hour delivery. Though data management and QC processes made it difficult for PGE to achieve a shorter timeframe, PGE continued to improve its processes for delivering feedback and achieved close to a 24-hour turnaround in Summer 2017.

- **PGE dispatched too many BDR events.** PGE received feedback from some BDR customers that it dispatched too many events. As PGE does not compensate BDR customers, it is mindful of not calling upon them to reduce demand too often. As a result, while BDR saved 1%–2% of demand for thousands of customers, PGE used BDR less frequently over the pilot's course and plans to use it even less frequently in the future. In contrast, PGE is considering dispatching more PTR events in future winter seasons because it is popular with customers and effective at reducing peak demand. Moreover, PGE reported that it could have communicated better with BDR customers about their options for receiving event notifications after receiving feedback that some customers had not been aware that they could change their event notification settings.

Conclusions and Recommendations

Peak-Time Rebates

Larger rebates did not yield more Flex event savings.
Opt-In PTR customers saved about 20% of consumption during summer Flex events and between 7% and 12% of consumption during winter Flex events. No statistically significant differences in savings appeared by rebate amount. In summer, customers receiving a $0.80/kWh rebate achieved the same savings as customers receiving a $2.25/kWh rebate.

Of 12 treatments, Opt-In PTR-only customers were most satisfied with the Flex pilot.
In both seasons, Opt-In PTR-only respondents had the highest satisfaction rates with Flex (83% reported a program satisfaction score of 6 or higher on a 10-point scale in winter; 86% in summer) compared to Hybrids (71% in winter; 79% in summer) and TOU-only (61% in winter; 76% in summer).[39] Opt-In PTR2 treatment achieved the highest satisfaction rate of 92% in the summer survey. Opt-In PTR2 (89%) and PTR3 (89%) treatments also achieved high satisfaction rates in the winter survey. PTR customers may have been most satisfied as they faced no financial risk from participation. Customers could earn rebates for saving energy during Flex events, but were not penalized if their consumption increased.

Larger rebates (greater than $1.55/kWh) increased customer satisfaction with the Flex pilot.
PTR1 customers, who received the smallest rebate ($0.80/kWh), had lower satisfaction with Flex for both winter and summer seasons than PTR2 ($1.55/kWh) or PTR3 ($2.25/kWh) customers. In summer, 79% of PTR1 customers expressed satisfaction with the program, while 92% of PTR2 customers and 84% of PTR3 customers expressed satisfaction. In winter, PTR1 had a satisfaction rate of 80%, about 10 percentage points lower than that of PTR2 (89%) and PTR3 (89%).

Flex event savings from peak-time rebates did not depend on outside temperatures.
A statistical relationship was not found between PTR savings and outside temperatures during Flex events in winter or summer. Outside temperatures during Flex events ranged between 82°F and 96°F in summer and 28°F and 45°F in winter.

PTR Recommendation

- When setting rebates for future PTR programs, PGE should consider the tradeoff arising from offering a higher rebate: over the lower range of rebates tested ($0.80/kWh to $1.55/kWh), there were positive effects on customer satisfaction but no impacts on Flex event savings from increasing the rebate. This suggests that larger rebates may raise customer satisfaction, but lower program cost-effectiveness.

[39] Respondents rated their overall satisfaction with the program on a 0–10 scale, where 0 meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defined a 6–10 rating as *satisfied*.

TOU Rates

Customers under the TOU1 rate schedule encountered difficulties in shifting consumption from peak to off-peak hours.

The TOU1 rate used "day/night" off-peak and on-peak period definitions. As the on-peak period was set from 6:00 a.m. to 10:00 p.m., many customers were awake only during peak hours and asleep during off-peak hours, making load shifting inconvenient or difficult. Shifting loads would require many customers to adjust their sleep schedules or to have appliances programmed to run at night. Among TOU customers, those on the TOU1 rate had the lowest program satisfaction rates (57% in summer and 54% in winter) and did not achieve peak savings in either season. TOU1 respondents dissatisfied with Flex most often mentioned the rate schedule being difficult for their households; these respondents said it was not convenient or worth changing one's sleep time to do chores during off-peak periods.

TOU rate schedules with short peak-period definitions yielded peak savings and high satisfaction in summer.

In summer, TOU2 and TOU3 customers achieved significant savings during peak periods (8% and5%, respectively). They also saved 5%–6% during Flex event hours, which Cadmus used as a proxy for the peak capacity impact of TOU, even though TOU customers did not receive Flex event notifications or incentives. In summer, the TOU2 and TOU3 schedules had relatively short peak periods, from 3:00 p.m. to 8:00 p.m., which coincided with PGE's summer system peak and enabled customers to shift loads to off-peak periods. In summer, TOU2 and TOU3 customers had relatively high customer satisfaction ratings of 82%.

The simpler TOU rate schedule achieved the same peak period savings and satisfaction as the more complex one.

In summer, the TOU3 rate, with peak (3:00 p.m.–8:00 p.m.), mid-peak (11:00 a.m.–3:00 p.m.), and off-peak periods, reduced loads by 5% during the mid-peak period. However, no differences emerged in peak period savings between the simpler TOU2 rate, which only had peak (3:00 p.m.–8:00 p.m.) and off-peak periods, and the more complex TOU3 rate. TOU2 and TOU3 showed statistically similar program satisfaction rates in summer (TOU2 82%; TOU3 82%) and winter (TOU2 62%; TOU3 68%).

In winter, TOU customers experienced difficulties in shifting loads from peak to off-peak periods and achieving bill savings.

During winter, none of the TOU-only treatments produced statistically significant reductions in or shifts in peak-period loads. Either TOU did not affect customer loads, or the load impacts were too small to detect with the existing sample sizes. TOU customers also reported relatively low satisfaction with Flex (54%–68%) because of adverse bill impacts and the rate schedule being difficult for their households. TOU schedules had morning *and* evening peak periods. Notably in the survey's open-ended comments, TOU-only and Hybrid customers mentioned the program was more difficult to participate in during winter than summer. Moreover, TOU-only and Hybrid treatments showed significantly lower program satisfaction rates in winter (61%–71%) than in summer (76%–79%).[40] This seasonal pattern in program satisfaction for TOU-only and Hybrid treatments suggests that the TOU aspect may be more challenging for customers in winter than in summer.

TOU Recommendations

- Unless an economic case justifies shifting customer loads from mid-peak to off-peak hours, PGE should implement the TOU2 rate schedule, which is simpler for customers to understand.
- PGE should consider redesigning the winter TOU rate schedules by removing the morning peak period. This would minimize the potential for adverse customer bill impacts and simplify the customer experience.
- PGE should redesign the TOU1 rate schedule or offer TOU1 customers enabling technology to facilitate load shifting from peak to off-peak periods.
- PGE did not test the impacts of pairing enabling technology with TOU pricing, but studies of other TOU pricing programs suggest that enabling technology such as price-responsive smart thermostats can increase load shifting. PGE should consider testing the load impacts of enabling technology in the future.
- PGE should consider enhancing customer screening during the enrollment process to determine whether a customer is a good fit for a TOU rate.
- Given TOU customers' challenges in achieving winter bill savings, PGE should offer them more education about how to save energy or shift loads from peak to off-peak periods.

Opt-Out Behavioral Demand Response

Behavior-based treatments caused PGE customers to save energy during Flex events.
BDR-OO customers saved an average of 2.3% of consumption in summer and 1.2% of consumption in winter. PGE sent opt-out BDR customers Flex event alerts, encouragement to reduce consumption, and individualized post-event feedback but did not charge them higher electricity prices or provide them with rebates during Flex events, demonstrating that residential customers responded to non-price interventions.

Opt-out BDR program design yielded capacity benefits, but resulted in relatively low customer satisfaction.
PGE automatically enrolled over 12,000 residential customers in the BDR-OO treatment. While average savings per treated customer were small (only 1%–2% of consumption), total program demand savings were large due to the size of the treated population. In the future, PGE can deploy the BDR program to help manage system peaks, but at the potential cost of lower customer satisfaction: only 51% of BDR-OO customers in winter and 57% in summer rated the program a 6 or higher on a 10-point scale.

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40 Significant difference with 90% confidence (p≤.10).

Satisfaction ratings were likely low due to the opt-out program design and the unfamiliarity of many customers with behavioral demand response and the costs of supplying energy during utility system peaks. The program sent event notifications to many customers who had little interest in receiving them or participating in a BDR program. PGE also mentioned in the interviews that it received feedback from some BDR customers that it dispatched too many events and that these customers had not been aware that they could change their event notification settings.

BDR Recommendations

- PGE should consider using opt-out BDR for achieving capacity savings targets, given its success with BDR in reducing loads during this pilot; but it should consider possible changes to program design to increase customer satisfaction, such as:
  - Limiting the frequency of future BDR events, which would also limit the number of event notifications customers received.
  - Shortening the duration of future BDR events to lessen the burden on customers.
  - Spacing out future BDR events to avoid calling back-to-back events or multiple events in the same week.
  - Sending BDR customers a handy reminder magnet or sticker about BDR events and how to save, akin to the clock sticker PGE sent to TOU customers.
- PGE should clearly inform opt-out BDR customers that they can opt out of treatment, and should make it relatively easy for customers to opt out if they do not want to participate.

Opt-Out Peak-Time Rebates

The opt-out participation program design significantly increased program participation. PGE attained a much higher participation by presenting customers with a choice to opt out of the program rather than opt in. PGE automatically enrolled approximately 1,600 customers in the PTR2-OO program. By the end of the Winter 2017/2018 season, only 2.3% of customers had opted out. In comparison, at the end of the recruitment period for opt-in PTR treatments, less than 7% of PGE customers accepted offers to participate in a PTR1 (4.3%), PTR2 (2.8%), or PTR3 (6.2%) treatment.[41] Of customers opting in to PTR treatment, between 4.5% and 6.3% subsequently opted out. The opt-out design took advantage of customers who were expected to be “complacent”: they would neither opt in nor opt out of a demand response program, if given the choice. Cadmus estimated that 92% of opt-out customers were complacent customers. By making participation the default choice, PGE obtained program participation and peak capacity that it would not have achieved otherwise.

[41] PGE experimented with different marketing strategies during the first two waves and obtained higher rates of acceptance during the third wave after improving its approach. Also, PGE stopped recruiting for the opt-in PTR2 treatment after the second wave.

The design of the pilot participation choice (opt-in vs. opt-out) presents a tradeoff between savings per customer and number of participants.

Depending on the rebate amount, opt-in PTR customers saved 17% to 21% of consumption during summer Flex events and from 7% to 12% of consumption during winter Flex events. Customers automatically enrolled in PTR2 saved an average of 7% during summer Flex events and 5% during winter Flex events.[42] Cadmus estimated that in Summer 2017, "complacent customers"—who would neither opt in nor opt out of a PTR program if given the choice—saved 6% during Flex events. While opt-in PTR customers saved more, the opt-out design enrolled many more customers. As noted above, fewer than 6% of PGE customers took up offers to participate in the PTR program. In contrast, more than 97% of customers defaulted onto PTR2-OO remained in treatment through the end of the Winter 2017/2018 season.

Adding a peak-time rebate to behavior-based demand response increased Flex event demand savings and customer satisfaction.

The opt-out BDR treatment and the opt-out PTR treatment only differed in the rebate paid to customers for saving energy during Flex events. PTR customers received the same notifications, tips for saving energy, and individualized feedback about savings as BDR-OO customers. Opt-out PTR customers, however, saved significantly more during Flex events than BDR-OO customers (5% in winter and 7% in summer vs. 1% and 2%, respectively), demonstrating that the rebate lifted savings and complemented the behavior-based treatment. The rebate also increased customer satisfaction. PTR2-OO customers reported 73% program satisfaction in summer and 79% in winter—high customer satisfaction rates for customers automatically enrolled in a program. In contrast, BDR-OO customers only reported program satisfaction rates of 51% in summer and 57% in winter.

Opt-Out PTR Recommendation

- Given the tradeoff between savings per customer and numbers of participants, PGE should analyze whether the opt-in or opt-out PTR design proved more cost-effective, and whether each design will generate the desired aggregate demand response capacity.

Hybrid Treatments

TOU pricing did not enhance (and possibly diminished) savings from PTR during Flex events and customer satisfaction (TOUxPTR vs. PTR).

[42] The surveys also found that a higher percentage of opt-in (75% in summer, 89% in winter) than opt-out (37% in summer, 75% in winter) PTR2 customers reported participating in Flex events.

During Summer Flex events, opt-in PTR customers saved 17% to 21% of consumption, but TOUxPTR customers only saved 9% to 19%[43]. During Winter Flex events, opt-in PTR customers saved 7% to 12%, but TOUxPTR customers only saved 4% to 12%. TOU pricing may cause PTR customers to become inattentive to Flex event alerts, or TOUxPTR customers may have less incentive to save energy during Flex events because their consumption baseline used for calculating rebates is lower. In summer and winter, satisfaction with Flex was 10 to 20 percentage points lower for TOUxPTR customers than for PTR-only customers.

Adding peak-time rebates to TOU pricing increased customer satisfaction and Flex event savings (TOUxPTR and TOUxBDR vs. TOU-Only).
Peak-time rebates had positive impacts on customer satisfaction for TOU customers. Depending on the TOU rate, TOU-only customers reported program satisfaction ranging from 57% to 82% in summer and 54% to 68% in winter. In contrast, TOUxPTR customers reported satisfaction levels ranging from 70% to 88% in summer and from 69% to 73% in winter, suggesting that the PTR enhanced customer satisfaction with the program.

During Flex events (i.e., hours used in this report to approximate system capacity conditions), TOUxPTR customers also saved more than TOU-only customers. In summer, TOUxPTR or TOUxBDR customers saved from 8% to 19% of Flex event demand, while TOU-only customers saved from 2% to 8%. During Winter events, TOU2xPTR2 and TOU3xPTR2 customers saved 12% of consumption, while TOU-only customers did not save any demand.

Hybrid Treatment Recommendations

- If PGE's primary objective is to save demand during system peaks, it should consider enrolling more customers in PTR-only treatments than hybrid TOUxPTR treatments to maximize the impact on system peak.
- If PGE deploys TOU rates on a wide scale, it should consider pairing TOU rates with a peak-time rebate to raise customer satisfaction and Flex event savings.

Customer Experience

TOU and Hybrid customers reported higher satisfaction with the Flex pilot in summer than winter, primarily due to greater summer bill savings.

[43] The Flex event savings estimate for Hybrid customers indicates the combined effects of TOU and PTR during Flex events. The savings are estimated relative to customers who are treated with neither PTR nor TOU pricing.

Overall, participant respondents were more satisfied with the Flex pilot in Summer 2017 (74% *satisfied*) than Winter 2017/2018 (69% *satisfied*).[44] The seasonal satisfaction differences, however, were greatest for treatments involving TOU pricing, which typically produced annual bill savings, with most or all savings occurring in summer. For TOU-only and Hybrid treatments, respondents reported significantly higher program satisfaction in summer (76%–79% *satisfied*) than in the winter (61%–71% *satisfied*).[45] Summer and winter respondents giving the program satisfied ratings most often noted that the program delivered bill savings. Respondents giving a less-than-satisfied rating most often noted seeing little to no difference in their bill savings. In summer, 16% of TOU survey respondents said they saved on their electric bills, compared to 9% of TOU survey respondents in winter. These program satisfaction results align with demand savings estimates showing participants achieved higher peak-period load reductions in summer than winter.

Although PGE automatically enrolled them, opt-out PTR and BDR customers showed high event awareness and engagement with the pilot.

As expected, customers opting into the pilot exhibited high awareness of and engagement with Flex events. Depending on the season, 93% to 96% of opt-in PTR-only respondents and 94% to 97% of opt-in Hybrid respondents remembered receiving event notifications. Also, 76% to 86% of opt-in respondents reported conserving electricity during events in both seasons. These awareness and engagement levels were higher than for BDR-OO and PTR2-OO customers automatically enrolled in the pilots. and 89% of opt-out respondents remembered receiving event notifications. Also, 48% of opt-out respondents in summer and 63% of respondents in winter reported conserving energy during these events. This suggests that PGE can engage customers in achieving demand savings who are automatically enrolled in demand response programs.

PGE has an opportunity to increase peak period and Flex event demand savings from TOU rates through additional education with existing TOU customers.

TOU2 and TOU3-only and Hybrid treatments saved 5% to 8% of demand during peak periods and 8% to 20% of demand during Flex events, indicating that TOU treatments proved effective. TOU customers, however, did not have strong awareness of their rate schedules. Only about one-half of TOU and Hybrid respondents (52%) correctly identified their rate schedules from a list of three rate schedule images. That was only slightly better than results one would expect (33%) if all customers guessed at random. This suggests TOU customers could save more if they knew of their rate schedules. PGE might be able to increase TOU customer demand savings through doing additional education and outreach.

PGE identified several pilot implementation issues that negatively affected customer experiences and either corrected the issues or will correct them in future Flex deployments.

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[44] Respondents rated their overall satisfaction with the program on a 0–10 scale, where a zero meant *extremely dissatisfied* and a 10 meant *extremely satisfied*. PGE defined a 6–10 rating as *satisfied*.

[45] Significant differences at the 90% level ($p \leq .10$).

In interviews with Cadmus, PGE managers and implementation contractors described several program implementation issues:

- PTR and BDR customers received inaccurate and delayed feedback regarding their demand savings during Flex events. The inaccurate feedback may have discouraged some customers from saving, and the delay in providing feedback prevented PGE from calling additional events until these issues resolved. By the start of Winter 2016/2017, PGE had resolved the savings calculation issues and managed to deliver feedback to participants within 24 to 48 hours of events.
- Another issue concerned communication about event notification settings. Some customers complained that they received too many notifications or that the notifications did not arrive through their preferred delivery channels. Many customers reported being unaware that they could change their notification settings. In the future, PGE plans to communicate more proactively with participants about options for program communications and will simplify the process for changing the settings.

Pairing technology with Flex treatments may improve customer's ability to achieve load reduction. While the Flex pilot did not test the impacts of pairing enabling technologies, such as smart thermostats, advanced water heaters, or in-home displays, with the pricing or behavior-based treatments, other studies have found the pairing of these technologies enhances peak demand savings. The experience of TOU1 customers illustrates the potential benefits of enabling technology. TOU1 customers reported challenges in shifting loads from daytime on-peak periods to nighttime off-peak periods; programmable or price-responsive enabling technologies may facilitate shifting of loads and increase TOU1 on-peak demand savings.

Customer Experience Recommendations

- PGE should consider modifying the TOU design and delivery for the winter season to help customers save or shift more electricity consumption. This would improve customer satisfaction and increase load impacts. Modifications could include eliminating the morning on-peak period, shortening the length of the on-peak periods, or automatically enrolling TOU customers in the PTR program. A conjoint analysis of the TOU program offering could examine tradeoffs between different rate schedule designs, customer satisfaction, and load impacts.
- PGE should provide TOU customers with additional education about their rate schedules. This information should be simple and easy to understand. One idea is delivering educational information through alternative media, such as online video.
- PGE should consider opt-out demand response programs as a component of its demand response portfolio. The Flex pilot demonstrated that opt-out programs can reach large numbers of customers and that 50% or more of customers automatically enrolled in PTR or BDR remained engaged, as measured by self-reported rates of Flex event awareness and conservation.

- PGE should conduct test events before the start of each season to assess readiness of its customer communications and data analytics platforms. Testing will allow PGE to correct issues before the season starts, refamiliarize customers with the program, and give customers a chance to change their communications preferences.
- PGE should consider conducting pilots to test the impacts of pairing enabling technologies such as smart thermostats or advanced water heaters with time-based rates or behavior-based treatments if PGE expects the technologies would be cost effective.

Marketing

Paper-based marketing and bill-savings messaging resonated most with customers.
PGE experimented with email, postcard, and business letter marketing, and found business letters achieved the highest customer marketing conversion rate (4.5%), followed by postcards (2.5%), and then email (1.5%).[46]

Business letters emphasized financial messaging (i.e., rate comparison information and a bill savings pitch). PGE initially used economic, control, and community messaging in the emails and post cards, but those approaches proved unsuccessful in enrolling customers. The recruitment survey also found a large majority of participants enrolled to save money on their electric bills (78%); far fewer respondents indicated enrolling to save energy (46%) or help the environment (28%).

Marketing Recommendation

- PGE should consider employing business letter marketing approach for future demand response programs to increase the cost-effectiveness of its marketing. This approach would include leading with bill savings and rate comparisons rather than energy savings or community as primary messages in postcards, emails, or other marketing channels.

[46] A conversion rate measures a given marketing channel's effectiveness in spurring enrollment, calculated by taking the number of customers who enrolled from a channel and dividing this by the total number of customers that the channel reached.

Appendix A. Data Preparation

AMI Meter Data

The AMI data included a mix of 15- and 60-minute interval readings. Cadmus removed a small number of duplicate interval readings from the data. After summing 15-minute interval consumption data to obtain hourly interval consumption, Cadmus dropped a small number of outliers and hourly observations with one or more missing 15-minute interval readings. Specifically, we removed hourly consumption readings greater than 24 kWh from the analysis sample.[47] Also, Cadmus dropped customers with high average monthly consumption, who were unlikely to have been residential customers. We dropped a small number of customers consuming an average of 300 or more kWh per day from the analysis sample.[48]

Cadmus encountered other issues with the AMI meter data and developed solutions to address them. First, the timestamps on the AMI meter datasets were set to different time zones. Some were recorded on Coordinated Universal Time (UTC) instead of Pacific Time (UTC -8 or UTC -7) and required adjustment. In these cases, Cadmus shifted the timestamps to the correct time zone and adjusted for daylight savings time. Cadmus performed a review of the raw, average daily load shapes in each dataset before and after each adjustment to verify the timestamp adjustments.

Second, during the pretreatment period, some customers' AMI interval data were reported in integer kWh instead of in watt-hours. PGE did not switch meters of many participants to record watt-hours until the customer enrolled in the pilot. Cadmus determined these data were not truncated or rounded to the nearest kilowatt hour, but instead represented the change in kilowatt hours between intervals.[49] Since the pretreatment consumption data were measured with error, Cadmus wanted to avoid having pretreatment period hourly consumption directly enter the regression models used to estimate savings. We selected a regression approach that did not require using pretreatment period hourly consumption as a dependent or independent variable. However, to explain variation between customers in hourly consumption during the treatment period, it would be important to control for pre-treatment consumption. We determined that averaging the integer kWh over hours and making an adjustment for expected small errors produced an accurate estimate of a customer's pretreatment mean kWh per hour.

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47 Twenty-four kWh represented the maximum possible hourly energy consumption of a home with a 100-amp service. Such observations were extremely rare, and more likely reflected bad data (or commercial/industrial activity) rather than true residential consumption. This filter removed any hours with incomplete data or multiple observations for the same period. The hour in fall when DST ended was the exception to this filter, resulting in two 1:00 a.m.–2:00 a.m. periods on the same day.

48 Customers consuming over 300 kWh per day on average unlikely lived in single-family residential homes. The 300 kWh/day bound is standard practice for evaluation of residential behavioral programs.

49 For example, if a customer consumed 0.4 kWh per hour for each hour over a three-hour period, the meter data would show 0, 0, and 1 in the kWh field.

Using AMI meter data for customers with consumption reported in watt-hours, we tested the accuracy of our methodology and found that it produced accurate estimates of mean consumption. As noted above, Cadmus included customer pretreatment mean consumption as an independent variable in the regressions to explain variation between customers in energy consumption during the treatment period.

Third, PGE did not provide pretreatment data for the same 12 months for all pilot customers as recruitment lasted longer than one year and PGE only retained interval meter data for the previous 13 months. The date range for the available pretreatment consumption data depended on the customer's recruitment wave. For example, for TOU customers opting into the pilot in spring 2016, PGE provided Cadmus with AMI meter interval data for calendar year 2015, but, for TOU customers opting into the pilot in spring 2017, PGE provided Cadmus with AMI meter interval data for the second half of 2015 and the first half of 2016. This complicated the calculation of each customer's pretreatment mean consumption, which would be included as a control variable.

To obtain comparable estimates of pretreatment consumption for customers from different recruitment waves, Cadmus built a regression model for each customer to predict the customer's pretreatment demand under a standard set of conditions. The standard set of conditions was defined by the specific hours and weather for which Cadmus was attempting to estimate demand savings during the treatment period. For example, to estimate TOU2 demand savings during the on-peak period in Summer 2017 analysis, Cadmus used pretreatment data to predict pretreatment consumption for each customer in the TOU2 test or control group during on-peak hours (between 3:00 p.m. and 8:00 p.m. on non-holiday weekdays) when the outside temperature equaled average outdoor temperatures during on-peak hours in 2017.

Specifically, using available pretreatment consumption data for summer or winter, Cadmus estimated individual customer regressions of hourly energy consumption on a constant and cooling or heating degree hours:

Equation 1

$$kWh_{it} = \alpha_i + \beta_i HD_{it} + \varepsilon_{it}$$

Where:

kWh_{it}	=	Electricity consumption of customer i during on-peak hour t of the summer or winter pre-treatment period.
α_i	=	Intercept for customer i indicating average consumption per hour during on-peak or off-peak hours.
β_i	=	Coefficient for customer i indicating average effect of cooling (heating) degree hours during summer (winter) on electricity consumption.
HD_{it}	=	Heating (cooling) degrees for customer i during peak or off-peak hour t using base temperature of 65°F in winter and 75°F in summer.
ε_{it}	=	Error term for consumption of customer i during peak or off-peak hour t.

Cadmus estimated the customer models by OLS and then predicted each customer's consumption for typical weather during on-peak and off-peak hours as follows:

Equation 2

$$\widehat{kWh_{ip}} = a_{ip} + b_i\overline{HD}_{ip}$$

where:

kWh_{ip} =		Predicted mean electricity consumption for customer i during on-peak or off-peak hours during the pre-treatment period.
a_i	=	Estimated intercept for customer i indicating average consumption per hour during on-peak or off-peak hours.
b_i	=	Coefficient for customer i indicating average effect of cooling (heating) degree hours during summer (winter) on electricity consumption during on-peak or off-peak hours.2.
$\overline{HD}_{ip}$	=	Mean cooling (heating) degree hours during on-peak or off-peak hours of the treatment period.

Cadmus included the predicted pre-treatment consumption as an explanatory variable in Equation 2.

Ineligible Customers and Account Closures

A small number of customers opting into the pilot or automatically enrolled in opt-out treatments were determined ineligible for participation. Cadmus removed any customer from the analysis sample if PGE determined they were ineligible (e.g., customers with solar arrays or participants in the Rush Hour Rewards program). Cadmus applied these sample selection criteria identically to customers in the randomized test and control groups.

Also, some customers opting in or automatically enrolled in the pilot moved residences. When a customer moved, their participation in the pilot ceased, and Cadmus removed all AMI data for the period after the customer's move-out date.

Appendix B. Model Specifications

Event-Based Treatments

Cadmus estimated the demand savings from event-based treatments (PTR1-PTR3, opt-out BDR, and Opt-out PTR2) by comparing the hourly consumption of customers in each treatment's randomized test and control groups. Using data for event hours during each winter or summer season, Cadmus estimated a panel regression of customer hourly energy consumption on control variables for pretreatment consumption, hour-of-sample fixed effects, and assignment to treatment. Letting i, i=1, 2, ..., N, denote customer, and t, t=1, 2, ..., T, denote the Flex hour, the model took the following form:

Equation 3

$$kWh_{it} = \beta_1 Test_i + \mathbf{kWh}^{Pre}_{it}{}'\gamma + \tau_t + \varepsilon_{it}$$

Where:

kWh_{it}	=	Electricity consumption of customer i during Flex event hour t.
β_1	=	A coefficient indicating average treatment effect (in kWh) per customer per hour.
$Test_i$	=	An indicator variable for whether customer i was assigned to receive the treatment. This variable equals one if the customer was assigned to the treatment group and zero otherwise.
$\mathbf{kWh}^{Pre}_{it}$	=	A vector of variables characterizing mean consumption during the pretreatment period for customer i.
γ	=	A vector of coefficients indicating average effect of pretreatment consumption on consumption of customer i during Flex events.
τ_t	=	Error term for Flex hour t of the analysis period. Cadmus captured these effects with hour-of-the-sample fixed effects (i.e., a separate dummy variable for each Flex event hour).
ε_{it}	=	Error term for consumption of customer i and hour t.

The pretreatment consumption variables account for differences between customers in average consumption during Flex event hours. Cadmus calculated separate morning and evening pretreatment consumption means using data for hours when events typically occur (e.g., 4:00 p.m. to 7:00 p.m.) on non-holiday weekdays before the Flex season began or before the first PTR or BDR event occurred.[50] Cadmus attempted to use days that had low (winter) or high (summer) temperatures to temperatures experienced during Flex events.[51] Cadmus did not calculate mean consumption using non-event days

[50] For Summer 2017, Cadmus selected days between April 1, 2017, and July 23, 2017. For Winter 2017–2018, Cadmus selected days between November 1, 2017, and December 31, 2017. In each case, the last day of the period was the last non-holiday weekday before the first event of the season.

[51] Only days where the mean temperature fell no lower than 10 degrees below the event day mean temperature.

during the demand response season because of evidence from other studies showing that event-based treatment can produce savings on non-event days. The hour-of-sample fixed effects control for weather and other unobserved factors specific to each event hour.

Cadmus estimated a separate model for each treatment by OLS and clustered the standard errors on customers to account for correlation of consumption for individual customers, and estimated alternative model specifications to test the robustness of the estimates to specification changes. These alternative specifications included the following:

- Substituting day-of-the week and hour-of-the-day variables for the hour-of-the-sample fixed effects.
- Adding weather variables such as cooling degree hours (CDH) or heating degree hours (HDH) to the regression.
- Omitting pretreatment mean consumption from the regression equation.
- Adding indicator variables for a customer's recruitment wave (Wave 1, Wave 2, or Wave 3) as standalone variables and interacted with other variables.

These specification changes affected the estimated standard error, but not the point estimates of savings.

Time of Use Rate-Based Treatments

Cadmus estimated treatment effects for TOU rate and hybrid-TOU rate treatments by comparing consumption of customers in each treatment's randomized test and control groups. Using data on customer consumption for event and non-event hours during each winter or summer season, Cadmus estimated a panel regression of customer hourly energy consumption on control variables for pretreatment consumption, peak and off-peak hours, day-of-the-week, weather, and assignment to treatment. Again, letting i, i=1, 2, ..., N, denote customer, and t, t=1, 2, ..., T, denote the Flex hour, the TOU and TOU-hybrid treatment models took the following form:

Equation 4

$$kWh_{it} = \alpha + \gamma_1 \, OffPeak_t + \gamma_2 Peak_t + \beta_1 Test_i * OffPeak_t + \beta_2 Test_i * Peak_t + \beta_3 Treatment_i * OffPeak_t * Wkend_t + \mathbf{kWh}^{Pre}_{it}{}'\gamma + \varepsilon_{it}$$

Where:

$(kWh/hour)_{it}$	=	Electricity consumption of customer i during hour t of the summer or winter treatment period.
α	=	Intercept indicating baseline average consumption (kWh) per customer per TOU weekend (off-peak) hour.
γ_1 `	=	Coefficient on $OffPeak_t$ indicating baseline average consumption (kWh) per customer per TOU off-peak period hour.

$Offpeak_t$	=	An indicator variable for whether the hour is a TOU off-peak period weekday hour. This variable equals one if the hour was not a peak period hour or weekend hour and zero otherwise.
γ_2	=	Coefficient on $Peak_t$ indicating baseline average consumption per customer (kWh) per TOU peak period hour.
$Peak_t$	=	An indicator variable for whether the hour is a TOU peak period hour. This variable equals one if the hour was a peak period hour and zero otherwise.
$Test_i$	=	An indicator variable for whether customer i was assigned to receive the treatment. This variable equals one if the customer was assigned to the treatment group and zero otherwise.
β_1	=	Coefficient on $Treatment_i$*$OffPeak_t$ indicating average TOU treatment effect per customer during off-peak period hours in kWh per hour.
β_2	=	Coefficient on $Treatment_i$*$Peak_t$ indicating average TOU treatment effect per customer during peak period hours in kWh per hour.
β_3	=	Coefficient on $Treatment_i$*$OffPeak_t$*$Wkend_t$ indicating average TOU treatment effect per customer during period weekend hours in kWh per hour.
$Wkend_t$	=	An indicator variable for whether the hour is a weekend (TOU off-peak) hour. This variable equals one if the hour was a weekend period hour and zero otherwise.
$\mathbf{kWh}^{Pre}_{it}$	=	A vector of variables characterizing mean consumption during the pretreatment period for customer i. This vector included mean off-peak period mean hourly consumption interacted with *$Offpeak_t$*, on-peak period mean hourly consumption interacted with *$Peak_t$*, and weekend (non-peak period) mean hourly consumption interacted with *$Wkend_t$*.
γ	=	A vector of coefficients indicating average effect of pretreatment kWh on consumption of customer i.
ε_{it}	=	Error term for consumption of customer i and hour t.

In the regression equation, the omitted variable is the indicator for the weekend (off-peak) period. The main coefficients of interest are β_1, β_2, and β_3, which indicate, respectively, TOU treatment effects during off-peak, peak, and weekend hours.

Cadmus estimated a separate model for each TOU treatment by OLS and clustered the standard errors on customers. To estimate the treatment effect for the TOU3 rate, which included a mid-peak period, Cadmus added an indicator variable for the mid-peak period to the specification. Again, because of the random assignment of customers to test and control groups, the regression was expected to produce an unbiased estimate of the treatment effect.

Cadmus estimated the following alternative model specifications to test the robustness of the TOU treatment effect estimates to specification changes:

- Substituting hour-of-sample fixed effects for the peak hour and off-peak hour variables.
- Adding weather variables such as cooling degree hours (CDH) or heating degree hours (HDH) to the regression.

- Omitting pretreatment mean consumption from the regression equation.
- Adding indicator variables for a customer's recruitment wave (Wave 1, Wave 2, or Wave 3) as standalone variables and interacted with other variables.

The point estimates of savings proved robust to these specification changes. The main effect was to increase or decrease the estimated standard errors.

Hybrid TOU Treatments

To estimate treatment effects for the hybrid treatments such as TOU1xPTR2 or TOU2xBDR, in Equation 2, Cadmus substituted *Peak**Event* and *Peak**(1-*Event*) *indicator* variables for the *Peak* variable, thereby allowing the effects of *Peak* and *Peak**Test* to depend on whether the hour was a Flex event hour. The *Event* variable equals 1 if the hour is a Flex event hour and equals zero otherwise.

Appendix C. Equivalency Checks and Analysis

Sample Summary Statistics

Table 19 presents results from tests of differences in pre-treatment consumption between the randomized test and control groups for each treatment. Cadmus regressed customer mean pre-treatment consumption on an indicator variable for assignment to the test group and separate indicator variables for the different recruitment waves. For the PTR-only, opt-in PTR, and BDR treatments, Cadmus presents balance tests of demand in hours that would have qualified as Flex events during the pretreatment period. For the TOU-based treatments, Cadmus presents separate balance tests of demand in on-peak period and off-peak period hours during the pre-treatment period.

Table 19. Balance Tests for Flex Pilot Randomized Test and Control Groups

	Summer 2017					Winter 2017/2018				
Treatment	N	Control Group kW	ΔkW (T-C)	Std. Error	T-stat	N	Control Group kW	ΔkW (T-C)	Std. Error	T-stat
PTR1	722	1.543	0.127	0.086	1.48	678	0.828	0.020	0.058	0.34
PTR2	408	1.528	0.167	0.116	1.44	380	0.892	0.062	0.092	0.68
PTR3	889	1.608	-0.061	0.076	0.80	823	0.871	-0.047	0.055	0.85
PTR-OO	1,256	1.588	0.057	0.068	0.84	1,149	0.876	0.032	0.050	0.65
BDR	19,587	1.644	-0.006	0.017	0.35	17,889	0.891	-0.006	0.013	0.44
TOU1										
Peak	827	0.932	0.036	0.033	1.09	787	1.459	-0.007	0.052	0.14
Off-Peak	827	0.799	0.037	0.029	1.28	787	1.326	-0.001	0.048	0.01
TOU2										
Peak	1,510	1.209	0.023	0.033	0.70	1,406	1.481	-0.004	0.040	0.09
Off-Peak	1,510	0.951	-0.023	0.025	0.93	1,406	1.320	-0.011	0.037	0.30
TOU3										
Peak	849	1.059	0.002	0.027	0.07	805	1.499	-0.010	0.037	0.27
Off-Peak	849	0.889	-0.020	0.022	0.90	805	1.372	-0.010	0.035	0.29
TOU1xPTR2										
Peak	638	0.981	0.025	0.044	0.57	612	1.451	0.018	0.059	0.30
Off-Peak	638	0.784	0.012	0.037	0.33	612	1.264	0.033	0.055	0.60
TOU2xPTR2										
Peak	385	1.051	0.181	0.064	2.83	354	1.551	-0.073	0.076	0.96
Off-Peak	385	0.899	-0.015	0.042	0.36	354	1.302	-0.074	0.064	1.16
TOU2xBDR										
Peak	1,398	1.209	-0.018	0.071	0.25	1,317	1.481	0.000	0.082	0.00
Off-Peak	1,398	0.951	-0.015	0.056	0.27	1,317	1.320	0.038	0.079	0.48
TOU3xPTR2										
Peak	598	1.076	0.027	0.034	0.80	559	1.501	-0.009	0.045	0.20
Off-Peak	598.0	0.802	-0.009	0.022	0.41	559	1.300	-0.017	0.038	0.45

Notes: N is number of test and control group customers. For PTR, PTR-OO, and BDR treatments, pre-treatment demand was average kW during event hours on 10 warmest (summer) or coldest (winter) non-holiday weekdays during 60 days preceding start of treatment. For TOU and Hybrid treatments, pre-treatment demand was predicted average demand during on-peak (off-peak) hours and was estimated with a separate regression for each customer of hourly demand during peak (off-peak) period hours for summer (winter) in the year before start of treatment. Difference between test and control group demand estimated with regression of customer mean pre-treatment demand on an indicator variable for assignment to the test group and separate indicator variables for the different recruitment waves.

The results of the balance tests show the test and control groups for almost all treatments and periods were well balanced on mean pre-treatment consumption, as expected from the random assignment to treatment. The only statistically significant difference was for the TOU2xPTR2 treatment.

Table 20 presents the sample mean and standard deviation of electricity demand during Summer 2017 and Winter 2017/2018 Flex events for test and control group customers in the PTR-only, opt-in PTR, and opt-in BDR treatments.

Table 20. Analysis Sample Summary Statistics for PTR and BDR Treatments

		Summer 2017			Winter 2017/2018		
Treatment		N	Mean	Std. Dev.	N	Mean	Std. Dev.
PTR1							
	Control	8,577	2.273	1.756	6,780	1.719	1.526
	Test	8,541	2.039	1.823	6,780	1.625	1.551
PTR2							
	Control	4,446	2.222	1.898	3,500	1.826	1.792
	Test	5,178	1.939	1.781	4,100	1.802	1.727
PTR3							
	Control	10,472	2.248	1.838	8,260	1.774	1.639
	Test	10,584	1.818	1.727	8,200	1.505	1.484
PTR-OO							
	Control	15,098	2.287	1.896	11,880	1.841	1.656
	Test	14,508	2.196	1.846	11,094	1.819	1.724
BDR							
	Control	230,912	2.243	1.860	107,210	1.915	1.791
	Test	231,371	2.193	1.840	107,373	1.891	1.803

Notes: Table shows sample means and standard deviations of demand during Flex event hours for event-based treatments. N is the number of observations of hourly demand for customers.

Table 21 presents sample means and standard deviations of electricity demand during Summer 2017 and Winter 2017/2018 on-peak and off-peak hours for test and control group customers in the TOU and Hybrid treatments.

Table 21. Analysis Sample Summary Statistics for TOU and Hybrid Treatments

		Off-peak			On-Peak		
Summer 2017							
Treatment		N	Mean	Std. Dev.	N	Mean	Std. Dev.
TOU1							
	Control	625,512	0.954	1.036	559,632	1.101	1.158
	Treatment	604,901	1.038	1.180	541,227	1.155	1.216
TOU2							
	Control	1,270,420	1.042	1.203	219,965	1.417	1.447
	Treatment	4,463,949	0.990	1.077	772,815	1.306	1.365
TOU3							
	Control	1,008,796	1.019	1.125	174,680	1.352	1.365
	Treatment	1,033,528	0.972	1.099	178,925	1.281	1.297
TOU1xPTR2							
	Control	448,735	0.916	1.014	401,584	1.114	1.193
	Treatment	509,200	0.955	1.100	455,600	1.122	1.234
TOU2xPTR2							
	Control	407,496	0.988	1.088	70,560	1.370	1.376
	Treatment	510,935	0.989	1.050	88,465	1.389	1.345
TOU2xBDR							
	Control	1,270,420	1.042	1.203	219,965	1.417	1.447
	Treatment	2,092,450	0.978	1.072	362,270	1.264	1.339
TOU3xPTR2							
	Control	686,774	0.957	1.030	118,895	1.335	1.318
	Treatment	755,520	0.935	1.041	130,800	1.292	1.388
Winter 2017/2018							
Treatment		N	Mean	Std. Dev.	N	Mean	Std. Dev.
TOU1							
	Control	438,002	1.237	1.321	372,556	1.422	1.467
	Treatment	397,696	1.309	1.347	338,224	1.428	1.377
TOU2							
	Control	720,000	1.344	1.452	251,054	1.520	1.478
	Treatment	2,543,971	1.292	1.381	887,119	1.433	1.450
TOU3							
	Control	606,091	1.314	1.384	211,341	1.466	1.420
	Treatment	569,966	1.309	1.469	198,737	1.439	1.508
TOU1xPTR2							
	Control	306,386	1.221	1.366	260,568	1.450	1.515
	Treatment	344,911	1.272	1.394	293,392	1.466	1.501
TOU2xPTR2							
	Control	239,910	1.363	1.453	83,639	1.607	1.621
	Treatment	277,087	1.213	1.250	96,624	1.402	1.310
TOU2xBDR							
	Control	720,000	1.344	1.452	251,054	1.520	1.478
	Treatment	2,543,971	1.292	1.381	887,119	1.433	1.450
TOU3xPTR2							
	Control	398,239	1.294	1.392	138,865	1.526	1.535
	Treatment	419,036	1.242	1.371	146,113	1.442	1.475

Notes: Table shows sample means and standard deviations of demand during TOU on-peak and off-peak periods for TOU and Hybrid treatments. N is the number of observations of hourly demand for customers.

Appendix D. Load Impact Estimates for Summer 2016 and Winter 2016/2017

Table 22 presents savings estimates for Flex treatments during summer 2016, which was the pilot's first season. At the beginning of summer 2016, PGE had not completed customer recruitment, and many of the treatments were not fully enrolled. As a result, the sample sizes were small and the savings estimates were not precise and not statistically different from zero for many treatments. In particular, almost all TOU impact estimates were statistically insignificant.

Table 22. Flex Evaluation Findings by Treatment – Summer 2016

Category	Treatment		Summer 2016				
			N of customers	PGE Planning Savings Estimate	Evaluation		
					Savings (%)	Abs. Precision at 90% Conf.	Savings (kW)
PTR-Only	PTR1		131	13%	34%	±11%	0.65
	PTR2		447		29%	±7%	0.53
	PTR3		198		33%	±10%	0.65
Opt-Out	PTR2-OO		737	6%	17%	±5%	0.37
	BDR-OO		11,618	3%	1.3%	±1.2%	0.03
TOU-Only	TOU1	On-Peak	241	5%	3%	±6%	0.03
		Flex Event			4%	±15%	0.08
	TOU2	On-Peak	847		1%	±4%	0.01
		Flex Event			2%	±8%	0.03
	TOU3	On-Peak	232		-7%	±10%	-0.08
		Flex Event			-21%	±17%	-0.33
Hybrids	TOU1xPTR2	On-Peak	242	12.9% PTR; 5.2% TOU	6%	±8%	0.05
		Flex Event			3%	±18%	0.05
	TOU2xPTR2	On-Peak	468	12.9% PTR; 5.2% TOU	-2%	±4%	-0.02
		Flex Event			5%	±9%	0.09
	TOU2xBDR	On-Peak	561	3.0% BDR; 5.2% TOU	1%	±4%	0.01
		Flex Event			0%	±10%	0.00
	TOU3xPTR2	On-Peak	245	12.9% PTR; 5.2% TOU	1%	±7%	0.01
		Flex Event			0%	±15%	0.00

Notes: n is the number of customers included in the impact analysis. All estimates were obtained through OLS regression analysis, with standard errors clustered on customers. Green denotes the estimate was statistically significant at the 10% level.

Table 23 presents savings estimates for Flex treatments during winter 2016/2017, which was the pilot's first winter season. At the beginning of this season, PGE had still not completed customer recruitment, and many of the treatments had not met their enrollment targets. As a result, the sample sizes were small and the savings estimates were not precise and not statistically different from zero for many treatments.

Table 23. Flex Evaluation Findings by Treatment—Winter 2016/2017

Category	Treatment		Winter 2016/2017								
			N of customers	PGE Planning Savings Estimate	Evaluation						
					AM			PM			
					Savings (%)	Abs. Precision at 90% Conf.	Savings (kW)	Savings (%)	Abs. Precision at 90% Conf.	Savings (kW)	
PTR-Only	PTR1		289	14%	6%	±10%	0.09	6%	±7%	0.13	
	PTR2		408		-2%	±9%	-0.03	3%	±7%	0.07	
	PTR3		420		1%	±8%	0.01	14%	±7%	0.31	
Opt-Out	PTR2-OO		680	7%	-3%	±6%	-0.05	-4%	±5%	-0.09	
	BDR-OO		10,665	3%	0.5%	±2%	0.01	0%	±1%	0.01	
TOU-Only	TOU1	On-Peak	256	6%	1%	±5%	0.01	1%	±5%	0.01	
		Flex Event			-4%	±9%	-0.07	3%	±8%	0.08	
	TOU2	On-Peak	919		4%	4%	0.06	4%	±4%	0.06	
		Flex Event			2%	±6%	0.04	2%	±5%	0.05	
	TOU3	On-Peak	268		-8%	6%	-0.14	-8%	±6%	-0.14	
		Flex Event			-17%	13%	-0.30	-14%	±11%	-0.30	
Hybrids	TOU1xPTR2	On-Peak	236	14.2% PTR;	13%	9%	0.21	13%	±9%	0.21	
		Flex Event		5.8% TOU	17%	14%	0.30	9%	±10%	0.19	
	TOU2xPTR2	On-Peak	408	14.2% PTR;	7%	±5%	0.13	7%	±5%	0.13	
		Flex Event		5.8% TOU	11%	9%	0.20	7%	±7%	0.15	
	TOU2xBDR	On-Peak	615	3.3% BDR;	0%	±5%	0.00	0%	±5%	0.00	
		Flex Event		5.8% TOU	-8%	±9%	-0.14	0%	±7%	0.00	
	TOU3xPTR2	On-Peak	278	14.2% PTR;	2%	±5%	0.04	2%	±5%	0.04	
		Flex Event		5.8% TOU	-2%	±11%	-0.03	8%	±8%	0.17	

Notes: n is the number of customers included in the impact analysis. All estimates were obtained through OLS regression analysis, with standard errors clustered on customers. Green denotes the estimate was statistically significant at the 10% level.

Appendix E. Survey Design and Samples

This appendix describes the six customer surveys and samples that Cadmus designed and administered.

Recruitment Survey

Because opt-in control customers were denied enrollment, Cadmus fielded the recruitment survey only to treatment customers in the 10 opt-in treatments. Test group customers in the two opt-out treatments did not receive the recruitment survey as these customers were automatically enrolled rather than recruited. The recruitment survey asked questions about how customers heard about Flex, their familiarity with TOU pricing, reasons for enrolling, and their satisfaction with PGE. Table 24 shows the number of test group customers contacted for the recruitment survey and the response rate.

Table 24. Recruitment Survey Sample and Response Rate

Treatment	Test Group		
	Number of Contacted	Number of Completes	Response Rate
TOU1	62	35	56%
TOU2	158	77	49%
TOU3	49	23	47%
PTR1	38	23	61%
PTR2	144	76	53%
PTR3	65	35	54%
TOU1xPTR2	53	30	57%
TOU2xPTR2	164	80	49%
TOU3xPTR2	58	36	62%
TOU2xBDR	74	43	58%
Total	**865**	**458**	**53%**

Summer 2016 Event Survey

Cadmus fielded the event survey with test customers in the nine treatments with an event component. PGE and Cadmus also decided to field the event survey with control customers in the PTR2-OO and BDR-OO treatments to obtain a baseline metric for satisfaction with PGE. The event survey asked test customers about event notifications, whether they did anything to reduce consumption during the events, and their satisfaction with Flex and PGE. The event survey asked control customers about their familiarity with peak demand, whether they did anything to reduce consumption during days associated with peak demand, and their satisfaction with PGE. Table 25 shows the number of customers contacted for the event survey and the response rate.

Table 25. Event Survey Sample and Response Rate – Summer 2016

Treatment	Test Group			Control Group		
	Number of Contacted	Number of Completes	Response Rate	Number of Contacted	Number of Completes	Response Rate
PTR1	68	22	32%	–	–	–
PTR2	246	103	42%	–	–	–
PTR3	105	43	41%	–	–	–
TOU1xPTR2	90	30	33%	–	–	–
TOU2xPTR2	255	87	34%	–	–	–
TOU3xPTR2	94	36	38%	–	–	–
TOU2xBDR	111	27	24%	–	–	–
PTR2-OO	277	27	10%	269	36	13%
BDR-OO	3,333	302	9%	3,333	353	11%
Total	**4,579**	**677**	**15%**	**3,602**	**389**	**11%**

Summer and Winter Experience Surveys

After the end of each season, Cadmus fielded the experience survey with test customers in all 12 treatments. The experience survey asked questions about events, pricing awareness, load-reducing behaviors, participation barriers, satisfaction with the program, satisfaction with PGE, and suggestions for program improvements. Control customers were also surveyed during the winter seasons to supply comparative data for satisfaction with PGE. Table 26, Table 27, Table 28, and Table 29 show survey samples and response rates for each of the four seasonal experience surveys.

Table 26. Experience Survey Sample and Response Rate – Summer 2016

Treatment	Test Group		
	Number of Contacted	Number of Completes	Response Rate
TOU1	65	13	20%
TOU2	242	57	24%
TOU3	100	32	32%
PTR1	96	24	25%
PTR2	335	59	18%
PTR3	95	14	15%
TOU1xPTR2	88	19	22%
TOU2xPTR2	243	68	28%
TOU3xPTR2	93	18	19%
TOU2xBDR	110	15	14%
PTR2-OO	218	11	5%
BDR-OO	3,333	108	3%
Total	**5,018**	**438**	**9%**

Table 27. Experience Survey Sample and Response Rate – Winter 2016/2017

Treatment	Test Group			Control Group		
	Number of Contacted	Number of Completes	Response Rate	Number of Contacted	Number of Completes	Response Rate
TOU1	110	18	16%	–	–	–
TOU2	402	66	16%	–	–	–
TOU3	115	19	17%	–	–	–
PTR1	103	24	23%	–	–	–
PTR2	206	61	30%	–	–	–
PTR3	157	40	25%	–	–	–
TOU1xPTR2	94	17	18%	–	–	–
TOU2xPTR2	203	39	19%	–	–	–
TOU3xPTR2	110	26	24%	–	–	–
TOU2xBDR	159	18	11%	–	–	–
PTR2-OO	346	28	8%	396	42	11%
BDR-OO	3,333	132	4%	3,333	303	9%
Total	**5,338**	**488**	**9%**	**3,729**	**345**	**9%**

Table 28. Experience Survey Sample and Response Rate – Summer 2017

Treatment	Test Group		
	Number of Contacted	Number of Completes	Response Rate
TOU1	342	70	20%
TOU2	781	146	19%
TOU3	365	72	20%
PTR1	306	81	26%
PTR2	188	26	14%
PTR3	358	98	27%
TOU1xPTR2	285	67	24%
TOU2xPTR2	177	44	25%
TOU3xPTR2	260	58	22%
TOU2xBDR	766	155	20%
PTR2-OO	562	45	8%
BDR-OO	3,333	157	5%
Total	**7,723**	**1,019**	**13%**

Table 29. Experience Survey Sample and Response Rate – Winter 2017/2018

Treatment	Test Group			Control Group		
	Number of Contacted	Number of Completes	Response Rate	Number of Contacted	Number of Completes	Response Rate
TOU1	318	74	23%	389	83	21%
TOU2	746	133	18%	388	79	20%
TOU3	338	71	21%	389	88	23%
PTR1	289	88	30%	295	77	26%
PTR2	181	47	26%	169	43	25%
PTR3	339	104	31%	351	83	24%
TOU1xPTR2	275	71	26%	265	53	20%
TOU2xPTR2	172	45	26%	153	41	27%
TOU3xPTR2	251	57	23%	248	52	21%
TOU2xBDR	726	143	20%	–	–	–
PTR2-OO	507	57	11%	593	53	9%
BDR-OO	3,333	220	7%	3,333	309	9%
Total	**7,475**	**1,110**	**15%**	**6,573**	**961**	**15%**

Appendix F. Additional Survey Results

Table 30, Table 31, Table 32, Table 33, Table 34, Table 35, Table 36, Table 37, Table 38, Table 39, and Table 40 provide additional survey results, which the report's main body does not include.

Table 30. Percentage of Correct Rate Schedule Identification – Winter 2016/2017

Treatment	% Who Correctly Identified Their Rate Schedule	n
TOU-Only	**63%**	**103**
TOU1	78%	18
TOU2	58%	66
TOU3	53%	19
Hybrids	**65%**	**100**
TOU1xPTR2	76%	17
TOU2xPTR2	79%	39
TOU3xPTR2	50%	26
TOU2xBDR	56%	18
All	**64%**	**203**

Survey Question: Which image describes the rates you pay for electricity on the Flex Program?

Table 31. Flex Event Energy Conservation Participation Rates – Winter 2016/2017

Treatment	% Who Responded "Yes" to Conserving During Events	n
PTR-Only	**79%**	**125**
PTR1	79%	24
PTR2	75%	61
PTR3	85%	40
Hybrids	**81%**	**100**
TOU1xPTR2	94%	17
TOU2xPTR2	82%	39
TOU3xPTR2	92%	26
TOU2xBDR	50%	18
Opt-Outs	**64%**	**160**
BDR-OO	64%	132
PTR2-OO	61%	28
All	**73%**	**385**

Survey Question: Did you and your household do anything to conserve energy during "Flex Time" events?

Table 32. How Participants Conserved During Flex Events – Winter 2016/2017

Action Taken	% (n=313)
Shifted cooking, washing, or other chores to off-peak times	77%
Turned off lights or reduced use of lights	70%
Adjusted the heating thermostat settings by lowering the temperature	53%
Put on more layers of clothes or blankets	43%
Left the house	28%
Unplugged appliances or electronics not in use	25%
Used non-electric heating source such as wood, gas, and pellets	17%
Turned off the electric heater	15%
Lowered the water heating temperature	7%
Took some other action	7%

Survey Question: How did you and your household conserve energy during "Flex Time" events? (Select all that apply)

Table 33. Overall Satisfaction with Flex – Summer 2016

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**7.0**	**31%**	**68%**	**97**
TOU1	5.4	17%	38%	24
TOU2	7.3	34%	76%	59
TOU3	8.1	43%	86%	14
PTR-Only	**7.5**	**41%**	**78%**	**102**
PTR1	7.5	46%	85%	13
PTR2	7.0	33%	72%	57
PTR3	8.3	53%	88%	32
Hybrids	**7.1**	**32%**	**73%**	**120**
TOU1xPTR2	6.3	32%	63%	19
TOU2xPTR2	7.5	38%	79%	68
TOU3xPTR2	6.6	17%	56%	18
TOU2xBDR	6.7	20%	73%	15
Opt-Outs	**6.4**	**18%**	**53%**	**119**
BDR-OO	6.4	17%	54%	108
PTR2-OO	6.4	27%	45%	11
All	**7.0**	**30%**	**68%**	**438**

Survey Question: Please rate your overall satisfaction with the Flex Program using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 34. Overall Satisfaction with Flex – Winter 2016/2017

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**4.4**	**17%**	**33%**	**103**
TOU1	2.8	6%	28%	18
TOU2	4.4	15%	27%	66
TOU3	6.0	32%	58%	19
PTR-Only	**7.3**	**41%**	**78%**	**125**
PTR1	5.8	17%	63%	24
PTR2	7.3	36%	77%	61
PTR3	8.3	63%	90%	40
Hybrids	**5.9**	**20%**	**58%**	**100**
TOU1xPTR2	6.5	24%	71%	17
TOU2xPTR2	5.7	13%	54%	39
TOU3xPTR2	7.0	38%	69%	26
TOU2xBDR	4.3	6%	39%	18
Opt-Outs	**6.4**	**26%**	**63%**	**160**
BDR-OO	6.3	22%	64%	132
PTR2-OO	6.7	43%	57%	28
All	**6.1**	**26%**	**59%**	**488**

Survey Question: Please rate your overall satisfaction with the Flex Program using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 35. Overall Satisfaction with Flex – Summer 2017

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**7.4**	**39%**	**76%**	**288**
TOU1	6.5	23%	57%	70
TOU2	7.7	45%	82%	146
TOU3	7.8	42%	82%	72
PTR-Only	**8.1**	**48%**	**83%**	**205**
PTR1	7.9	46%	79%	81
PTR2	8.0	42%	92%	26
PTR3	8.2	52%	84%	98
Hybrids	**7.5**	**37%**	**79%**	**324**
TOU1xPTR2	7.2	34%	72%	67
TOU2xPTR2	6.9	27%	70%	44
TOU3xPTR2	8.0	50%	88%	58
TOU2xBDR	7.6	37%	81%	155
Opt-Outs	**6.4**	**27%**	**56%**	**202**
BDR-OO	6.1	23%	51%	157
PTR2-OO	7.8	40%	73%	45
All	**7.4**	**38%**	**74%**	**1,019**

Survey Question: Please rate your overall satisfaction with the Flex Program using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 36. Overall Satisfaction with Flex – Winter 2017/2018

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**6.3**	**23%**	**61%**	**278**
TOU1	5.9	23%	54%	74
TOU2	6.5	23%	62%	133
TOU3	6.2	23%	68%	71
PTR-Only	**8.1**	**52%**	**86%**	**239**
PTR1	7.7	44%	80%	88
PTR2	8.2	55%	89%	47
PTR3	8.3	58%	89%	104
Hybrids	**6.9**	**35%**	**71%**	**316**
TOU1xPTR2	6.9	38%	69%	71
TOU2xPTR2	6.7	18%	73%	45
TOU3xPTR2	7.1	46%	72%	57
TOU2xBDR	7.0	36%	71%	143
Opt-Outs	**6.4**	**27%**	**61%**	**277**
BDR-OO	6.2	25%	57%	220
PTR2-OO	7.3	35%	79%	57
All	**6.9**	**34%**	**69%**	**1,110**

Survey Question: Please rate your overall satisfaction with the Flex Program using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 37. Overall Satisfaction with PGE – Summer 2016

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**8.2**	**43%**	**93%**	**97**
TOU1	8.2	33%	92%	24
TOU2	8.2	44%	93%	59
TOU3	8.6	57%	93%	14
PTR-Only	**8.1**	**44%**	**89%**	**102**
PTR1	8.4	46%	92%	13
PTR2	7.8	37%	88%	57
PTR3	8.5	56%	91%	32
Hybrids	**7.9**	**40%**	**88%**	**120**
TOU1xPTR2	7.9	47%	84%	19
TOU2xPTR2	8.1	43%	88%	68
TOU3xPTR2	7.5	39%	89%	18
TOU2xBDR	7.6	20%	93%	15
Opt-Outs	**7.6**	**45%**	**80%**	**119**
BDR-OO	7.6	45%	80%	108
PTR2-OO	7.5	36%	82%	11
All	**7.9**	**43%**	**87%**	**438**

Survey Question: Please rate your overall satisfaction with PGE using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 38. Overall Satisfaction with PGE – Winter 2016/2017

Treatment	Test Group				Control Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**7.1**	**28%**	**78%**	**103**	**–**	**–**	**–**	**–**
TOU1	6.4	17%	72%	18	–	–	–	–
TOU2	7.3	30%	79%	66	–	–	–	–
TOU3	7.4	32%	79%	19	–	–	–	–
PTR-Only	**8.0**	**46%**	**87%**	**125**	**–**	**–**	**–**	**–**
PTR1	7.8	42%	88%	24	–	–	–	–
PTR2	7.9	46%	85%	61	–	–	–	–
PTR3	8.3	50%	90%	40	–	–	–	–
Hybrids	**7.5**	**35%**	**82%**	**100**	**–**	**–**	**–**	**–**
TOU1xPTR2	7.7	47%	88%	17	–	–	–	–
TOU2xPTR2	7.2	28%	79%	39	–	–	–	–
TOU3xPTR2	8.2	50%	88%	26	–	–	–	–
TOU2xBDR	6.8	17%	72%	18	–	–	–	–
Opt-Outs	**7.6**	**39%**	**83%**	**160**	**8.2**	**47%**	**90%**	**345**
BDR-OO	7.7	39%	83%	132	8.2	46%	91%	303
PTR2-OO	7.4	39%	79%	28	8.1	55%	88%	42
All	**7.6**	**38%**	**83%**	**488**	**8.2**	**47%**	**90%**	**345**

Survey Question: Please rate your overall satisfaction with PGE using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 39. Overall Satisfaction with PGE – Summer 2017

Treatment	Test Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**8.4**	**56%**	**91%**	**288**
TOU1	8.0	41%	91%	70
TOU2	8.5	62%	92%	146
TOU3	8.5	56%	90%	72
PTR-Only	**8.7**	**63%**	**93%**	**205**
PTR1	8.5	59%	94%	81
PTR2	8.7	65%	92%	26
PTR3	8.8	66%	93%	98
Hybrids	**8.3**	**54%**	**88%**	**324**
TOU1xPTR2	8.6	55%	91%	67
TOU2xPTR2	7.4	36%	77%	44
TOU3xPTR2	8.3	60%	86%	58
TOU2xBDR	8.5	57%	90%	155
Opt-Outs	**8.1**	**50%**	**85%**	**202**
BDR-OO	8.0	48%	83%	157
PTR2-OO	8.3	53%	91%	45
All	**8.4**	**56%**	**89%**	**1,019**

Survey Question: Please rate your overall satisfaction with PGE using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

Table 40. Overall Satisfaction with PGE – Winter 2017/2018

Treatment	Test Group				Control Group			
	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n	Mean Rating	% Delighted (9–10 Rating)	% Satisfied (6–10 Rating)	n
TOU-Only	**7.7**	**42%**	**79%**	**278**	**8.4**	**55%**	**90%**	**250**
TOU1	7.3	36%	78%	74	8.2	52%	87%	83
TOU2	7.8	47%	77%	133	8.8	65%	96%	79
TOU3	7.8	38%	86%	71	8.2	50%	86%	88
PTR-Only	**8.5**	**54%**	**91%**	**239**	**8.4**	**53%**	**91%**	**203**
PTR1	8.4	51%	88%	88	8.3	47%	91%	77
PTR2	8.3	51%	91%	47	8.2	49%	88%	43
PTR3	8.7	59%	93%	104	8.5	61%	93%	83
Hybrids	**7.9**	**47%**	**84%**	**316**	**8.2**	**51%**	**91%**	**146**
TOU1xPTR2	8.2	54%	86%	71	7.9	51%	89%	53
TOU2xPTR2	7.7	40%	84%	45	8.4	54%	95%	41
TOU3xPTR2	7.7	44%	79%	57	8.4	50%	90%	52
TOU2xBDR	7.9	46%	85%	143	–	–	–	–
Opt-Outs	**7.8**	**42%**	**84%**	**277**	**8.2**	**49%**	**88%**	**362**
BDR-OO	7.7	40%	81%	220	8.2	50%	89%	309
PTR2-OO	8.3	49%	95%	57	7.7	42%	81%	53
All	**8.0**	**46%**	**84%**	**1,110**	**8.3**	**52%**	**89%**	**961**

Survey Question: Please rate your overall satisfaction with PGE using a 0 to 10 scale where a zero means you are "extremely dissatisfied" and a 10 means you are "extremely satisfied."

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