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May 31, 2013

Via Email
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OPUC Filing Center
550 Capitol Street, N.E., Ste 215
PO Box 2148
Salem, OR 97308-2148

RE: **2013 Smart Grid Report**

Commission Order No. 12-158 (Docket No. UM 1460) has directed PGE to submit annual reports beginning this year on June 1, 2013, regarding their strategy, goals and objectives for adoption of smart grid technologies and the status of their smart grid investments. In addition, PGE was required to provide opportunities for the public to contribute input on PGE's smart-grid investments and applications.

In formulating PGE's Smart Grid Report, on May 6, 2013, PGE held a Smart Grid workshop to receive and consider feedback from stakeholders on PGE's Smart Grid Draft Report. Pursuant to Order No. 12-158, PGE provides the attached 2013 Smart Grid Report.

If you have any questions or require further information, please call Spenser Williams at (503) 464-7490. Please direct all formal correspondence and requests to the following email address: pge.opuc.filings@pgn.com.

Sincerely,

Patrick G. Hager
Manager, Regulatory Affairs

cc: UM 1460 Service List
UE 262 Service List
LC 56 Service List

Portland General Electric

Smart Grid Report

June 1, 2013

Contents

1. Executive Summary

1.1 Introduction

This report has been prepared in response to the Oregon Public Utility Commission (OPUC) Order No. 12-158 in UM 1460. By providing a framework for Portland General Electric's (PGE) plans to develop a smarter grid over the next decade, this document will share the vision of what PGE believes may be achievable during the five-year planning period, based on the maturity of Smart Grid technologies, the value they can deliver and customer readiness. PGE anticipates that the cost of implementing the projects and initiatives described herein will be on the order of $94 million over the five-year planning period. Approximately $54 million of the $94 million of investments are dedicated to Smart Grid-specific projects,[1] with the remainder supporting other business improvements that also provide the necessary back-office solutions for enabling Smart Grid technologies.[2] PGE has invested almost $200 million on systems and technologies, such as Advanced Metering Infrastructure (AMI),[3] Supervisory Control and Data Acquisition (SCADA), Dispatchable Standby Generation (DSG) and the Salem Smart Power Project, which support PGE's efforts to transition towards a smarter grid.

PGE has been delivering Smart Grid solutions to our customers for many years. In the past decade alone, the company's work in the deployment of Smart Meters and Dispatchable Standby Generation (DSG) has demonstrated industry leadership. That leadership continues today with programs like Energy Tracker[SM], which provides customers timely, comprehensive information about their energy usage, and demonstrations like the Salem Smart Power Project (SSPP), arguably the first true 'microgrid' within a utility system. PGE, in a joint effort with Electric Power Research Institute (EPRI), National Institute of Standards and Technology (NIST), and the USNAP Alliance, has also provided national leadership in the creation of a water heater standard for direct load control that could greatly reduce the cost of demand response.

These early efforts by PGE will serve as a platform for the delivery of value-added energy services, providing customers with new options that can improve the quality of their lives. It also holds the potential to improve reliability, operational efficiency and to ease the integration of renewable resources as energy storage and smart appliances become more common.

The Smart Grid represents an opportunity to enhance the value customers receive from the electrical system, and PGE is committed to continued leadership in delivering that value to our customers. This transition will be a significant challenge — one that involves not only leveraging new technology, but also making major changes in the way electricity is provided and used, which will take time and require additional resources.

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[1] $30 million for PGE's Energy Partner[SM] Demand Response Program, $12 million for DSG, $8 million for other T&D Smart Grid including SCADA expansion, $3 million for additional research, development and demonstration, and $1 million for PGE's Smart Power[SM] Platform software.

[2] $22 million in capital costs for Geographic Information System with Graphic Work Design and $18 million capital costs for Outage Management System.

[3] $153 million for AMI, $8 million on SCADA, $32 million on DSG, and $6 million on the Salem Smart Power Project.

This report discusses existing and planned PGE efforts and outlines a disciplined approach to decision making regarding which Smart Grid activities and projects are implemented.

1.2 PGE's Smart Grid Vision

PGE envisions an end-to-end transformation of its electrical distribution system to deliver enhanced value and control to customers while allowing us to operate the system more efficiently, safely and reliably. The transition to a Smart Grid will be *evolutionary, not revolutionary*. Over the planning period, we anticipate the following initiatives to be the major focus of our efforts with respect to the Smart Grid.

- Leverage the replacement of four obsolete enterprise systems (Outage Management System, Geographic Information System, Customer Information System, and Meter Data Management System) with modern systems that enable Smart Grid applications.
- Build on the capabilities of the AMI system to enable demand response and pricing programs to improve asset utilization.
- Accelerate the completion of the SCADA build-out to substations, reclosers, tie switches, strategically placed sensors and faulted circuit indicators.
- Expand research, development and demonstration (RD&D) efforts in support of Smart Grid applications and deployments.

1.3 Defining Features

The table below compares the characteristics of the current power grid with a Smart Grid. In pursuing the enhancements discussed in this report, PGE's objective is to continue moving its grid towards the defining features of a Smart Grid.

Smart Grid Features	
Existing Grid	**Smart Grid**
Largely Electromechanical	Increasingly Digital
One-Way Communication	Two-Way Communication
Centralized Generation	More Distributed Generation
Hierarchical Controls	Networked Controls
Few Sensors	Sensors Throughout
Human Monitoring	Self-Monitoring
Manual Intervention	Self-Correction
Failures and Blackouts	Self-reconfiguring and Islanding
Program Dispatch	Optimized Economic Dispatch
Limited Control	Pervasive Control
Few Customer Choices	Many Customer Choices

To build into the grid the level of intelligence described above will require controls and the creation of unique software that can process large amounts of data.

1.4 PGE's Strategy for Smart Grid Development

Consistent with guidance from the OPUC, PGE will follow these strategic principles to introduce incremental Smart Grid development:

- Enable Smart Grid capabilities when equipment fails or becomes obsolete.
- Be strategic with regard to the Smart Grid technologies pursued, looking for opportunities to provide customers with more choices, higher reliability and greater value.
- Use proven and interoperable technology as industry standards emerge, when feasible.
- Work collaboratively to demonstrate technologies in the early stages of commercialization, when those technologies address an immediate need (e.g., renewables integration) or have a particularly strong value proposition.
- Track early stage technologies through industry organizations, such as EPRI and standards development through working groups, including NIST and the Smart Grid Interoperability Panel (SGIP).

1.5 Development Process

When PGE elects to explore a selected Smart Grid technology we use a disciplined, staged approach to decision making (depicted below). Technologies are assessed at each step, based on the strategic principles provided in Section 1.4.

PGE conducts customer research on a regular basis to ensure customer expectations are aligned with the company's Smart Grid engagement. PGE leverages this research to inform our product and program offerings and identify ways to better engage customers in the Smart Grid. As PGE develops pilots/studies, we will share the results with OPUC staff and interested stakeholders, offering an opportunity for business cases for major investments to be vetted prior to deployment.

1.6 Connection to the Integrated Resource Plan (IRP)

In the decades ahead, PGE will interconnect increasing amounts of variable renewable resources to our system, and the Smart Grid will better support this. The Smart Grid will also enable system operators to use demand-side resources to help dynamically balance supply and demand, which helps mitigate the need for transmission upgrades and the development of fossil-fuel generation for load following. ***PGE foresees Smart Grid investments becoming viable alternatives to supply-side resources in the IRP, similar to the way cost-effective energy efficiency and demand response are considered as alternatives to supply-side resources.*** Many of PGE's Smart Grid initiatives will likely be vetted during IRP public meetings.

1.7 Stakeholder Involvement

In developing our Smart Grid Report, PGE considered feedback from customers, community and regulatory stakeholders. To understand customer desires with respect to the Smart Grid, PGE has worked with Market Strategies International to complete the Energy + Environment Study (E2 Study).[4] PGE conducts customer research on a regular basis to ensure our vision aligns with customer expectations regarding Smart Grid engagement.

PGE offered stakeholders the opportunity to provide feedback on this report at the May 6, 2013 workshop for this filing. Feedback was received from Citizens Utility Board, Northwest Energy Coalition and OPUC Staff. Some of the feedback was immediately addressable in this report, while other feedback was deemed best addressed in follow-up work. Below PGE has summarized the feedback received from our workshop.

Stakeholders will have the opportunity to provide additional feedback at the OPUC's public meeting related to this filing on July 23, 2013. Input from stakeholders will be sought prior to filing annual updates of this report. It should be noted that many of PGE's Smart Grid initiatives will be vetted during public meetings as part of the IRP process. Results from pilots/studies will be shared with Staff and stakeholders as they become available.

Citizens' Utility Board (CUB) Feedback

CUB's comments centered on PGE's AMI system and our utilization of the two-way communication network that went into place with its deployment. PGE has provided an update on AMI benefits where appropriate for a UM1460 report. Specifically, status updates are provided to CUB's requests for information around potential AMI benefits cited in UE 189 testimony, i.e. identification of overloaded transformers and isolated outages and reduction of service restoration costs. Additionally, CUB requested additional information be provided on the potential for a direct load control air conditioning program and how the Smart Grid can aid energy efficiency programs. This information has been added to Chapter 3, Customer Engagement.

CUB also expressed interest in having PGE demonstrate usage of the two-way communication network for other purposes such as appliance control. At this time PGE has elected to leave the question of communication path inside the home open since it may ultimately be through the AMI system— but at this time it is too early to say. It should be noted that other utilities, such as Southern California Edison, are moving away from using Smart Meters as a gateway.

Northwest Energy Coalition (NWEC) Feedback

Similar to CUB, NWEC's comments focused on creating a more explicit link between the Smart Grid and energy efficiency programs, which have been addressed. NWEC also asked PGE to clarify how the Energy Trust of Oregon (ETO) would be interfaced with on programs like Smart

[4] A total of 1,116 PGE online residential customer interviews were completed from May 6-13, 2013. The responses of this group were compared against the answers from 1,004 interviews completed from December 17-27, 2012 with consumers nationwide.

Water Heaters, where incentives may be provided. Because a detailed plan would need to be coordinated with the ETO, we have not addressed this issue in this year's report.

NWEC also requested more information around PGE's perspective on Vehicle-to-Grid and suggested a vision for a comprehensive customer engagement strategy be included in this report that complements PGE's Smart Grid plans. PGE is currently working on developing this type of strategy and will be able to share this information in the 2014 update of this report.

OPUC Staff Feedback

Staff requested a better description of how the work discussed in this report ties in with the IRP, how planned investments are budgeted, and a more in-depth treatment of the work underway in Conservation Voltage Reduction. PGE has sought to include more information on how various projects relate to the IRP and budget information where firm plans exist; budget information for future work that is still speculative has not been included. Staff also asked how each action would reduce customer costs, which we have included where appropriate since many actions will improve reliability and/or provide other benefits rather than reduce costs.

Staff further requested that we provide a more direct link between 'providing customers the products and services they desire' and financial benefits to individual customers and all ratepayers. Staff also requested further information on PGE's plans for pricing programs. At this time, PGE does not have business cases in place to provide financial benefits to individual customers or to pursue additional pricing programs prior to the replacement of PGE's Customer Information and Meter Data Management Systems.

1.8 Staffing & Resource Requirements

The transition to a smarter grid presents a significant financial and staffing challenge. To date PGE's Smart Grid efforts have been funded primarily through the replacement of obsolete systems, by using existing capital budgets for reliability improvements, or through access to limited RD&D funds. To derive a thoughtful, customer-supported business cases for advanced Smart Grid applications and to facilitate Smart Grid planning and implementation, additional RD&D funds will be required, as detailed in Appendices C and D, and 5 Full-Time Equivalent employees are needed. Necessary analysis and research requires in-house engineers and analysts who have advanced skill sets in technologies and a comprehensive understanding of PGE data systems, including AMI, GIS, OMS, marketing and other mass data support. These new positions were included and discussed as part of PGE's 2014 Test Year General Rate Case (UE 262) testimony. A listing and justification of the positions can be found in Appendix D.

1.9 Report Structure

Following the format of UM1460, PGE has divided the enhancements included in this Smart Grid Report into the following sections:

- Grid Optimization
- Customer Engagement
- Distributed & Renewable Resources
- Smart Power[SM]

- General Business Enhancements

The enhancements discussed in each of the above sections will be addressed in the context of work to date, work in progress, and future initiatives.

2. Grid Optimization

This section covers transmission, substation and distribution Smart Grid initiatives. In the past decade, PGE has engaged in a number of activities in this area that are now considered to be part of the Smart Grid. Over the planning period, we will continue to make advances in grid optimization that provide the most value to our customers and advance PGE towards a fully functioning Smart Grid.

2.1 Work to Date

Over the past 10 years, PGE has completed the following work that is foundational to our current and planned Smart Grid efforts:

- Installed more than 825,000 digital Smart Meters.
- Enhanced system efficiency and reliability by implementing:
    - An Energy Management System for our generation and transmission system
    - SCADA at more than 70 percent of PGE substations
    - Substation automation
    - Fiber optic communication upgrades
    - Pilot projects for Conservation Voltage Reduction (CVR)[5]
    - Automated feeder switches on feeders with greater than average outage duration
- Established nearly 90 MWs of DSG.
- Created a substantial public electric vehicle (EV) charging infrastructure (see Section 2.3.2 for future EV initiatives).
- Built systems that utilize Smart Meter data to identify overloaded transformers and confirm outages prior to dispatching crews.

These initiatives have made PGE's system more digital, more connected in terms of two-way communication and more supportive of new distributed forms of renewable-power generation. PGE's grid now has more sensors and monitors, providing real-time assessments of grid performance and helping with grid self-monitoring and self-correction to avoid predictable faults and failures. These features boost grid reliability for our customers.

2.2 Work in Progress

PGE's grid optimization efforts are focused on completing baseline deployment, i.e. basic, but critical, system enhancements that will allow:

- Improved visibility into PGE's system,
- Enhanced communications, monitoring and control,[6]

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[5] Results of a recently completed CVR Feasibility Study are attached in Appendix E.

[6] PGE will continue to implement SCADA in the remaining 30 percent of our substations as the availability of engineering and field technician subject matter experts permit.

- Planning and implementation of platforms necessary for future grid enhancements and utilization of Smart Meter data (for example, an Outage Management System or Distribution Management System),[7] and
- Business cases to be developed for the deployment of field equipment needed to reduce line losses, outage time and improve power quality.[8]

PGE is also piloting an application using voltage information collected from the AMI system to identify unusual line losses.

2.2.1 Systems Development

PGE's Transmission & Distribution (T&D) Transformation Project focuses on the replacement of antiquated enterprise systems associated with the management of T&D, such as Outage Management System (OMS) and Geographical Information System (GIS) with Graphic Work Design, and adds asset management and workforce automation tools. While the primary reason for implementing these enterprise systems is their obsolescence and prospective productivity gains, these applications are also a pre-requisite to implement certain Smart Grid field hardware and tap into the capabilities they offer.

- **GIS** lets the utility visualize, analyze, interpret and understand data to reveal relationships, patterns, and trends across a geographic space. PGE's GIS replacement will allow for tighter integration between work management, outage management and distribution management systems. It will become the system of record for the as-built distribution system. For example, during an outage repair, the record of installing a new transformer will automatically flow to the new GIS near real-time, building a quality database that is a critical prerequisite for implementing an advanced control and monitoring network. GIS provides the foundation for all engineering planning functions and helps support the reduction of line losses and identification of alternate feeds to non-faulted distribution wires during an outage. Expected to be available in 2015, the system is expected to have capital costs of approximately $22 million.[9]

- **OMS** will feature a near real-time feed of outage and restoration information from the Smart Meter system. This means PGE will no longer rely on customer calls to know when an outage has occurred. When tap lines are restored to service, restore messages from the downstream Smart Meters can be tracked before repair crews leave the area to identify isolated broken service drops. In support of these new capabilities, PGE has already streamlined work processes that will rely on this technology by taking the following steps:

    - Centralized outage repair and automated vehicle locating, which reduce travel time for outage repair by using the closest vehicle/crew.

[7] Long-term, a Distribution Management System will be needed to capture operational efficiencies and to enable many distribution automation pilots.
[8] These changes anticipate the need to manage the impact of a growing population of distributed energy resources (solar generation, battery storage systems and possibly EVs flowing power into the grid). Also, a growing number of automated re-closers will need to be installed to improve the reliability of problem feeders.
[9] Includes Graphic Work Design.

    - Automated field transactions populate GIS and OMS in near real-time, enabling more efficient crew dispatch during outages.

  At the heart of each of these new systems is a modern database used to store dynamic and static information required to support smart applications. As part of the new OMS system integration, significant, real-time events in both OMS and SCADA will be exchanged for the mutual benefit of both systems. The increased situational awareness in both systems will allow operators to make faster and better informed decisions during system restoration efforts. Future linkages to Maximo (PGE's asset management system) will yield proactive identification of equipment performance issues to guide future operations and purchases. Expected to be available in 2015, the system is expected to have capital costs of approximately $18 million.

Resource and budget requirements for GIS and OMS have been included in PGE's 2014 Test Year General Rate Case (UE 262). Commission support is critical to moving them ahead.

2.2.2 Infrastructure Enhancements

- **SCADA.** Completing SCADA deployment on substations increases visibility of the grid to T&D operations, reducing the need to rely on customer-sourced information. Adding SCADA to reclosers, tie switches, strategically placed sensors and faulted circuit indicators will increase visibility of the grid to T&D operations. PGE is adding communications to all existing electronic reclosers. A pilot is also underway to install Faulted Circuit Indicators on five feeders and integrate the data via AMI-FlexNet infrastructure.
- **Distribution Automation** (DA) will provide the potential for self-correcting and self-sustaining distribution feeders or micro-grids where distributed energy resources/energy storage exists. A DA Pilot is underway at Gales Creek, where a centralized DA server has been established. It has already resulted in operational and System Average Interruption Duration Index (SAIDI) savings.[10] The pace at which development occurs in this area will be dependent on gaining the resources described in Appendix D.
- **Enhanced communication infrastructure to substation field devices** will enable remote substation management data collection through a non-operational or Smart Grid data path. On distribution feeders, it enables an extensive control-and-monitoring network. In 2011, PGE completed a pilot to manage intelligent electronic devices via an Ethernet connection. A project is underway to put secure network access to intelligent devices at more than 40 substations to:
    - Provide remote management capability,
    - Enable advanced asset management via a communication link, and
    - Meet North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) compliance requirements.
- As part of **enhanced T&D asset monitoring,** intelligent electronic devices will keep track of large capital assets, promoting a more reliable grid and increased asset utilization. PGE has nearly completed the advanced transformer monitors/controls project to install real-time

[10] SAIDI is the total time without power for the average customer per year, measured in minutes.

dissolved-gas-analysis monitors on critical power transformers. In 2013, PGE will install travelling wave fault location protective relays on the Bethel-to-Round Butte 230kV line, enabling faulted line pinpointing to within two transmission spans, greatly reducing the duration of transmission outages. A network of voltage disturbance monitors has been completed for selected customer sites.

- **SCADA and protective device upgrades** will increase our ability to operate an adaptive grid as well as optimize utilization of the T&D system, by eliminating all electromechanical relays,[11] transducers and legacy SCADA remote terminal unit systems[12]. In 2013, PGE will add new fault recorders to provide more accurate power quality and disturbance information.
- By introducing **advanced regulation of distribution voltage-and-reactive power flow**, via intelligent SCADA-enabled controllers,[13] we can minimize system losses in the distribution system.[14] A pilot CVR installation is scheduled for 2013. Future CVR installations will be determined pending pilot results. Development of a volt/VAR application will be dependent on gaining the resources described in Appendix D.

These ongoing grid enhancements are, or will be, demonstrating their value in pilot projects and, if viable, will be included in PGE's annual construction budget for T&D. At this time, the estimated costs associated with these programs over the next 5 years are approximately $8 million, and will become more refined as projects are further developed.

2.3 Future Initiatives

2.3.1 Systems Development

Also part of the T&D Transformation Project is the addition of a **Distribution Management System (DMS).** DMSs play a key role in managing automated distribution field hardware, or the telemetry and automated switching operations. The combination of a DMS and automated switching devices creates the potential for a self-configuring network.[15] The continuous feed of power flow data allows a DMS to provide functionality similar to what an Energy Management System provides on generation and transmission assets. In other words, a DMS is a tool to track dynamic loading (relative to maximum ratings) on all distribution assets to determine if alternative feeds are possible. Even without communication to automated switching devices in the field, this system can speed the determination of safe switch orders during an outage. In non-outage conditions, a DMS can identify feeders where phase imbalances exist and quantify the savings possible under various "what if" configuration changes, recommend seasonal switch changes to minimize energy loss and manage field hardware to enable conservation voltage reduction benefits. PGE is considering adding a DMS in the 2018-2020 timeframe. The ability

[11] This annual program to upgrade electromechanical protective relays on the transmission system with digital relays is on track for completion in the next 10 years.
[12] A program is underway to replace first generation substation automation systems beginning in 2013 with new Ethernet-based systems.
[13] A DMS would also be able to support this function.
[14] The required sensors also will increase visibility of the grid.
[15] Self-configuring networks will require a combination of intelligent learning control software, automated switching, real-time two-way communications with field hardware, and advanced monitoring capability with line voltage, VAR and frequency reactive assets, including distribution, generation and load.

to implement a DMS will be dependent on gaining the resources described in Appendix D. A cost estimate is not included as the project costs are still being developed and are largely outside the planning horizon.

PGE is also continuing its work with its Smart Meter vendor to implement a fault detection device that will communicate through the AMI network to help pinpoint fault locations. We expect this functionality, which should yield a significant improvement in SAIDI statistics, to be available within a five-year timeframe.

PGE plans to evaluate the merits of a future pilot program for a **T&D Smart Grid** (non-operational) **data server** to increase operational efficiency by providing the information needed for faster service restoration, accurate system modeling and improved asset maintenance. PGE is collecting a list of possible beneficial applications that depend on advanced data analytics. Our ability to pilot this application depends on gaining the resources described in Appendix D.

2.3.2 Electric Vehicles as a Grid Resource

Oregon already has the highest per capita number of EV charging stations in the United States. PGE expects 23,000 EVs in Oregon by 2020 and will work closely with EV manufacturers to prepare the market, establish standard communications protocols, as well as demonstrate smart charging, vehicle-to-home and second-life battery applications. Our goal is to have a majority of EV owners use smart charging techniques to manage their charging load. PGE expects to evaluate the following programs during the planning phase:

- **Timed Charging:** Timers in cars or charging stations would enable more off-peak charging.
- **Smart Charging:** Demand response technology would manage the charging process, signaling the cars or charging stations to adjust demand up and down in real time to optimize resource and system utilization.
- **Vehicle to Home:** The vehicle would provide back-up power to residential homes through outlets or a service-panel connection. This program could also use the EV battery to provide 'smart' power to the owner's home through a Home Energy Management System to maximize efficiency and cost-savings benefits and help integrate renewables.
- **Vehicle to Grid (V2G):** Discussions with EV manufacturers, and the current growth rate of EVs, suggest that V2G is a decade away. PGE plans to conduct RD&D projects during the interim and, as EVs attain critical mass, evaluate their use as an alternative to supply-side resources for ancillary services and renewables integration in PGE's IRP.
- **Second-Life Battery for Home or Grid:** As used EV batteries become available, PGE anticipates an opportunity to utilize them for electricity storage. This may take the form of home or small business-size storage for outage backup, EV charging support or other peak load buffering. Depending on battery availability, a pilot may be developed to demonstrate the viability of home and business-based storage as a cost-effective alternative to building supply-side resources for balancing renewable generation or meeting peak demand.

3. Customer Engagement

Customer engagement includes customer information and demand-side management Smart Grid initiatives. To advance customer engagement in the Smart Grid, utility outreach and customer education will be required. As with any new, behind-the-scenes technology, a significant effort will have to be made to raise customer awareness and lay the groundwork for customer engagement. PGE has successfully accomplished this in other arenas, with its customers leading the nation in embracing sustainable practices, such as energy efficiency, purchasing renewable power and driving electric or hybrid vehicles. We anticipate these values will be reflected in customer choices around Smart Grid products and services.

The PGE Smart Power[SM] umbrella is being used to help educate customers and communicate the benefits of our Smart Grid-related products and services. A critical education goal is to demystify the new options available as a result of the evolving grid to help customers, employees and other stakeholders understand how each fits into the larger picture of a Smart Grid and Oregon's energy future. For this reason, when PGE began rolling out Smart Meters in 2008, each customer was engaged through a well-researched comprehensive communications plan. Nevertheless, awareness remains low and communications efforts need to be intensified.

Even though more than 99 percent of PGE customers have Smart Meters, nearly three quarters aren't aware they have one.[16] However, when asked about Smart Meters, 83 percent of customers said they would be likely to use the information from Smart Meters to reduce their energy usage.[17] Though customer awareness remains low, 82 percent feel PGE should start work on the Smart Grid now — and work quickly to implement the technology, once the concept is explained to them.[18]

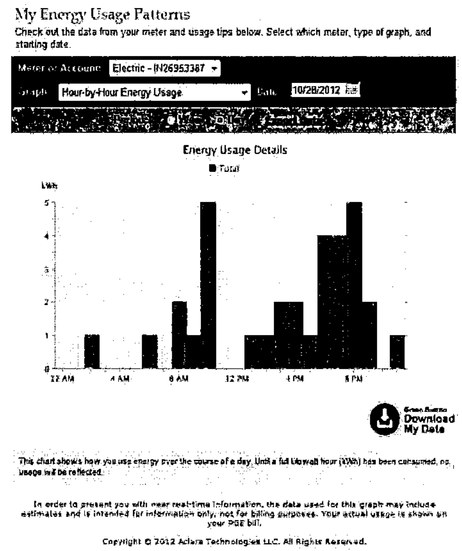
It will be PGE's role to:

- Supply customers with better information about their energy consumption to help them use electricity more efficiently,
- Offer pricing options that provide appropriate price signals that allow customers to realize the value of more efficient utility asset utilization, and
- Partner with customers to reduce their usage during critical system peaks.

Customer research and industry best practices are the cornerstones of PGE's Smart Grid awareness, education and engagement efforts. In the years to come, we will continue to analyze customer data, research and segmentation to match programs to customer needs and interests. We will also continue our active participation in organizations such as the Smart Grid Consumer Collaborative and Smart Grid Oregon.

[16] MSI E2 Research, 2013.
[17] MSI E2 Research, 2013.
[18] MSI E2 Research, 2013.

3.1 Work to Date



Providing customers timely information about their energy usage represents a major opportunity to enable behavioral changes that will save energy and reduce energy bills. For customers who want to actively manage their energy consumption, time of use pricing programs enabled by Smart Meters provide additional opportunities for bill savings.

3.1.1 Energy Tracker℠

Launched in December 2011, Energy Tracker℠ provides residential and general business customers access to their smart-meter data through their accounts on PortlandGeneral.com. Energy Tracker℠ provides:

- Daily and hourly energy usage charts,[19]
- Export of energy usage data via the Green Button for use with third party applications,[20]
- Data export for use with Excel,
- Billing insights that compare one billing period to another,[21]
- Savings tips that allow customers to create a profile, set a savings goal and receive tailored recommendations, and
- Direct links to ETO incentives for energy efficiency measures.

By offering customers this information, PGE is able to make strides toward its IRP goals by actively engaging customers in the wise and efficient use of energy. PGE hopes this information will empower customers to control their electricity bills by understanding when they are using power and looking into whether a demand response or pricing program might be right for them. More than 100,000 customers used the Energy Tracker tool since it was launched. Of those using the tool, sixty percent have looked at the suggested ways they can lower their power bill, and 58 percent have reviewed their energy-use charts to gain insights on their use patterns.

3.1.2 Pricing

PGE's pricing programs seek to provide customers another tool for controlling their electric bill. As the cost of energy varies over time, customers can shift their usage to hours that are lower price. In return, customers agree to pay higher prices during times when the demand for power

[19] Time of Use and Flex Price℠ customers see their data displayed according to their various pricing components.
[20] The Green Button is a White House Initiative by which utilities provide downloadable usage information in a standard format (XML) that customers can upload to the app provider of their choice.
[21] This feature helps customers problem solve on how things like overnight guests, new appliances, etc. impact their bill.

on the local grid is greater. PGE has two established pricing programs available to customers, and 68 percent of customers are aware of their availability:[22]

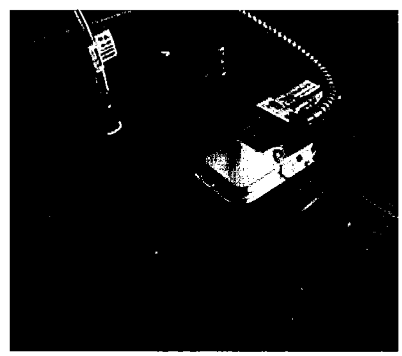
- **Commercial and Industrial Time-of-Day Pricing** (TOD) encourages customers to shift load based on price signals. In 2011, PGE's long-standing TOD tariff for Schedule 89 large non-residential customers was extended to Schedule 85. Consequently, TOD pricing expanded from customers exceeding 1,000 kW of monthly demand to all customers with more than 200 kW of monthly demand. PGE has proposed further expansion of TOD pricing to Schedule 83 customers in the current General Rate Case, opening the program to customers with monthly demand in excess of 30 kW.

- **Residential and Small Commercial Time-of-Use Pricing** is a voluntary program available to customers with up to 30kW of demand.[23] This program will have more potential with the expanded availability of interval data.

3.1.3 Demand Response

- **Firm Load Reduction Pilot for Commercial & Industrial**, a pilot launched in 2010, via tariff Schedule 77, is offered to PGE's large non-residential customers who are able to commit to a load reduction of at least 1 MW of demand at a single point of delivery. After providing the customer the required notice, PGE can initiate a four-hour load reduction event. To date, two customers have participated in this pilot, and they have demonstrated that load reductions of 17 MWs can be achieved with a high degree of reliability. These reductions are considered a resource available to mitigate the forecasted capacity shortfall identified in our IRP.

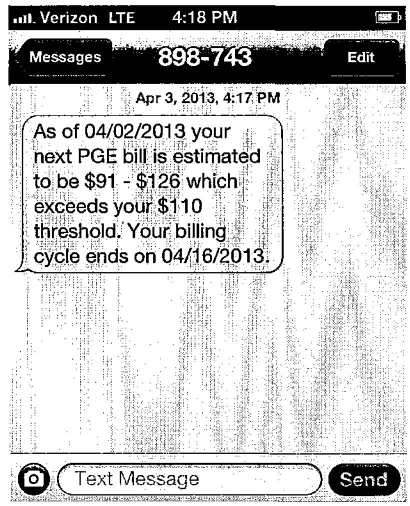
- **Residential Direct Load Control Pilots** are being conducted with 20 conventional water heaters as part of the Salem Smart Power Project (see Section 5.1.2). PGE is testing a new control strategy where water heaters are cycled frequently in response to the dynamic changes to wind generation. We will evaluate the power (kW) benefit of this method as well as whether customers are aware of the frequent cycling. The pilot has been operational since August 2012 and will continue through 2014. In 2013, automated and manual dispatch of these assets will be tested, using recommendations from a software-based feeder simulation that seeks to improve dispatch economics and improve system reliability in real-time, based on real-time grid and environmental conditions.[24]



[22] MSI E2 Research, 2013.
[23] The TOU program differs from TOD in that TOU pricing offers on-peak, mid-peak and off-peak rates.
[24] PGE dispatches the water heater control with a radio signal triggered by a transactive control price signal from SSPP through a "machine learning" software simulation.

3.2 Work in Progress

3.1.4 Energy TrackerSM Enhancements



Energy Tracker functionality is in the process of being expanded to allow customers the ability to sign up for usage alerts, which are a key component of customer engagement and education. These alerts rely on two new features – bill-to-date[25] and forecasted bill[26] information – all of which will be available on Portlandgeneral.com in the second half of 2013. Customers will be able to enroll for the following text or email alerts:

- A weekly alert on usage-to-date and forecasted bill.
- An alert that is triggered to come mid-billing cycle if the forecasted bill exceeds the customer's budget target.

PGE sees this functionality as having particular importance to low income and other cost-conscious customers. Development on these features is complete and is expected to be released in late 2013.

3.1.5 Flex PriceSM Pilot

This Critical Peak Pricing pilot was launched in November 2011 with 1,000 customers. The 2-year pilot was designed to send a price signal that encourages customers to conserve energy during times of system need. The program uses a dynamic pricing structure, based on Time-of-Use rates, to encourage peak-load reduction during times of unusually high demand. Under the tariff, PGE provides day-ahead notice to participants when a 'critical peak' event is expected. During the four-hour event, the customers' energy price is approximately four times higher than normal. Customer attrition has been higher than expected and will be factored into any future program design. PGE has secured a third-party evaluator to assess the pilot results and customer satisfaction with the Flex PriceSM Pilot's program design.[27] Final evaluation results will be available in the second quarter of 2014 and will guide the development of future Flex PriceSM program design.

3.1.6 Energy PartnerSM Programs

In the coming years, PGE plans to implement cost-effective demand response at levels sufficient to be considered a capacity resource in our IRP. We have a number of offerings under development as part of the Energy PartnerSM portfolio.

- **Smart Water Heaters.** PGE will initiate a small customer pilot in 2013 that uses a standard modular communication interface in a new type of "smart" water heater to

[25] This feature will be made available to residential and commercial customers in 2013. The system is not real time; it offers data that is a day behind.
[26] This feature will be made available to residential customers only in 2013.
[27] The full evaluation report is expected to be available in April 2014.

demonstrate simple peak load management.[28] The objective of this effort is to test a program offer with 100 of our 350,000 residential customers who have electric water heaters.[29] The goal of the program, if deployed system-wide, is to provide at least 100 MW of peak load reduction at a lower cost than building supply-side resources to meet capacity requirements.

- The **Energy Partner**[SM] Automated Demand Response Pilot will use automated controls to enable participating customers[30] to respond to event signals within 10 minutes.[31] In May 2013, PGE signed a contract with EnerNOC to provide at least 25 MW of firm capacity from customers with 30kW of demand or higher by December 2016. PGE will work with EnerNOC to begin calling events in August 2013. If the objectives of the pilot are met, the pilot will be transitioned into a program, the demand-response capacity of which would be treated as a firm resource, helping meet the forecasted capacity shortfall identified in our IRP and qualify as non-spinning reserves. If expanded, the program would represent an investment of up to $30 million for a cost-effective alternative to a supply-side capacity resource. A comprehensive evaluation of the pilot will be available in early 2016.

3.2 Future Initiatives

3.2.1 System Replacement

During the next five years, PGE will leverage its previous investment in the Smart Meter system as we continue our work towards a flexible platform for initiating programs. The Customer Engagement Transformation (CET) project is a set of initiatives that includes replacing PGE's Customer Information System (CIS) and Meter Data Management System (MDMS) with systems that can support the Smart Grid-enabled products and services PGE's customers' desires, and create efficiencies by automating manual processes. Although replacing these systems is part of planned vintage replacement, these applications will also enable the delivery of new distributed resources, pricing and demand-side programs to customers.

PGE's CIS and MDMS have been prudent investments for our customers. Put in place in 2002 and 2000, respectively, they will be more than 15 years old by the time they are obsolete and in need of replacement. While PGE is consistently improving service to customers with the tools we already have, these systems have high maintenance costs and are no longer supported by vendors. They also are not technically or functionally suited to existing programs such as billing for Net Metering, emerging Smart Grid requirements such as new pricing options, or programs such as prepaid metering. We believe that further enhancements and changes to existing systems will be costly and slow, leading to even more manual processes as the systems become more

[28] This communication approach has a much lower cost to implement and maintain than the established practice utilities have used for three decades. However, a scalable program depends on getting wide or universal adoption of the interface in new and replacement water heaters.
[29] In PGE's service area, these water heaters create a 280 MW demand on winter mornings, or a 210 MW demand every day at 6 p.m.
[30] Eligible participants will be a commercial or industrial customer who has an annual average peak demand of 30 kW or more.
[31] Lighting and heating, ventilation and air conditioning systems are expected to be the primary sources of load reduction.

aged and obsolete. While the need to replace the existing MDMS isn't as urgent as CIS, by implementing CIS and MDMS in parallel, PGE can integrate the systems to avoid additional costs and duplicative work.

To take advantage of the opportunities presented by new systems and to maximize the benefits of these new systems, PGE plans to take an integrated approach to the CET program by implementing people, process and technology initiatives. We have had considerable success using this approach with the implementation of two large systems already: AMI and Financial System Replacement Project. Similar to these projects, we expect that using this integrated approach with CET will provide benefits and reduce the overall cost of system replacement, although it is too early in the process to quantify these savings precisely.

3.2.2 Program Development

During the next five years, PGE will monitor and evaluate the following program areas and technologies to determine whether a pilot or full-scale deployment is warranted.

3.2.2.1 Green Button 2.0

PGE is a participant in the White House's Green Button initiative. Green Button 2.0 is an expansion of that program that would enable customers to automatically download and transfer their energy-use data on an ongoing basis to a third party. PGE expects to evaluate this option in 2014 and will consider Green Button usage trends in the decision to expand the availability of this program.

3.2.2.2 Pricing Programs

PGE will be taking a strategic look at which pricing options and models offer the most value to our customers and will identify the programs we intend to pursue in the 2014 update of this document. It should be noted that PGE is not currently planning to pursue a dynamic pricing model until the CIS & MDMS replacement is complete.

If pursued, dynamic pricing would be offered on a voluntary basis. Future offerings could combine pricing programs with smart appliances/thermostats and energy management systems to maximize customer benefits. If programs leverage enabling technologies, PGE will work with the ETO to ensure synergies with energy efficiency efforts are captured. At this time, PGE research with respect to leveraging enabling technologies in a pricing program shows that the majority of customers surveyed would not be willing to use these types of technologies or change their lifestyle.[32]

3.2.2.3 Prepaid Metering

With prepaid metering, customers can pay a set amount of money for their energy use upfront and deduct daily usage fees from the credit balance. Participating customers are provided frequent communications, alerting them to their remaining balance and how many days of service remain based on their current use rate. When the customer exhausts the credit balance,

[32] MSI E2 Research, 2013.

service is disconnected until additional payment is made. For budget-conscious customers, this program can be a valuable tool for managing energy spending. In addition, it gives participants a strong incentive to pay attention to their energy use.

PGE is monitoring the activities of utilities that have this program, including Salt River Project and Direct Energy, and those that are piloting it, including Arizona Public Service. Implementation of a prepaid metering pilot would not be pursued until CIS and MDMS replacement is complete.

3.2.2.4 Home Energy Monitors and In-Home Displays (IHD)

For customers who want to regularly check how much energy their home is using, a home energy monitor or IHD may be a good option. However, according to PGE research, most customers quickly lose interest in these tools, relegating them to the kitchen drawer. One program where IHDs do seem to provide enhanced customer value is in prepaid metering. Aside from possible use as part of a prepaid metering pilot, PGE is unlikely to offer IHDs without a significant improvement in the engagement model used by these tools.

PGE will continue to monitor the efforts of third-party providers in this space, such as Verizon, Comcast and Ceiva, and seek collaborative opportunities where appropriate. Demonstration of in-home display capability will be dependent on gaining the resources described in Appendix D.

3.2.2.5 HVAC Demand Response

Once PGE has successfully implemented a water-heater demand response program, the next major focus area will be smart HVAC systems. Previous bids by vendors to implement air conditioner control programs have not been cost-effective due to the high cost of enabling technology and the relatively low levels of usage in our service territory. However, new, customer-friendly, smart thermostats are emerging that may prove viable when both demand response and energy efficiency savings are taken into account. Should PGE pursue an HVAC demand response program, we will seek to engage with the ETO to make it a joint initiative.

To a large degree, future developments will be dependent upon customer acceptance. Several new smart thermostats are currently being demonstrated in California and Texas. We will track their progress in these markets. If demonstration projects are warranted, they will require an expanded RD&D budget as well as employees skilled at identifying and evaluating new technology to support PGE's Smart Grid initiatives. One such position is described in Appendix D.

4. Distributed & Renewable Resources

In many ways, Portland General Electric has led the industry in the integration of Distributed Generation (DG) into the electric grid. In 2000, we began creating a 'virtual power plant' through our DSG program that is both unique to the industry and is a great example of providing benefits to the grid. Looking forward, PGE will continue identifying and developing innovative programs to support customer interest in renewable resources and distributed generation. Toward this end, PGE is currently developing a Distributed Generation Strategy that we expect to incorporate into the 2014 update of this Report. As part of the Strategy, we have identified large-scale rooftop systems, and utility-scale projects that customers can purchase a share of their generation from, as some of the programs we are considering cultivating. We expect to be active in the development of standards and control systems that ensure that these installations become assets to grid rather than liabilities.

One liability associated with DG is that the output can be intermittent and unpredictable. With customer-owned solar photovoltaic (PV) systems rapidly proliferating, PGE must be prepared to address the challenge created by these systems intermittently injecting power at various points in the grid, causing voltage swings on the distribution lines as the output of these systems' fluctuate. PGE is experimenting with enhanced inverter functionality at its Salem Smart Power Project and its Baldock Solar Station to manage the voltage within an allowed operating range through dynamic reactive power control. The goal of this enhanced inverter functionality is to achieve fault ride-through capability, so that distributed PV generators contribute to grid stability during system disturbances instead of disconnecting and exacerbating the problem.

Beyond the distributed resources mentioned above, there are nascent technologies such as thermal and electric energy storage that could significantly impact PGE's Smart Grid efforts. For example, if EV batteries are available on a large enough scale, they could be utilized as a distributed power resource. This section of the report will address the development of distributed resources. Section 5 will address the control, management and interfaces required in the back office in order for system operators to effectively use these resources. The pace of development in these areas will be dependent on gaining the resources described in Appendix D.

4.1 Work to Date

4.1.1 Dispatchable Standby Generation (DSG)

This partnership between PGE and some of its larger customers that own on-site back-up power generators has proved to be a reliable, firm resource during the past decade and has filled a growing need for capacity resources in our IRP. PGE has 90 MW online and expects to reach 120 MW of DSG within the next five years. This resource is presently classified as non-spinning reserve power in our power dispatch hierarchy. Load control for all of PGE's distributed resources is provided by our proprietary DSG software (GenOnSys). Over the last 10 years, PGE has invested $26 million in DSG; we expect to invest an additional $12 million in the next 30 MW.

4.1.2 Solar Energy Grid Integration Systems (SEGIS)

Initiated in 2008, this project is a partnership between the U.S. Department of Energy (USDOE), Sandia National Laboratories, power equipment manufacturers, electric utilities and universities.[33] Its goal is the development of technologies required to facilitate the integration of high-penetration connections and large-scale solar PV power generation into the nation's grid. The USDOE provides the bulk of the project funding.

One focus of SEGIS is to remove the barriers to large-scale integration of PV and to enhance the value proposition of its energy by enabling it to act as if it were equivalent to a conventional utility power plant, as much as possible. To do so would require advanced inverters and controllers that go beyond conventional power electronics. However, if effective, this will make high-penetrations of PV not just acceptable, but more desirable to interconnected utilities.

Major successes to date include the demonstration of synchrophasor-enabled anti-islanding, VAR control, ramp-rate control, power factor control, and low-voltage ride through, and power management functions.

4.2 Work in Progress

4.2.1 SunShot Initiative

PGE is on one of the eight teams selected under the USDOE's SunShot Initiative for a SEGIS-Advanced Concepts grant in 2011.[34] The project tasks utility and solar experts with exploring solar shaping, i.e. the firming and shaping of solar PV power.[35] Over a three-year period the team will work to develop, demonstrate and commercialize the following:

- A storage pilot to map out and understand the economic cost/benefit of using storage to reduce the effects of cloud-induced transients, and determine the amount of storage required to make solar more compatible with conventional dispatchable resources.
- Synchrophasor-based island detection to provide the additional system protection that higher levels of intermittent generation sources require.
- The use of synchrophasors to protect and optimize feeders on the distribution network.

Effectively using renewable energy assets and implementation of Phasor Measurement Units (PMUs) [36] on the electrical grid will enhance reliability and could help regulate the flow of power, making instant reactions possible.[37] From the utility perspective, the developed

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[33] To date, the SEGIS program has been a 3-year program initiative that included conceptual design and market analysis (Stage 1), prototype development and testing (Stage 2), and movement towards actual commercialization (Stage 3).

[34] PGE is a sub-contractor to Advanced Energy of Bend, Oregon, as part of this award.

[35] Demonstrations of the solar shaping initiative are scheduled for 2014.

[36] PMUs are devices that produce precise time-stamped phasor measurements of current and voltage at a rate of 30 to 60 samples per second (far exceeding the rate of modern SCADA systems).

[37] PGE is in the process of installing five PMUs between its Canby substation and the Baldock Solar Station. These will be used in combination with a 500 kWh/500kW Li+ battery energy system scheduled for installation at Baldock in late 2013/early 2014 pending funding approval from both the USDOE and PGE's capital review process.

technologies allow for increased levels of solar PV across the distribution feeders due to better voltage support through local reactive power control. Transmission capacity is also improved by sourcing and synching VAR demand closer to the point of use, improving overall broad system efficiency through line loss reductions.

4.3 Future Initiatives

4.3.1 Thermal Storage

Because water heaters are a location of thermal storage, "smart" water heaters could be controlled under advanced applications to enable load and generation following by system operators. Additionally they can be controlled to shift some heating usage to take advantage of periods with lower priced energy. With additional research, development and demonstration work during the next five years, PGE hopes to demonstrate that aggregated water heater control can fill a need in our IRP that currently only power plants can meet (see Appendix B).

5. Smart Power^{SM}

The Smart Grid will evolve with software programming that will eventually rely on artificial intelligence code creation to create "learning systems" programs. As a result, the Smart Grid of the future will simply know more about grid performance and potential disturbances, making the system perform better and be more reliable. With the appropriate equipment automation, the Smart Grid of the future also will be able to head off, or self-correct, potential faults and failures.

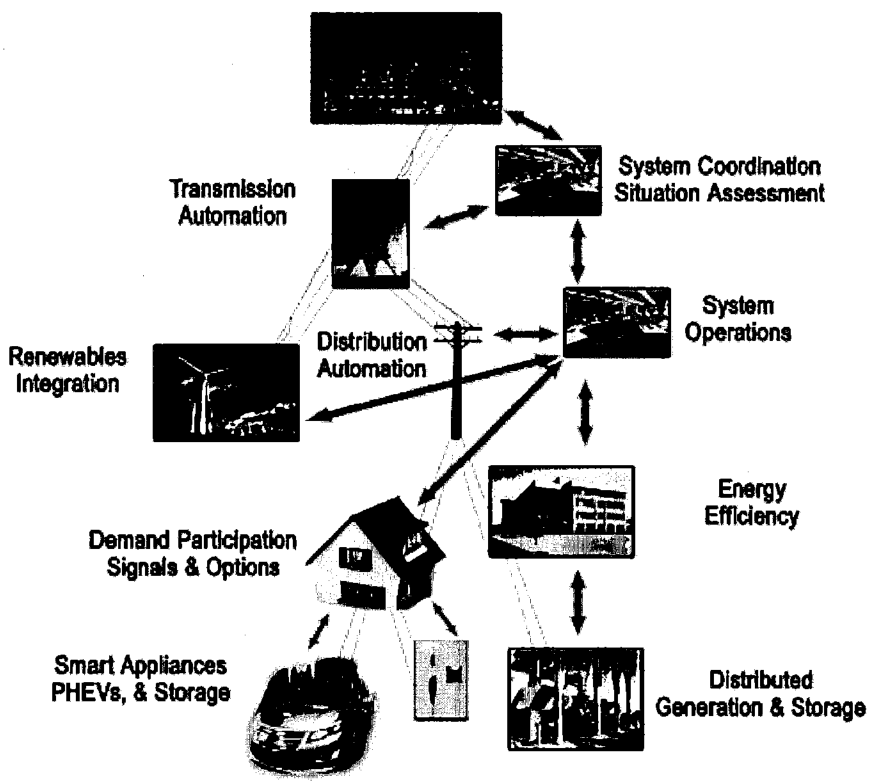
While the Smart Grid will evolve using a combination of existing and new programming languages and approaches, all control will eventually reside on a single platform that will be capable of absorbing, then synthesizing, large amounts of data and translating those into control functions on the grid. PGE has taken steps toward establishing just this type of system in our Smart Power^{SM} Platform. PGE has invested in this platform as part of the Salem Smart Power Project and expects to spend an additional $1 million over the next two years.

5.1 Work in Progress

5.1.1 Smart Power^{SM} Platform

The graphic below in Figure 1a shows the extent to which PGE's Smart Power^{SM} Platform will be active.

Figure 1a: Smart Grid Communications and Control Landscape



Future demand response and critical peak pricing programs, VAR support, firming and shaping of renewable power and integration of EV infrastructure will all be facilitated through a combination of our Smart Power[SM] Platform and the DSG system control software.

Figure 1b below provides a visual status of what has already been connected to this platform and what the future will hold.

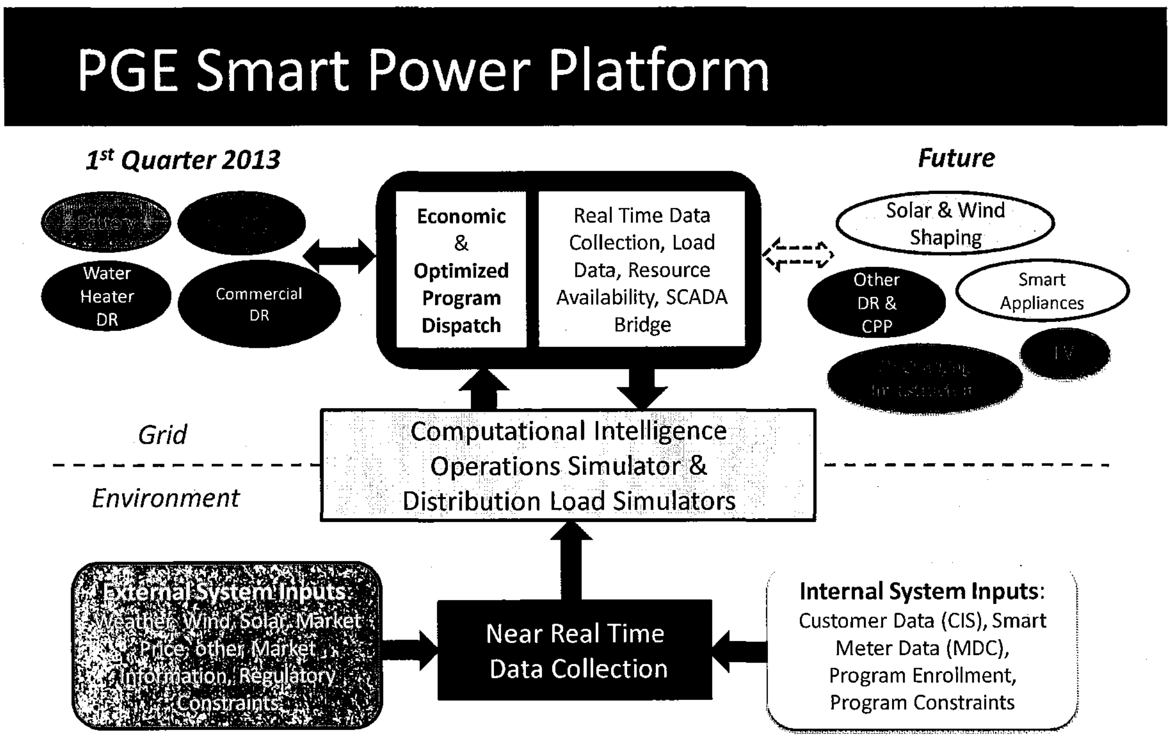


Figure 1b: PGE's Translation and Design of a Smart Power[SM] Platform

5.1.2 Salem Smart Power Project (SSPP)

The SSPP demonstration project is co-funded by the USDOE under the American Recovery and Reinvestment Act as part of the Pacific Northwest Smart Grid Demonstration. The primary contractor is Battelle, with PGE serving as a sub-contractor on the project. PGE has created substantial leverage through its approximately $6 million investment, which has been matched three-to-one by the USDOE and other partners. The project was formally initiated in 2010 and is expected to 'go live' in mid-2013; the next phase implements specific demonstration objectives for two years. At the end of the demonstration, portions of the project will continue to operate as part of PGE's T&D system. Routine usage over time should allow continued assessment of its value to system reliability and renewables integration.

Key features of the Salem Smart Power Project include the following, all of which are enabled by the Smart Power^{SM} Platform:

- **High Reliability/Microgrid:** Support the automatic isolation of a feeder segment from the grid with loads that can then be served with local DSG and the battery. In this condition, as long as there is fuel to power the six DSG generators, a microgrid is formed that can be operated independently of the PGE grid.
- **Automated Regional Coordination:** A substantial programmatic effort is built around the nascent concept of fully automated, regional coordination of power generation and price matching. PGE will use price as the basis for automated, transaction-based optimization of supply and demand.[38] Such an approach is especially attractive for improved integration of intermittent power resources such as wind and solar.
- **Self-Correcting Feeder:** A grid data sampling system will be used to rapidly detect a faulted portion of the service feeder and automatically isolate it from the grid with fast switching where possible. The unfaulted portion of the feeder could be automatically supported by the battery and, if needed, by DSG during longer outages, causing the customer to experience a minimal event versus a prolonged outage.
- **Storage:** An advanced Li-ion battery system (1,250 kW-hr, 5 MW) will provide uninterrupted power, reactive power (VAR support), power cost hedging and ancillary services.[39]
- **Demand Response**: A direct load control pilot of residential and commercial customer equipment demonstrates demand response capability.[40] (See Section 3.1.3)
- **Transforming Renewable Energy Assets into Dispatchable Energy Solutions:** The 5 MW battery can be configured for use as energy storage for small-scale ancillary services in firming and shaping intermittent resources, such as solar and wind generation. With sufficient advances, it is possible that PGE's Smart Power^{SM} Platform will be able to anticipate weather trends in order to better predict renewable generation.

5.2 Future Initiatives

Post-demonstration, PGE also expects to use the Smart Power^{SM} Platform to test new control methods that demonstrate storage as a potentially lower cost alternative to generation for renewables integration. Future work and the commercialization of this application will require in-depth evaluation (see position description in Appendix D).

[38] Leverage Battelle's Transactive Control System to demonstrate real-time solutions for regional power issues such as low/high wind, high/low prices for transmission-supplied power to regional distribution resources and regional congestion management.
[39] All of these services can be monetized for value to the system and PGE customers, depending on the application and the opportunity.
[40] The demand response program includes 20 residential water heaters and 51 commercial customers who have agreed to do a voluntary program where they will be urged to lower their power use for a set period of time.

6. General Business

6.1 Physical Security, Off-Normal Events

There is nothing "smart" about a grid if the poles and wires and/or other equipment are down or malfunctioning. In the face of uncertainty due to an increased magnitude and frequency of off-normal weather effects, it would benefit engineering design in the energy sector to attempt to factor in adaptable and adaptive approaches. In some events, this might mean traditional system or component hardening (for example, steel poles, undergrounding, improved anchoring and switch gear elevation in potentially flood-prone areas). It could also mean factoring in the advent and anticipation of more advanced Smart Grid designs and programming that make the energy supply system more robust, recoverable and self-correcting.

For electrical energy supply, transmission and distribution systems, there are now emerging designs that implement Smart Grid features allowing for rapid sectionalizing of power lines due to disturbances and/or to predicted faults. These designs, although nascent, could allow electrical infrastructure to remain relatively unchanged but simply operate with a higher degree of built-in "intelligence" and automation and this, in turn, provides some buffer to the effects of increased intensity and frequency of off-normal weather events.

Another form of adaptation would be to plan for and enfold combined energy infrastructure so as to provide back up and/or alternative resources should the primary infrastructure be lost. Thus, community or home batteries that are recharged locally with solar photovoltaic cells or distributed microgrids of the type being implemented at our Salem Smart Power Project could be viable responses or emergency alternatives to catastrophic or partial loss of the primary electrical grid.

6.2 Work in Progress

6.2.1 RD&D Demonstration funding

In order to build a Smart Grid of the future that results in a more reliable, sustainable electric power system and offers customers the products and services they need to manage their usage and get the most value for their energy dollar, PGE will need to invest in RD&D. In fact, most of the future initiatives described in this report depend on an expanded budget for RD&D, as well the resources described in Appendix D.

As part of its 2014 Test Year General Rate Case (UE 262) submission, PGE identified 19 specific RD&D opportunities in the Smart Grid or related space. Smart Grid projects account for nearly $1 million of PGE's proposed RD&D budget for 2014. A listing of Smart Grid projects and their associated costs can be found in Appendix C.

Several of these projects explore Smart Grid technology to mitigate the issues created with large amounts of renewable power on the distribution lines. Since these resources have variable output they present significant challenges to reliability and system operation. Addressing these issues effectively and safely will be critical to the region's ability to handle the large amount of distributed renewable resources we expect to bring into the system in the years ahead.

Other projects focus on software development to sense, monitor and control the grid in much greater detail and frequency as grid operations evolve. This is a fundamental Smart Grid need, because this software utilizes, synthesizes, interprets and reacts to the data available from our Smart Meters.

Many of these proposed projects are leveraged financially by working with government entities (Pacific Northwest National Laboratory, USDOE, and Oregon Department of Energy), other utilities and universities to sponsor shared RD&D. This means PGE contributes a fraction of the overall research costs but will receive the full benefit much earlier than we would if we did not contribute.

6.2.2 Cyber Security

The Smart Grid is designed to be more reliable, safe and secure than the traditional grid. However, the systems developed to monitor and automate grid operations could potentially be compromised, undermining the high-reliability objective. Several projects are underway to revamp PGE's internal networks to provide "secure-by-default infrastructure zones" designed to support critical control systems (for example, SCADA) and NERC CIP mandates.

These secure-by-default zones are designated in advance and positioned to support sensitive command and control systems, such as AMI, SCADA and DSG, in a consistent, unified, predictable, repeatable and automated fashion. While similar zones and security measures exist today, they are typically not implemented in the way Smart Grid interoperability demands.

By using a consistent architecture, technology footprint and management toolset, PGE can quickly and repeatedly respond to new vulnerabilities or threats. Since Smart Grid relies on the unified integration of many disparate systems operating in unison, this consistent approach to infrastructure, architecture and security is critical to the interoperability and flexibility necessary to adapt to changing uses of a Smart Grid.

During the next five years, PGE will pursue the following cyber security initiatives:

- Implement upgrades to AMI in support of advanced encryption management tools brought about from Sensus' partnership with IBM
- Reposition command and control systems in secure-by-default infrastructure zones
- Extend virtualization and virtualization security benefits to command and control systems
- Improve posture-assessment capability for remote access
- Implement CIP compliance for network systems and substation remote access
- Mitigate the impact of new NERC requirements (for example, CIPv5) to utility systems
- Implement technology to provide trusted computing environments within hardware systems

PGE already has infrastructure in place to safely support pilot initiatives, such as SSPP interoperability trials and automated demand response. PGE is well-positioned to apply the lessons learned from these implementations to future design patterns and system architecture templates across multiple data domains (see table below).

Cyber Security Efforts		
Domain	**Short Term**	**Long Term**
Transmission	• Remote Access enhancements • NERC CIPv5	Integration with AMI radio network
Distribution	• Mobility/Scheduling initiatives • SCADA implementation	
Operations	• NERC CIPv5 • Energy Management System Upgrades • Sensus/IBM encryption upgrades • Virtualization • Substation Remote Access	
Bulk Generation	• NERC CIPv5 • Consistent security controls	
Markets	• Application Programming Interfaces (APIs)	
Customer	• APIs/Privacy controls	Mobile Applications
Service Provider	• APIs	

6.2.3 Data Privacy

The Smart Grid encourages expanded use of data, which will require deeper coordination with customers in order to consider their individual privacy concerns. PGE's IT policy requires every system to classify the data within and to adhere to consistent handling requirements for that data. For example, data classified as confidential must be encrypted in transit and follow proper destruction procedures when no longer needed. [41]

PGE is considering projects that will allow customers detailed control over which external parties can gain access to their billing, usage or other data. This will make it easier for customers to enable publishing of their individual data to things such as mobile apps that monitor changes in account billing or apps that gather and compare usage data. In addition to the options presented through the PGE website, such as Energy Tracker[SM] and the Green Button, application programming interfaces have been proposed that would allow 3rd parties access to customer data through the detailed controls mentioned above. This would allow customers new choices over where their data goes, how they interact with it and how or if it is distributed.

[41] Confidential information includes social security number, driver's license number, credit card numbers or financial information.

As part of these and other projects, data privacy issues related to customer data will be addressed by answering the following questions:

- What customer data will be gathered and/or transferred, and to whom?
- Can part of the individual customer data be effectively masked, and is the identity/location of the customer of critical value to the recipient?
- Is a data-sharing agreement needed with the customer? If not, would it be wise to have one?
- Who will be responsible for evaluating and/or monitoring data protection efforts by 3rd parties receiving the data?
- Do opt-in or opt-out capabilities need to be offered for the data transfer and under what conditions?
- Who will be responsible for communicating the applicable privacy policy to customers and how?
- Who will be responsible for breaches of these policies and unauthorized access of the data that occurs as a result of these transfers?

6.3 Future Initiatives

6.3.1 IT Architecture for Advance Smart Grid Applications

As PGE implements its new enterprise system platforms described earlier and plans for future Smart Grid applications, we need to research and evaluate solutions that simplify system integration between existing systems as well as solutions that can reduce latency for time-sensitive solutions. Solutions such as data warehouses and cloud computing might be recommended if they can be cost justified.

6.3.2 Cyber Security

Longer term projects will involve migration to Internet Protocol (IP) Version 6, CIPv5 remediation, upgrades to encryption schemes, deployment of IP to traditionally non-IP environments, unified communications and further extending virtualization technologies where appropriate.

7. Summation

The transition to a smarter grid will be a significant challenge, involving not only leveraging new technology but introducing major changes in the way electricity is delivered and used. Arriving there will take time as the current Smart Grid-enabling technologies become mainstream, customers become effectively engaged, and for potential vulnerabilities, such as cyber security, to be addressed. Even so, the Smart Grid represents an unprecedented opportunity to transform the electrical system and the benefits customers receive from it.

Significant actions PGE intends to take during the next five years include:

- Replacing obsolete customer and distribution enterprise systems with modern systems that enable Smart Grid applications,
- Building on the capabilities of the AMI system to enable demand response and pricing programs to improve asset utilization and reduce the need for peaking resources in our IRP,
- Developing and enhancing customer services that build on the capabilities of the AMI system,
- Accelerating SCADA build-out to the remaining substations without this capability,
- Expanding RD&D efforts in support of Smart Grid applications and pilots.

PGE is committed to continued leadership in delivering Smart Grid benefits to our customers — safer, more reliable and more efficient service along with new products and services that better meet their needs and expectations.

Appendix A: AMI – Customer Benefits

In 2010, PGE completed its deployment of approximately 825,000 residential, commercial and industrial Smart Meters. With the implementation, we gained capabilities that include collection of interval data on all meters, remote connection functionality on about one-third of meters and the ability to remotely change the meter configuration, including firmware upgrades.

As a result of this Smart Grid project, $18 million in targeted operational benefits were achieved:

- **Cost of meter reading reduced:** PGE is network reading 98 percent of its meters, with plans in place to read virtually all meters by the end of 2013. The unit cost to read a meter went from $5.19 (manual) to $0.21 (network).

- **Detection of meter theft and broken meters:** PGE developed a Lost Revenue Portal, which uses alarms and data analytics to alert staff to possible theft and/or broken meters. In 2011, more than $5 million in protected revenue resulted from this system.

- **More effective handling of connection/disconnection practices:** PGE installed approximately 220,000 remote connect Smart Meters. Costs went from approximately $22 for a field connect/disconnect (direct labor costs), to less than $2; and customers are able to re-connect much quicker.

AMI deployment has also enabled a number of value-added customer services (for example, Energy Tracker℠) as well as new pricing options (for example, Flex Price℠).

Appendix B: Smart Appliances & Demand Response

The 350,000 residential water heaters in PGE's service area represent a system peak contribution of about 280 MW in winter mornings and 210 MW every day at 6 p.m. Between 80 and 90 percent of this peak could be avoided. All of this potential is economic; however, this potential cannot be developed without market transformation that requires regional cooperation. PGE has made **smart water heaters** its second scalable priority in demand response after our Energy Partner^{SM} Automated Demand Response pilot.

The economics of controlling smart appliances has greatly improved for several reasons:

- Unlike control switches used in the last 30 years, the new approach uses the control hardware already operating in the appliance. In the case of water heaters, the manufacturing cost at volume, to go from mechanical to electronic control, is about $15 per tank (versus $100 for the control switch).
- An electrician and city permit is not required to install the control device (or later to uninstall it). This represents a cost savings of more than $200.
- Because the appliance comes ready to communicate using a national standard, the cost of the electronic communication device that links the appliance to the utility will drop dramatically when consumers widely adopt Smart Grid control.[42]
- This approach resembles the plug and play approach used with computers and smart phones, providing a process customers can readily adopt. Consequently, program overhead costs will be considerably less per point of control.

Recognizing that smart appliances would greatly improve the economics and customer experience of residential DR, PGE has been a leader since 2006 in creating a national standard to enable this capability. PGE has received national recognition for its efforts from the GridWise® Architecture Council, the SGIP, and EPRI.

The choice of starting with water heaters instead of some other smart appliance, e.g. smart thermostats, is an easy choice for several reasons.. First, unlike the thermostat, the customer has almost no interaction with the water heater. Second, because the tank stores hot water, utility control of reheating the cold water at the bottom of the tank should be invisible to the customer. Finally, not only is simple peak demand mitigation possible, but storage also makes possible real time load control as a tool to compensate for the output that varies from renewable generation.

The business case requires that all water heaters sold in PGE's service territory arrive with the $15 incremental cost to make the water heater a smart water heater. During the next 15 years (the average life of a water heater), most customers will install a smart water heater and could choose to join the program any year once they become aware of its value. On the program side, even if only 20 percent of customers join the program during the 15-year period, the business case is still positive.

[42] Once participation reaches 100,000, the cost of communication devices will be less than $40.

To enable this resource, PGE is pursuing two efforts. The first is networking with regional stakeholders to "sell" the business case for incurring the needed $3.5 million per year to cover the incremental cost until market transformation has been achieved. This amount may sound high, but at a regional level, the resource potential is 2,200 MW, and it comes with the ability to shape 21,000 MWh every day to firm renewable resource output variation. The alternative generation resource would cost more than $2.5 billion, and it would produce more than 2 million tons of CO2 that can be avoided using smart water heaters.

The second effort is a series of increasingly large development efforts to build the program, the control and the communication infrastructure required to reach the water heaters. This effort will include working with EPRI and water heater manufacturers. In 2013, we hope to solve the technical challenges to launch a pilot with 100 PGE customers.

Appendix C: Proposed RD&D Smart Grid Projects

2014 Proposed RD&D Smart Grid Projects

Project Description	Project Cost
EPRI Targets: Battery, Demand Response & Distributed Energy Resources **Description:** By 2014, PGE expects to be in the position to engage EPRI in the research areas of energy storage via batteries, demand response and distributed energy resources on an integrated basis. It is also likely that PGE will be in a leadership role due to present aggressive R&D in these topical areas. **Benefits:** The advent of cheaper energy storage solutions as well as increased penetration of demand response and distributed energy resources would argue easily for PGE to participate with its peers in these areas of research and development cogent to the electrical utility industry.	$80,540
Second-Life Application – EV Batteries **Description:** This is an RD&D demonstration project to showcase the second-life use of a Nissan LEAF battery by placing it in a quick charger, tentatively planned at the World Trade Center. Nissan would provide the batteries, a quick charge manufacturer (e.g. Kanematsu) would be recruited to provide a quick charger (although there is a possibility of using a new Nissan quick charger). PGE would make the necessary arrangements for hosting the project and providing the necessary improvements to the electric infrastructure needed to support the demonstration. **Benefits:** It is currently estimated that as much as 80% of the vehicle battery life may remain for other uses and duty cycles. This project would test and demonstrate one such possible use. PGE and its customers will gain intelligence from data on second life use of Li-ion batteries systems that could be applied to demand response applications. Learning will lead to possible demonstration projects to get power to quick chargers in rural areas of the service territory.	$53,692
Vehicle to Home Concept (V2H) **Description:** The V2H system would enable energy stored in an EV battery to be used in residential homes; for example, the Nissan Leaf's 24 kW lithium-ion battery pack should be able to provide the typical household with enough electricity for up to two full days, when the battery is fully charged. This project proposes to devise and integrate a power control system that would be supplied by *Nichicon*. Nissan would modify a Leaf for the demonstration at	$67,115

their expense. **Benefits:** This project will help determine the effectiveness of an EV acting as a back-up power source in the event of a power outage or when needed to meet critical peak. The project also hopes to integrate time of use (TOU) price signaling capabilities for vehicle smart charging. It is anticipated that PGE would host and provide the host vehicle for the demonstration, as well as manage the project and evaluate it. PGE would also be responsible for developing the mechanism for communicating price signals. The learning from this project would be a first step in assessing feasibility of larger scale demonstrations.	
Load Control EV Charging Station Demonstration **Description:** This project would team PGE staff with an EV charging station manufacturer and software tool provider to develop a prototype that can control charging load in real time. **Benefits:** Two benefits would be explored: (1) the reduction of utility demand charges by controlling total EV charging load, and (2) the creation of a new demand response resource by controlling EV charging load. Researchers from PSU's Power Engineering Group would also support this effort by providing fundamental research and documentation.	$34,900
Green EV Charging Integration **Description:** This project would team PGE staff with Xatori or another application developer to demonstrate how customers can integrate their EV charging habits with their preference of using renewable power as a transportation fuel. **Benefits:** This project supports the larger EV vision of powering transportation using electricity generated from a PGE power generation mix that is becoming increasingly renewable in its character.	$13,425
Home Battery Backup Demonstration **Description:** This project seeks to demonstrate an AQUION (NaMnO2), 25 kWhr (about 7 or 8 kW) battery for home installation on a manual switch on/off basis in order to test the new chemistry type in the battery and to understand the basic electrical problems (NEC) that may evolve, performance, durability (supposedly 20 years), customer acceptance and feedback. **Benefits:** More community based energy sources are emerging that are closely related to distributed sources of power generation, energy storage and even	$53,700

leveraging existing infrastructure for energy efficiency or generation purposes (e.g., water pipe turbines, ground source or groundwater source or water main heat exchange for heat pump technology). This is a very stable battery capable of operating with a wide voltage range; in conjunction with the battery an appropriate inverter will also need to be tested to assess whether the system can live up to its billing.	
Demonstrating a Battery Buffered, Solar & Wind Charging Station **Description:** This project would retrofit the OMSI EV charging site with a battery buffered DC Quick Charging station. The battery would utilize wind and solar power as its primary charging sources. **Benefits:** The demonstration would be unique in the Pacific NW and it is intended to couple the demonstration with exhibit-quality display panels that would indicate when the battery is charging with wind power or with solar power, in addition to showing the automobile charging cycle.	$34,900
Inductive Charging Demonstration **Description:** This project would demonstrate inductive charging at three potential sites: (1) with a PGE fleet car, (2) with a public transit vehicle (such as one of the parking shuttle vans at the Portland International Airport) and (3) with an electric forklift truck. **Benefits:** This broad array of demonstrations would allow users to see and evaluate the potential and any concerns around the inductive charging approach.	$32,315
Single Phase DC Quick Charging Station Demonstration **Description:** This project would utilize battery storage to enable a DC Quick Charger to operate where only single-phase power is available. Currently, all DC Quick Charging equipment requires three-phase power. **Benefits:** This project would demonstrate the potential to "fill in the gaps" in outlying areas of the grid that are, nonetheless, popular travel routes.	$26,850
Evaluative Metrics and Verification for Transactive Control Architecture **Description:** PGE has evolved substantial capacity in the development of Transactive Node (TN) Control Architecture in support of learning systems (computational intelligence) that optimize load and cost between an energy provider and an energy user. Nonetheless, there are many aspects that bear continued refinement including assessing and specifying conditions where it is	$34,900

safe to operate a section of a distribution system under TN control. **Benefits:** Further exploitation of other data inputs to the transaction are possible and even desirable such as including important environmental factors like temperature, irradiance, wind. This project addresses these and other developmental questions in partnership with Portland State University's Power Engineering group. Evaluative metrics still need development in order to assess whether the Transactive Node software actually delivered optimized economic dispatch.	
Inverter Usage and Grid Interaction with Increased PV Penetration **Description:** As solar PV continues to increase, the associated power inverters will have a more prominent interaction with the electrical grid. This project assesses the types of functions that inverters must begin to assume beyond power conversion in order to best facilitate continued high penetration of photovoltaics. For example, can inverters be designed to serve as distribution-scale static synchronous compensators (STATCOM) providing power quality and volt/VAR services? **Benefits:** Establishment of more clustered solar Photovoltaic installations lends some urgency to improve both PGE's understanding of the role of inverters and, to the extent possible - to assess abilities to exploit their presence for other uses on the grid and to improve the reliability of the grid itself. Much of this work will be done in collaboration with the Portland State University Power Engineering Group. Solar power penetration in a distributed format is expected to increase with attendant grid integration concerns; this research helps PGE better understand how to optimally accommodate this future.	$32,215
Educational Program for In-Home Display w/ Energy Tracker **Description:** The project seeks to develop and pilot a programed learning guide/tool aimed at 5^{th} graders but administered by the grade science teacher with PGE support. In-home display would be added to the homes of students (of one class). The programmed learning guide would have simple exercises that use both energy tracker and the in-home display over a period of about 3 weeks. Goal would be a "report" at the end of the exercise that itemizes how the home uses energy and its cost; also the list of the top ten devices that use the most power when operating. **Benefits:** The overall benefits would be to derive a curriculum that teaches students the difference between power and energy as well as value (benefit minus cost) of energy used in the home. As smart grid technologies penetrate to the home or commercial space even beyond a Smart Meter it would be desirable to assess how these can be integrated more fully and optimally into	$64,400

PGE's grid operation even at the consumer level. Acceptance of these technologies and penetration will depend to some (if not large) degree on consumer and user education regarding the benefits and costs.	
<u>Oxford Substation – Rural Feeder Distribution Automation</u> **<u>Description</u>:** Five automatic switches have been installed on the Rural Feeder with funding from the SSPP which used highly leveraged funding from a USDOE Stimulus grant. These switches will be used in commissioning, testing and start-up of the energy storage system. The switches are S&C Intellirupter switches and are unique in that they have a high level of functionality. If used solely for the Salem Smart Power Project, these switches will be underutilized. This project proposes to utilize these switches at a higher level functionality for distribution automation. **<u>Benefits</u>:** This project anticipates growth of Smart Grid systems and integration components with renewable power and distribution systems; it supports efficient operations through increased reliability on PGE's Rural Feeder (SAIFI, SAIDI); faster outage recovery and safer operations for line crews. Not utilizing these switches will delay PGE's understanding of an important Smart Grid feature, i.e., "rapid fault detection and line sectionalizing" as a prelude to self-healing.	$59,060
<u>Street Light PV Integrated into Salem Smart Power Center</u> **<u>Description</u>:** This project proposes to install 30 street light micro-inverter solar panels in the Salem Smart Power Project feeder region or an equivalent capacity. The demonstration is a component of PGE's commitment to better integrating smart grid and renewable energy opportunities. The plan presently includes installation of 30 Petra Solar streetlight panels and micro-inverters in the Salem Smart Feeder region. Data integration is from IEEE 802.15.4 compliant communications to the evolving PGE Smart Power Platform and will allow remote configuration via substation. **<u>Benefits</u>:** The project will provide regional grid voltage measurement for data collection and forecasting needs through use of synchrophasor technology. Also, it provides additional resources for managing reactive power at the distribution layer.	$75,168
<u>Smart Power Platform "Sonification of Electric Usage"</u> **<u>Description</u>:** Sonification is a proven technology for signal processing from raw data into audible music. Recent successes in the UK and at US universities have demonstrated transformation of electrical usage patterns into an audible waveform (not 60 Hz buzz – but real music). This project seeks to investigate	$44,564

changing a customer's real-time energy usage into a novel musical format which is customizable for a customer's musical interests. Data will be collected in real-time from a home energy management system and transformed via an application into music. It is well known that many customers are not "in tune" with their own usage, and the electric bill is not a sufficient channel to maintain customer interest in usage metrics. This project would explore methods and complete a prototype system. In detail, the project would acquire one energy home management system and connect it to a workstation computer and an electrical device (a fan is sufficient) with a usage meter at the plug. An application would be developed in collaboration with university researchers to sonify the real- time electrical signal into a custom-configurable musical work. **Benefits:** This project seeks to understand whether there is a benefit of linking the customer to their own usage in a new way that may prove both unique and exciting as a form of customer outreach and for keeping interest in electrical usage data on a daily basis. It is well accepted that the last frontier of successful energy efficiency programming will require human behavior engagement. Sonification is akin to other behavioral efforts (e.g., game playing) to get past this boundary.	
Smart Power Synchrophasor Reliability & Fast Command System **Description:** This project would add Synchrophasor system components to PGE"s Salem Smart Power feeder system and Smart Power Platform supervisory distributed resource controller. Synchrophasor measurement systems are a proven method for increasing system reliability; performing distributed power factor regulation for system efficiency and financial benefits; improving distribution automation to reduce SAIDI and SAIFI and to improve safety, efficiency and customer relations; the system would further integration of smart grid onto PGE's grid. The project plan includes the purchase and installation of three (3) phase measurement units (PMU's) at strategic locations on the feeder. Concurrently there would be the purchase and installation of SEL Synchrowave software to gather phase measurement data from the PMU's to help make economic and operating decisions; finally, the collected data will be integrated into PGE's nascent Smart Power^{SM} Platform for informing PGE's Smart Power^{SM} supervisory control system of real-time feeder data via fast messaging, including real power, voltage, frequency, and phasor measurements. **Benefits:** The project will also investigate and research best methods of transforming the data into actionable commands to increase reliability and efficiency, within the Smart Power^{SM} Platform controller. Achieving this level of highly automated data acquisition and response will allow PGE to begin exploring the concept of grid "self-healing" on a sizable feeder line. The SSPP is a highly leveraged (financially) demonstration. Adding advanced grid monitoring via synchrophasors permits a natural evolution for the concept of	$91,280

"self-healing" grid and in this case at a significant level of scale.	
Big Data Analytics Project **Description:** This project seeks to develop a collaborative partnership between PGE and a major player in the emerging 'Big Data' space (e.g. GE, IBM). This project will help demonstrate the usefulness of big data analytic capabilities in improving system planning and reliability, outage restoration, and other operational features. New analytic structures will be required in order to be responsive and proactive to increasing penetration of smart grid concepts into PGE's system. **Benefits:** It is envisioned that PGE would learn about efficient data analytics and how they could be a useful tool to examine and understand large amounts of data quickly to make effective business and operational decisions on behalf of its customers. This would be particularly true in the use of very short time interval data. The project envisions that a 'Big Data' provider/integrator would partner with PGE on a trial demonstration project requiring access to PGE's systems and staff resources for ongoing implementation and demonstrations.	$80,538
Home Communicating Thermostat Demonstration **Description:** This project works with a Programmable Communicating T-Stat (PCT – aka "Smart Thermostat"). The goal is to research available models; pilot 2 to 3 in actual home usage for demonstration. **Benefits:** As part of the demonstration the project will filter the selected model(s) so as to be compatible with PGE's smart meter and or other network communications pathways that PGE ultimately uses. As smart grid technologies penetrate to the home or commercial space even beyond a Smart Meter it would be desirable to assess how these can be integrated more fully and optimally into PGE's grid operation even at the consumer level.	$42,954
SEGIS-AC (Solar Energy and Smart Grid Integrated System – Advanced Concepts) **Description:** This project is focused on creating cost-effective technologies to mitigate potential grid reliability issues associated with solar installations. This includes testing both distribution and transmission level voltage impacts mitigation through use of a 500 kW battery. SEGIS-AC aims to showcase technologies that use advanced voltage control functions developed in compliance with the EPRI Smart Inverter Initiative. Advanced Energy (Bend, OR) is the lead project manager partnering with PGE and others. PGE is in	$42,950

discussions with Saft Batteries, LG Chem, Panasonic, Samsung and Mitsubishi Heavy Industries to potentially be the battery supplier on this project. **Benefits:** The project is predominantly funded by the US DOE SunShot Initiative Project which provides funding over a three year cycle. PGE would be responsible for 20% of the 2014 funds and 50% of capital cost sharing. PGE labor resources will be utilized over the span of the project through project management and ongoing interactions with Advanced Energy, the battery supplier, etc. Success in the project will help further help develop, demonstrate and commercialize load ramp control and solar smoothing through energy storage, islanding detection and system protection, and distributed automation using synchrophasor technologies.	
Total Smart Grid Projects	$965,466

Appendix D: Staffing & Resource Requirements

It is PGE's view that accommodating a future with embedded Smart Grid features justifies additional resources to help bring this potential to fruition cost-effectively and safely. Five full-time equivalent employees are needed. Necessary analysis and research requires in-house engineers and analysts who have advanced skill sets in technologies and a comprehensive understanding of PGE data systems, including AMI, GIS, OMS, marketing and other mass data support.

Building on what we already have and know: The first FTE would be responsible for sophisticated statistical analyses of voltage, energy and outage data from PGE's AMI and SCADA systems in order to proactively identify where O&M savings can be achieved through creation of specific Smart Grid actions. This position will collect business requirements for advanced data analytics and then work with IT as it develops software architecture to integrate Smart Grid data features.

Understanding and anticipating emerging standards: The second FTE would support analysis and integration of emerging standards based on demand-response programming found in smart appliances emerging in the marketplace. This expertise is needed to review and recommend equipment suitable for future programs. This position also works to create requirements for vendors and IT in order to minimize customer-experience problems.

Developing and getting the software right: The third FTE would be a full-time lead within the business model development group. This position will work with program managers to define IT system requirements for new software applications (both purchased and built internally) to support data analytics as well as manage demand response and distributed generation. This position will also serve as a resource during the Customer Systems Application Architecture and Vendor Selection process for potential large customer system replacements to ensure integration of Smart Grid features in these transitions.

Developing cost-effective business cases: The fourth FTE would be an engineering position to provide project management support and engineering liaison to field trials, research emerging technology and provide reporting to PGE management and OPUC. These reports would include early economics evaluation for business-case development work.

Deploying cost-effective Smart Grid technology: The fifth FTE will be in PGE's distribution area. This will be an engineering position that will help identify desirable distribution technology to support PGE's Smart Grid initiatives. The position also will design and recommend field trials as required. Finally, it will help develop business cases for field technology as part of major Smart Grid deployments.

Summary of Needed Staffing Resources to Explore and Deploy Smart Grid

There is little question that over time, PGE's grid will evolve to be more intelligent, automated and responsive. Even a casual review of analogous situations such as the advent of multi-featured smart phones and increasingly smart homes/buildings and even cars makes this more than just wishful thinking. PGE anticipates this outcome and wants to be well-prepared and thoughtful in welcoming such a future.

There is some sense of urgency. For example, as smart appliances begin making their debut onto the retail floor of stores, our customers and engineers will ask how these devices can or should interact programmatically with the PGE grid. Resolution of this one opportunity alone is not a trivial piece of work and certainly not one that can be addressed quickly in a matter of days or months. In some respects, this is reminiscent of when the first solar photovoltaic panels were being installed on rooftops in our service territory and our engineers were being asked by municipal inspectors what PGE's standards were for safe installation and operation of these new, substantial power-generating devices. In the same way, questions will soon be coming to PGE asking for guidelines and standards on how to integrate Smart Grid technologies, and we need to have both the answers and resources in place to respond.

Appendix E: Conservation Voltage Reduction

Background: PGE has completed a feasibility study to assess the technical potential for CVR savings on the Denny and Hogan South substations, which are considered representative of our urban substations. The objectives of the study were to:

- Determine the viability of implementing CVR without incurring power quality issues.
- Quantify the relationship between operating voltage and power demand.
- Evaluate how and where to implement a pilot project.

Methodology: Constant Implementation and Peak Shaving are two methods of implementing CVR. Energy consumption reduction is greater for Constant Implementation while Peak Shaving is preferred for peak demand management. Peak Shaving was judged to have greater potential for PGE's system and was tested in the feasibility study.

The PowerFlow model (CYME) was used to evaluate power flows under four load profiles: Heavy Winter, Light Winter, Heavy Summer and Light Summer. The study base case utilized feeder models that were balanced, and included the addition of strategically placed fixed capacitor banks, their location determined via simulation of the Light Winter load condition.

Results: CVR implementation was found to be sufficiently effective for peak load reduction during heavy winter peak load conditions to warrant moving ahead with a pilot project. The feasibility study also concluded that benefits will not be fully realized without substation-wide feeder balancing and strategic capacitor placement.

Next Steps: A pilot project to implement CVR as a peak shaving tool will commence in the 3rd quarter of 2013. Results from the pilot will be used to estimate peak demand reduction at substations with characteristics similar to those of Denny and Hogan South and project system-wide savings.

CERTIFICATE OF SERVICE

I hereby certify that I have this day caused **PORTLAND GENERAL ELECTRIC COMPANY'S ANNUAL SMART GRID REPORT** to be served by electronic mail to those parties whose email addresses appear on the attached service list for OPUC Docket No. UM 1460/UE 262/LC 56.

DATED at Portland, Oregon, this 31st day of May, 2013.

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