BEFORE THE PUBLIC UTILITY COMMISSION

OF THE STATE OF OREGON

UE 319

Corporate Support

PORTLAND GENERAL ELECTRIC COMPANY

Direct Testimony and Exhibits of

Jim Lobdell
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I. Introduction

Q. Please state your names and positions with Portland General Electric (PGE).

A. My name is Jim Lobdell. I am the Senior Vice President, Finance, Chief Financial Officer, and Treasurer at PGE. My qualifications appear at the end of PGE Exhibit 100.

My name is Alex Tooman. I am a Project Manager for PGE. My qualifications appear at the end of PGE Exhibit 200.

Q. What is the purpose of your testimony?

A. We explain PGE's request for $172.1 million in administrative and general (A&G) costs in 2018 and compare it to 2016 actuals of $170.9 million.

Q. What functions are classified as A&G and what are the costs of those functions?

A. We classify as A&G those functions that support PGE's direct operations to deliver electric power to customers, such as human resources, accounting and finance, insurance, contract services and purchasing, corporate security, regulatory affairs, legal services, and information technology (IT). We also include other costs such as employee benefits and incentives, support services, and regulatory fees that fall within the FERC definition of A&G.[1] PGE Exhibit 601 provides a list of A&G functions plus a summary of costs and full time equivalent (FTE) employees for 2014 (actuals) through 2018 (test year forecast). Table 1 below summarizes the major A&G costs by functional area.

[1] FERC defines administrative and general expenses as those that fall within FERC accounts 920 through 935.

Table 1
A&G Costs by Major Functional Area ($ millions)

Major Functional Areas	2016 Actuals	2018 Forecast	Delta*
Facilities	$5.5	$7.0	$1.5
Accounting/Finance/Tax	$9.9	$11.3	$1.4
HR/Employee Support	$9.8	$13.4	$3.6
Insurance, Injuries and Damages, etc.	$11.5	$12.2	$0.8
Legal	$10.0	$5.4	($4.6)
Regulatory Affairs/Compliance	$2.6	$3.4	$0.8
Corporate Governance	$4.6	$5.4	$0.8
Business Support Services	$2.4	$2.8	$0.3
Environmental Programs	$4.4	$2.2	($2.1)
Corporate R&D	$2.0	$3.0	$1.0
Contract Services/Purchasing	$1.4	$1.4	$0.0
Security and Business Continuity	$2.2	$2.9	$0.7
Corp Communications/Public Affairs	$2.2	$2.4	$0.2
Load Research	$0.1	$0.0	($0.1)
Hydro Licensing	$0.1	$0.1	$0.0
Performance Management	$1.3	$2.1	$0.8
Governmental Affairs	$1.2	$1.2	$0.0
Total for Major Functional Areas*	**$71.0**	**$76.3**	**$5.2**
IT: Direct and Allocated	$12.1	$13.4	$1.3
Labor Cost Adjustment	$0.0	($3.6)	($3.6)
Membership Costs	$3.1	$3.6	$0.5
Incentive Plans (net of capital allocations)	$21.6	$12.6	($9.0)
Severance	$1.6	$1.3	($0.3)
Regulatory Fees	$6.7	$8.7	$2.0
General Plant Maintenance	$2.6	$2.9	$0.3
Net PTO	$4.4	$6.3	$2.0
Net Loadings	$0.0	$0.0	$0.0
Benefits (net of capital allocations)	$51.8	$57.7	$5.9
Corporate Allocations	($5.7)	($8.7)	($3.0)
Revolver Fees, Margin Net Int., Broker Fees	$1.9	$1.8	($0.1)
Total Other A&G Costs*	**$99.9**	**$95.8**	**($4.1)**
Total A&G*	**$170.9**	**$172.1**	**$1.2**

** May not sum due to rounding.*

Q. What are the primary drivers for the increase in A&G costs from 2016 to 2018?

A. Most of the increases in A&G costs from 2016 to 2018 are attributable to three primary drivers: 1) Benefits, as discussed in PGE Exhibit 400, are largely driven by health care costs. 2) Security and emergency management, driven by the growing recognition of the potential for detrimental events and PGE's and our regulating bodies increasing emphasis on protecting critical energy infrastructure. 3) Human Resources, driven by PGE's continued efforts to reduce workplace injuries and move to best in class in workplace safety, along with increased demands on PGE's staffing and training departments. While we can and do actively manage costs associated with these drivers, they are, to some extent, external to PGE and reflect larger market conditions and/or regulatory requirements beyond our control.

Q. Will you be discussing any additional A&G related items?

A. Yes. In addition to the drivers highlighted above, we will discuss the following:

- Costs associated with PGE's corporate research and development (R&D) activities;
- Increasing membership costs for PGE's participation in the Western Electricity Coordinating Council (WECC) and the Northern Tier Transmission Group;
- Increases in labor and outside services for Accounting and Finance Services;
- The current insurance environment, as prudent insurance coverage is integral to PGE's operations; and
- PGE's forecast of A&G related environmental costs and their relationship to PGE's pending Environmental Remediation Costs Recovery Adjustment, PGE Tariff Schedule 149, (Docket No. UM 1789).

Q. How is the remainder of your testimony organized?

A. After this section, we have four sections:

- Section II: Primary A&G Cost Increases;
- Section III: Other Items;
- Section IV: Environmental and Licensing Services; and
- Section V: Summary.

II. Primary A&G Cost Increases

A. Benefits

Q. By how much do you forecast benefit costs to increase from 2016 to 2018?

A. The increase in net benefit costs from 2016 to 2018 is approximately $5.9 million. These costs include such items as health and dental plans, 401(k) plan, pension costs, and employee life and disability insurance.

Q. What accounts for this increase?

A. The primary driver of the increase in benefit costs is health-care costs, which reflect inflation and other cost pressures. PGE Exhibit 400 explains in greater detail how the compensation and benefits-related costs are affected by these increases and how PGE must address them to remain competitive in a market for specialized and qualified labor. Please note that the benefit amounts in Table 1 above represent the "net" changes within A&G.[2] PGE Exhibit 400 explains the gross corporate forecast for these costs.

B. Security and Emergency Management

Q. Please explain the cost increase for Business Continuity and Emergency Management (BCEM) and Security.

A. PGE's costs for BCEM are forecasted to increase from approximately $0.8 million to $1.2 million from 2016 to 2018, while security costs are expected to increase from approximately $1.4 million to $1.7 million over the same period. As discussed in PGE's 2016 general rate case (UE 294, Exhibit 600), the projected increase to BCEM costs is based on the continued development and completion of a BCEM roadmap. The roadmap establishes the activities PGE needs to perform to achieve a target level of regional

[2] Net A&G refers to the amount remaining in A&G after labor loadings apply certain amounts of these costs to capital projects, service providers, and "below-the-line" activities.

preparedness and resilience among PGE's primary departments/systems. The increase to security costs is due largely to increasing regulation and the expanding footprint of PGE's physical locations.

Q. What is the history and purpose of the BCEM department?

A. PGE established the BCEM department in 2007 to strengthen capacities and capabilities for the preparation, mitigation and response to significant emergency incidents that may adversely affect service to customers, company assets, and employees. This includes providing planning, training and exercise support to recover critical functions as quickly as possible, in compliance with all regulatory requirements. This department establishes business continuity and emergency management plans and procedures; conducts risk and business impact assessments; develops training programs and materials; and establishes and operates emergency operations center functions and facilities needed to effectively prepare for, respond to, and recover from, a variety of emergency incidents.

Q. You stated that PGE needs to meet a "target level of resilience". Please explain.

A. Resilience is the ability of a department to quickly restore its performance to an operational level after some form of detrimental event. By detrimental event, we are referring to natural events (e.g., major earthquake or flood), technological events (e.g., a significant system or plant failure due to mechanical or physical issues), or man-made (accidental or intentional) events (e.g., a successful cyber-attack or act of terrorism). In order to evaluate a department's resilience, the BCEM roadmap establishes a timeline for each primary department/system to undergo the following cycle:

- Develop plans to restore operations;
- Train employees on restoration procedures;

- Perform exercises to test employees; and
- Evaluate performance.

Once established, this cycle is an annual mechanism that will continue to strengthen PGE's capacities and capabilities for emergency response.

Q. Has PGE expanded its corporate resiliency and emergency preparedness efforts?

A. Yes. Through 2014, BCEM operated with only four or less FTEs (with approximately two of these FTEs for support and administration). This limited the number of areas within PGE that BCEM was able to support with its full range of duties. As the awareness of and potential for detrimental events continue to increase, PGE continues to expand its BCEM efforts. To this end, we hired three additional FTEs between 2015 and 2016 to help with the company-wide implementation of key initiatives established in the BCEM roadmap. For 2017 and 2018, BCEM is increasing outside services support in order to continue our efforts in meeting the annual elements identified within the roadmap's timeline. This effort is also based in part on The Oregon Resilience Plan,[3] which recommends that "Energy sector companies should institutionalize long-term seismic mitigation programs and should work with the appropriate oversight authority to further improve the resilience and operational reliability of their Critical Energy Infrastructure (CEI) facilities" (page 175).[4]

Q. What are some recent activities in which PGE's BCEM department has been involved to further PGE's corporate resiliency and emergency preparedness?

A. PGE was very active during 2016 in efforts to assess our corporate resiliency and emergency responsiveness to a Cascadia Subduction Zone earthquake and tsunami. In particular, PGE

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[3] Issued by the Oregon Seismic Safety Policy Advisory Commission to the Oregon State Legislature in February 2013.
[4] The Oregon Resilience Plan is available at:
http://www.oregon.gov/OMD/OEM/osspac/docs/Oregon_Resilience_Plan_Final.pdf

participated in the U.S. Department of Energy's Clear Path IV exercise and closely followed the region-wide Cascadia Rising 2016 functional exercise. Based on these exercises, the BCEM team plans to expand its core planning related to regional disasters, with improvements to fueling, staging and communications.

Q. Please describe the reasons for increasing security costs.

A. PGE's security costs are increasing due primarily to the expanding footprint of PGE's system and the addition of new regulations affecting some of PGE's substations. Recent and upcoming additions to PGE's footprint include two new plants at the end of 2014, Carty in 2016, and a number of smaller substation projects that will be completed over the next one to two years. Additionally, Critical Infrastructure Protection regulation 014-1 (CIP-14) has directed PGE to employ higher security measures at several of its transmission substations that "if rendered inoperable or damaged as a result of a physical attack could result in widespread instability, uncontrolled separation, or Cascading within an Interconnection."[5]

Q. What other trends are putting increased pressure on Corporate Security?

A. As Portland's homeless population has grown, PGE is seeing a significant increase in homeless camps in and around PGE facilities, most notably at or near PGE substations. Consequently, PGE's Corporate Security employees are responding to an increased volume of safety and security concerns related to these camps. PGE's current security staff cannot continue to meet the demands of this increased volume in a consistent manner.

Q. How is PGE addressing these issues?

A. In order to provide effective security coverage for our expanding footprint of assets, and to address the increased security concerns from our community, PGE is adding three FTEs between 2017 and 2018. One additional FTE will be hired to provide project management

[5] http://www.nerc.com/pa/Stand/Reliability%20Standards/CIP-014-1.pdf

support for CIP-14 and to lead the day-to-day operations of PGE's expanding physical security systems.

C. Human Resources

1. Safety

Q. Please discuss PGE's company-wide safety focus.

A. PGE has been and continues to be committed to providing a safe and healthy place for employees, customers, and the public. Safety is a core value that PGE integrates into everything we do. We believe most hazards can be identified and effectively controlled or eliminated to prevent incidents and their consequences. Thus, it is important that we focus on continuously improving our safety performance, to meet our goal of an injury-free workplace.

Q. Has PGE's safety record shown improvement?

A. Yes. There are a number of signs indicating that PGE's record on safety is improving. Most notably, PGE has seen a decrease in workplace accidents, as evidenced by a 23 percent overall decrease in Occupational Safety and Health Administration (OSHA) "recordable" accidents since 2014. [6]

Q. What additional steps is PGE taking to improve safety?

A. In order to increase the effectiveness of PGE's safety culture and continue to reduce injuries and incidents, PGE has developed a comprehensive five-year safety strategy plan. Additionally we are adding one FTE in 2017 and one FTE in 2018 that will help address the following:

[6] OSHA defines a recordable accident as any work-related injury or illness that causes a fatality, unconsciousness, lost work days, restricted work activity, job transfer or medical care beyond first aid.

- A greater level of support in auditing PGE's safety programs, providing technical writing support and general support of new and existing safety programs and practices;
- Thorough administrative and analytical support of PGE's safety reporting system to harness the system benefits of improved safety metrics analysis, incident reporting, and anonymous "near-miss" reporting;
- Support for an increased level of safety and work practices training; and
- Implementation and increased focus on specialized employee and contractor safety and injury prevention programs, such as:
    a. The MoveSmart program to reduce sprains and strains;
    b. The Early Injury Intervention Effort for preventative self-treatment strategies;
    c. The Safety Leadership Development Program to provide management and safety mentors the tools to promote safe practices; and
    d. The Contractor Safety Program to promote a safety culture throughout PGE's operations.

A copy of the five-year safety strategy map outlining the above activities is included in the work papers for PGE Exhibit 600.

2. Support Services

Q. How much are training and staffing services costs projected to increase for 2018?

A. PGE's costs for these support services are forecasted to increase from approximately $3.6 million to $5.2 million from 2016 to 2018.

Q. Please describe the drivers behind PGE's increase in staffing.

A. PGE continues to see an increase in the volume of hiring, placing increased demands on current staff, who are now operating beyond their capacity. As shown in Table 2 below, the actual and projected number of annual job requisitions staffing services has filled since 2014 is increasing substantially. This current and projected higher level of hiring reduces staffing services effectiveness and cannot be maintained at the current staffing levels. Additionally, with a high number of senior professionals nearing retirement at PGE (and throughout the utility industry), the demands for skilled utility professionals has increased. At the same time, an improved economy has increased the difficulty and time requirements involved to recruit, hire, and retain these in-demand professionals.[7]

Table 2
Filled Position Requisitions

Year	Filled Requisitions
2014	638
2015	838
2016	930
2017*	1,200
2018*	950

*Estimated

Q. Are there other pressures increasing the workload for PGE's Staffing Services?

A. Yes. Along with the pressures associated with the overall increases in hiring, PGE is hiring more PGE employees, rather than outside contractors, for recent capital project work. Specifically, PGE is increasing the level and pace of transmission and distribution (T&D) maintenance and reliability work throughout our system. To perform this work, PGE is relying more on internal PGE labor as opposed to the outside services traditionally used for large-scale generation projects. PGE decided on this strategy primarily due to the scarcity of qualified labor, the high turnover rate of contract labor, and commitment to the projects, which are long-term in nature. However, using more of an internal, rather than external

[7] According to the Bureau of Labor Statistics, as of December 2016, Oregon's unemployment rate was 4.6%. https://www.bls.gov/eag/eag.or.htm#eag_or.f.p

workforce does place additional strain and workload on our Staffing Services department. PGE Exhibits 400 and 800 provide more detail on this hiring strategy.

Q. How is PGE addressing these pressures?

A. To address the increased hiring pressures and maintain recruiting competitiveness, Staffing Services is adding three and a half FTEs between 2017 and 2018. Staffing Services has also increased its budget for outside services to assist with the recruitment process. These additional FTEs will allow Staffing Services to meet the increased demand in hiring, while maintaining its current time-to-fill-ratio. Additionally, Staffing Services will continue supporting management in its selection process and engage in proactive recruiting strategies such as career fairs, data-driven analytics, college internships, line pre-apprenticeship programs, and social media outreach.

Q. How have PGE's training needs changed over the last couple of years?

A. The demands for training continue to increase as PGE continually implements and integrates new systems and programs. At the same time, the electric utility industry continues to evolve, leading to a greater complexity of systems, processes, and regulatory requirements. Due to this complexity, and for program consistency, PGE has begun centralizing the majority of our training programs in order to gain maximum efficiency of effort. This centralization effort also allows PGE's functional area subject matter experts to focus on their job-specific requirements. As such, with this centralization of both instructor-led and computer-based training, PGE's training department is adding three FTEs in 2018 and increasing its contract labor budget. These additional FTEs are in support of the centralization effort along with the following increases to training demands:

- Additional pre-apprenticeship program offerings and continued growth associated with the existing apprenticeship program;
- New curriculum development including: safety leadership, service design management, and soft tissue injury prevention;
- Increasing mandatory regulatory training and development;
- Additional Generation Excellence training;
- New engineer curriculum for Transmission, Distribution and Generation engineers; and
- Company-wide skill track creation and maintenance.

III. Other Items

A. Research and Development

Q. Why does PGE engage in Research and Development (R&D) activities?

A. PGE conducts R&D on behalf of customers to both preserve and improve system reliability and at the same time to anticipate changes that could profoundly alter the grid.

Q. What are PGE's forecasted 2018 costs for PGE's corporate R&D activities?

A. For 2018, we forecast approximately $3.0 million in R&D expenses, of which approximately $2.8 million is for specific R&D projects and the remainder is for administrative expenses. This reflects an increase of approximately $1.0 million over 2016 actuals. PGE's increased spending represents numerous selected projects that will address the significant changes and new technologies facing PGE and the electric industry. These R&D projects primarily relate to Smart Grid (SG) applications, system reliability (SR), renewable power (RP), operational efficiency (OE), energy storage (ES), and system resiliency (SY). These R&D projects directly contribute to PGE's ability to evaluate and deploy technologies and resources that will benefit our customers for decades to come; they help shape Oregon's energy future to conform to customer priorities for an even more reliable, sustainable and smarter electric power system. Table 3 below provides a listing of the 2018 R&D project categories and number of expected projects within each category. We also provide a complete listing with descriptions and project benefits in PGE Exhibit 604.

Table 3
Topical Summary of 2018 R&D Applications

	Category	Approx. Cost	Number of Projects
SG	Smart Grid	$925,300	18
SR	System Reliability	$578,000	10
RP	Renewable Power	$535,000	7
OE	Operational Efficiency	$430,000	7
ES	Energy Storage	$210,000	4
SY	System Resiliency	$75,000	2
	Total	**$2,753,300**	**48**

Q. Please summarize why PGE is requesting an increase in R&D funding.

A. The U.S. electrical grid is aging and changing in very substantial ways. It is increasingly clear that central station power generation and the "one-way" power flow that it fostered will slowly be replaced with distributed forms of power generation, including solar, biomass, small/low head hydrokinetic devices, and wind resources. The arrival of these smaller sources of power generation will by necessity, require "bi-directional" power flow that can emanate from residential and commercial structures and even PGE electrical substations. Smart AC/DC inverters for autonomous control of batteries and distributed generation devices, smart switches capable of sectionalized isolation and heightened concern for cybersecurity will all have important roles going forward. It is important that PGE, for safety and efficient application, understands how this new and substantial transformation will unfold. This means that PGE should study now the possible implications and preparations needed to accommodate industry advances.

Q. What is PGE doing to pursue R&D in a cost effective manner?

A. PGE recently assessed its R&D cost effectiveness using two principal approaches: 1) participation in a nationwide benchmarking study and 2) limiting overhead cost.

Q. Describe the Benchmarking Study results as they pertain to PGE's R&D spending.

A. PGE and 48 utilities voluntarily participated in a 2016 R&D Benchmarking Survey conducted by the Electric Power Research Institute (EPRI). In that study, PGE's annual R&D expenditure of $2 million was the fifth lowest out of the 12 participating western utilities. PGE also ranked below average on a revenue-adjusted basis, when compared to all 48 utilities.[8] On absolute and relative bases, PGE's R&D expenditure is low when compared to western utilities and low on a revenue-normalized basis compared to 48 U.S. utilities.

Q. Describe the Benchmarking Study results as they pertain to R&D administrative costs.

A. PGE limits its overhead costs in pursuing R&D even in the face of increased funding and program efforts. PGE's FTEs for R&D administration have decreased from 1.7 in past years to only 1.0 for 2018. The EPRI R&D benchmarking study showed that for investor owned utilities the average number of R&D FTEs was 1.3. The fact that PGE's FTE levels associated with R&D administration are lower than the utility average validates the efficiency of PGE's R&D program.

Q. Does PGE engage research partners?

A. Yes. PGE leverages many of its R&D projects financially by working with other utilities as well as universities to co-sponsor and/or share R&D. In doing so, PGE and its customers receive 100% of the benefits for a fraction of the overall research costs; often receiving useful knowledge much earlier than if we did not contribute or otherwise engage with research partners. PGE's university partners view PGE's R&D dollar contributions as part of required matching funds for much larger federal or other institutional grants, and would

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[8] Out of 48 utilities, PGE ranked 20th from low to high when R&D expense was normalized to revenue, and was about 75% of the overall average of 0.21% of R&D expense as a percent of revenue.

otherwise be unable to receive the necessary funding without PGE's co-sponsorship. PGE will work with several universities on shared projects that support unique, regional renewable power research that include wave, wind, solar, and CO_2 capture, as well as sequestration through torrefied biomass fuel used to displace coal. PGE will continue to co-sponsor projects with Portland State University, Oregon State University, Washington State University, University of Oregon and Oregon Institute of Technology.

Q. How have PGE's customers benefited from R&D in the past?

A. PGE recently completed a 20-year retrospective report covering its R&D activities over the period 1994-2014. An experienced consultant, funded by PGE, performed seven detailed case studies to assess value and benefit to customers. Value determinations involved both operating savings and avoided capital expenditures (netting these against operating costs and capital costs). The net value for these seven case studies were then compared to the base R&D costs that made these projects possible. The comparison showed a $37 to $1 net value over the original R&D cost. PGE's work papers for Exhibit 600 include this 20-year report.

Q. What is PGE's plan for 2018 Smart Grid projects?

A. PGE has identified 48 total projects for 2018 of which 18 relate to Smart Grid (or "Integrated Grid") topics. Smart Grid work comprises 38% of the total project numbers and 34% of the 2018 R&D funding request. Of the 18 Smart Grid projects, 12 are primarily on the behalf of residential and commercial customers. This is timely due to the influx of electrical devices that are rapidly becoming "smart" and finding their way into the "internet of things" ecosystem. Examples include more granular and autonomous energy controls at the device level (e.g., water heaters, thermostats, and lighting of all types). The energy control devices, when aggregated appropriately, may be harnessed to benefit the power grid, and thus customers in terms of load shifting and demand response support, which ultimately can lower operational costs.

Q. Please summarize PGE's other 2018 R&D efforts and the reasons behind these efforts.

A. PGE's 2018 R&D effort also supports System Reliability, Renewable Power and Operational Efficiency and these proposed R&D projects are in proportions varying from 15% to 20% of the 2018 R&D effort. System Reliability and Operational Efficiency work focuses on PGE's established infrastructure (e.g., power plants, poles, wires and substations), making it more reliable, safe and efficient. R&D in these areas, especially when coupled with EPRI programs, help PGE to keep abreast of industry best practices and lessons learned in power generation and transmission and distribution areas. PGE R&D projects include twelve EPRI programs, and are part of the 24 projects that form the three areas of interest. Finally, there are four Energy Storage and two System Resiliency projects targeted for 2018 R&D efforts. Due to cost, energy storage options such as batteries continue to hover at the edge of practicality; nonetheless, PGE needs to be aware of advances in this area especially as it relates to system resiliency support in the event of large, disruptive events such as a Cascadia Subduction Zone earthquake. In these types of emergencies, energy storage capability, whether stationary or mobile such as in electric vehicles, can play a meaningful role in recovery and restoration efforts. PGE will continue its efforts to validate use cases for the five MW, 1.25 MWh lithium ion battery inverter system (BIS) at its Salem Smart Power Center. This substantial BIS was highly subsidized by the United States Department of Energy as part of its five-year Pacific NW Smart Grid Demonstration Program of which PGE was a participant from inception.

B. Memberships

Q. Please explain the increase in membership expenses from 2016 to 2018.

A. PGE's membership costs have increased by approximately $475 thousand from 2016 to 2018. This increase is largely attributed to PGE's mandatory participation in WECC and PEAK Reliability (PEAK), projected at $2.3 million in 2018, compared to $2.0 million in 2016.

Q. What process does PGE use to budget for annual WECC and Peak expenses or fees?

A. PGE bases its budget for 2017 and 2018 on the estimated amounts provided to PGE from WECC and PEAK that are included in their annual business plan and budget documents.

Q. What reasons do WECC and PEAK provide for the increased fees?

A. According to annual budget documents, both WECC and PEAK are increasing membership fees due primarily to rising personnel expenses and increases in fixed asset additions.

Q. Have there been any other significant increases in membership costs?

A. Yes. PGE's share of membership in the Northern Tier Transmission Group (NTTG) will increase by approximately $100,000 from 2016 to 2018.

Q. What is the NTTG?

A. The NTTG is comprised of transmission providers and customers that actively purchase and sell transmission capacity on the Northwest and Mountain States grid. The group coordinates individual transmission systems planning of their high-voltage transmission network to meet and improve transmission services that deliver power to customers. NTTG coordinates its planning activities with the three other Regional Transmission organizations in WECC (Columbia Grid, West Connect, and CAISO). PGE participates in the NTTG along with a number of other utilities, transmission owners, and stakeholders in the region.

Q. What reasons does NTTG provide regarding their fee increase?

A. Beginning in 2017, NTTG anticipates a sizable increase in consulting and legal fees regarding potential modifications to Federal Energy Regulatory Commission (FERC) Order No. 1000, which establishes the requirements for transmission planning.[9] NTTG also anticipates increased modeling and analysis to support the development and implementation of the WECC Anchor Data Set (ADS). Benefits of the ADS include establishing a common starting point for all production cost model and power flow datasets, produced by WECC and the Planning Regions, which will result in aligned assumptions used in the planning model development for The Transmission Expansion Planning Policy Committee and the Western Planning Regions.

Q. Has PGE included an adjustment to Memberships in this case?

A. No. In the past PGE has included a pre-filing adjustment to remove costs associated with non-utility memberships and lobbying. However, because these costs are identifiable when PGE is charged for them, PGE now records and budgets for them in applicable, non-utility accounts that are not included in this filing.

C. Accounting and Finance Services

Q. How much are costs in PGE's Accounting and Finance organization projected to increase for 2018?

A. PGE's costs for these services are forecast to increase from approximately $9.9 million to $11.3 million from 2016 to 2018.

Q. Please briefly describe the drivers behind this increase.

A. This increase is due to the addition of four FTEs needed to support various functions in the Accounting and Finance area along with an increase in outside services support.

[9] See https://www.ferc.gov/industries/electric/indus-act/trans-plan.asp for more detail on FERC Order No. 1000.

Q. Why does Accounting and Finance require four additional FTEs?

A. PGE is adding four additional FTEs to help in the following areas:

- Supply Chain – We are adding two FTEs to Supply Chain Services to address the current lack of resources available for supporting increased activity in both purchasing and vendor management activities due to centralization and streamlining of all supply chain functions.
- Accounts Payable/Receivable (AP/AR) – One FTE is being added to the AP/AR department to provide additional compliance support for PGE's purchasing card (P-card) program. After auditing its P-card program, PGE determined that additional oversight was required to improve compliance management and provide timely reviews of expenditures. Doing this will reduce PGE's potential exposure to unauthorized/fraudulent charges. Additionally, compliance responsibilities will increase as PGE increases its ratio of P-card usage versus check or Automated Clearing House transactions, in order to reduce the average per-transaction charge.
- Corporate Finance – We are adding one FTE to provide company-wide Enterprise Risk Management (ERM) support. PGE does not currently have a full-time resource dedicated to ERM activities. This position will work throughout the organization with subject-matter experts to identify and assess particular events or circumstances in terms of their likelihood and magnitude of detrimental impact to PGE. The next steps after identification are to develop a response strategy and to monitor future progress.

Q. Why are outside services increasing for Accounting and Finance?

A. The outside services increase is largely attributable to increases in PGE's auditing costs for 2017 and 2018 as compared to 2016. Beginning in 2017, PGE's audit services increased their fees by approximately $100,000. Additionally, PGE is forecasting an increase of approximately $200,000 for additional auditing hours needed to identify and review the accounting and controls impacts related to a number of current and future accounting changes. Some of these changes include: 1) the implementation of PGE's new Customer Information System; 2) new lease accounting rules issued by the Financial Accounting Standards Board (FASB); and 3) new revenue recognition accounting standards issued by the FASB.

Q. Have outside services increased in any other accounting services areas from 2016 to 2018?

A. Yes. There is also an apparent increase in the budget for tax consulting services. However, this is due to an unusually limited need for these services during 2016, resulting in lower than average costs. If looking across the period of 2013 through 2016, PGE's tax department spent an average of approximately $480,000 per year for tax consulting services. This compares to the 2018 forecast of approximately $206,000. With a very active legislative session in 2017, which includes a large number of tax proposals, PGE fully expects to spend its consulting services budget for both 2017 and 2018.

D. Insurance

Q. What types of insurance coverage does PGE maintain?

A. PGE maintains a prudent portfolio of insurance coverage, which we list and describe in PGE Exhibit 602 and confidential PGE Exhibit 603. In general, the insurance coverage maintained by PGE falls into two broad programs: Property and Casualty. We discuss these below as well as address retained losses.

Q. What is PGE's forecast for insurance premiums for 2018?

A. As shown in Table 4 below, we expect total Property and Casualty premiums to be approximately $11.4 million, excluding 50% of non-primary layers of Directors and Officers (D&O) insurance. PGE expects the Property program premiums to increase slightly due to an increase in PGE's total insured value coupled with a mild annual 2.0% rate increase. The decrease in Property premiums from 2016 to 2018, shown in Table 4 below, show a decrease because there was a limited-time builder's risk policy extension in 2016. If the builder's risk policy is factored out ($0.35 million), premiums show a slight average annual increase of 2.5%. Within the Casualty program, PGE expects slight increases in premiums in its General Liability, Workers' Compensation and Cyber Liability coverages. Unforeseen severe Casualty losses would produce upward pressure on rates beyond the current forecast. Overall, we expect a mild 1% impact on premiums.

Table 4
Insurance Premiums ($ millions)

Type of Loss	2016 Actuals**	2018 Budget**	Annualized % Increase
Property	$5.93	$5.88	(0.5)%
Casualty	$4.86	$5.13	2.7%
Total*	**$10.79**	**$11.38**	**1.0%**

** May not sum due to rounding.*

*** Premium amounts do not include membership credits or non-primary layers of D&O insurance*

Q. What is PGE's forecast of expenditures for retained losses from 2016 to 2018?

A. As shown in Table 5 below, PGE's forecast of expenditures for retained losses increases by approximately 14.1% annually from 2016 to 2018. We discuss retained losses in more detail below in Section 2.

Table 5
Retained Losses ($ millions)

Type of Loss	**2016 Actuals**	**2018 Budget**	**Annualized % Increase**
Workers' Compensation	$1.57	$1.75	5.8%
Auto & General Liability	$1.19	$1.83	24.2%
Total*	**$2.75**	**$3.58**	**14.1%**

** May not sum due to rounding*

1. Casualty

Q. What types of coverage are included in PGE's Casualty insurance program?

A. The eight components of PGE's Casualty insurance program are as follows:

- General & Auto Liability
- Directors and Officers (D&O) Liability)
- Fiduciary Liability
- Workers' Compensation
- Nuclear Liability
- Cyber Liability
- Aviation Hull & Liability
- Surety Bonds

PGE Exhibit 602 describes each policy's purpose in more detail.

Q. Why is D&O insurance coverage important?

A. D&O liability insurance is important for the following reasons:

- It insulates customers and shareholders from having to shoulder the full financial impact in situations where PGE owes its directors and officers an indemnity obligation or where PGE is a named party in securities litigation;
- The limits purchased are consistent with utility industry standard practices and reduce overall risk to both customers and shareholders;

- Maintaining the appropriate limit and type of D&O insurance is necessary to attract and retain qualified and competent directors and officers; and
- It shields PGE's directors and officers against normal, but sometimes significant, risks associated with managing the business.

Q. Is PGE requesting 100% of the D&O premiums?

A. No. PGE is requesting 100% of the first layer of D&O coverage and 50% of supplemental layers. PGE made these adjustments to mitigate customer costs for insurance. Although we have made these reductions in this filing, we still believe that the inclusion of 100% of D&O insurance premiums in customer prices is appropriate.

Q. Why does PGE purchase Workers' Compensation insurance?

A. The State of Oregon requires PGE to maintain coverage to provide employees who are injured on the job with insurance coverage that will compensate them for lost wages, medical care, and if necessary, vocational rehabilitation.

2. Retained Losses

Q. Please explain Retained Losses.

A. Retained losses are the portion of any claim falling within PGE's self-insurance retentions for its Auto Liability, General Liability, and Workers' Compensation exposures that are frequent and predictable. Simply put, retained losses are the amounts borne by PGE before any insurance recoveries.

Q. What is the forecasted increase in annual claim expenditures for retained losses in Workers' Compensation and Auto and General Liability?

A. As shown in Table 5 above, PGE expects annual cash expenditures for retained losses for Workers' Compensation and Auto and General Liability claims to increase by an annual average of 14.1% from 2016 to 2018. The actuarial projection of annual expenditures for Workers' Compensation and Auto and General Liability retained losses is directly correlated to PGE's actual loss experience over time. In 2017 and 2018, PGE's annual expenditures are budgeted at the expected level, based on the actuarial projections.

IV. Environmental and Licensing Services

Q. Please describe the change in environmental and licensing costs from 2016 to 2018.

A. Environmental and Licensing Services (ELS) forecasted costs, as charged to A&G, are approximately $2.2 million for 2018 compared to approximately $4.4 million in actuals for 2016.

Q. Why did ELS costs decline?

A. This decrease is primarily due to the removal of environmental remediation costs and revenues associated with the Portland Harbor Superfund Sites (Portland Harbor), the Natural Resource Damage obligation (NRD),[10] the Downtown Reach portions of the Willamette River, and the Harborton Restoration Project (Harborton) from base rates. If excluding these costs from both 2016 actuals and the 2018 forecast, ELS costs charged to A&G still decrease by approximately $0.8 million.

Q. Why has PGE removed these costs from base rates?

A. PGE has removed these costs to reflect a stipulated agreement between PGE, Staff of the Public Utility Commission of Oregon, the Citizens' Utility Board, and the Industrial Customers of Northwest Utilities, stating that PGE will defer and record all environmental costs and offsetting revenues associated with Portland Harbor, NRD, Downtown Reach, and Harborton in the Portland Harbor Environmental Remediation Balancing Account (PHERA) as described in Docket No. UE 311, PGE Exhibit 100.[11] This agreement, however, is still awaiting a decision from the Commission. If the Commission's decision is materially different from the above referenced stipulation, PGE will seek to include the 2018

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[10] The amounts of NRD damages or mitigation to natural resources are measured in Discount Service Acre Years.
[11] Associated Docket Nos. UM 1789, UP 344, and UE 311 have since been consolidated into Docket No. UM 1789.

forecasted costs associated with Portland Harbor, NRD, Downtown Reach, and Harborton into our 2018 test year forecast.

V. Summary

Q. Please summarize your request for A&G in this filing.

A. We request that the Commission approve PGE's forecast of $172.1 million in A&G costs in the 2018 test year. This represents a $1.2 million increase from 2016 actuals due primarily to increases in employee benefits (i.e., health care and dental premiums), safety, security and emergency management, and support services.

Absent cost increases for employee benefits and IT (plus the increase associated with OPUC fees), PGE has reduced its 2018 A&G forecast with an overall annualized 4.1% cost decrease from 2016.

Q. Does this conclude your testimony?

A. Yes.

List of Exhibits

PGE Exhibit	**Description**
601	Summary of A&G Costs and FTEs
602	Description of Insurance Coverage
603C	Summary of Insurance Policies/Premiums
604	2018 R&D Proposed Projects

A&G Summary

Category	Costs ($ millions) 2014 Actuals	2015 Actuals	2016 Actuals	2017 Budget	2018 Forecast	2016 to 2018 $ Delta	2016 to 2018 Annual %	FTEs 2014 Actuals	2015 Actuals	2016 Actuals	2017 Budget	2018 Forecast	2016 to 2018 $ Delta	2016 to 2018 Annual %
Major Functional Areas														
Facilities and General Plant Maintenance	5.5	4.8	5.5	6.6	7.0	1.5	12.7%	12.9	28.2	23.3	21.9	21.9	(1.5)	-3.2%
Accounting/Finance/Tax	9.7	9.5	9.9	10.9	11.3	1.4	7.0%	69.9	69.3	70.8	79.8	79.8	9.1	6.2%
HR/Employee Support (net of capital allocs.)	8.5	9.0	9.8	11.1	13.4	3.6	16.7%	107.8	111.1	114.0	129.5	135.4	21.4	9.0%
Insurance / I&D	8.5	12.1	11.5	12.2	12.2	0.8	3.3%	6.9	6.9	7.0	7.0	7.0	0.0	0.2%
Legal	4.6	5.2	10.0	9.5	5.4	(4.6)	-26.3%	22.6	22.0	21.6	24.9	24.9	3.3	7.5%
Regulatory Affairs	2.6	2.8	2.6	3.3	3.4	0.8	15.1%	30.0	31.2	28.9	34.0	34.0	5.1	8.4%
Corporate Governance	4.5	4.5	4.6	5.1	5.4	0.8	8.0%	16.7	17.4	18.2	18.3	18.3	0.1	0.2%
Business Support Services	2.7	2.5	2.4	2.6	2.8	0.3	6.1%	7.0	7.0	5.1	5.5	5.5	0.4	4.0%
Environmental Services	2.7	4.7	4.4	2.1	2.2	(2.1)	-28.5%	-	-	-	-	-	-	#DIV/0!
Corporate R&D	1.3	1.4	2.0	1.9	3.0	1.0	23.3%	1.7	1.2	1.0	1.0	1.0	0.0	2.4%
Contract Services/Purchasing	1.2	1.3	1.4	1.4	1.4	0.0	1.0%	14.3	17.2	16.2	14.8	14.8	(1.4)	-4.6%
Security and Business Continuity	2.0	2.2	2.2	2.6	2.9	0.7	15.5%	11.4	15.0	14.0	18.0	19.0	4.9	16.2%
Corp Communications/Public Affairs	1.9	2.0	2.2	2.4	2.4	0.2	5.4%	23.4	24.3	25.0	26.2	26.2	1.3	2.5%
Load Research	0.2	0.0	0.1	-	-	(0.1)	-100.0%	-	-	-	-	-	-	#DIV/0!
Hydro Licensing and Support	0.1	0.1	0.1	0.1	0.1	0.0	4.4%	-	-	-	-	-	-	#DIV/0!
Performance Management	1.5	1.3	1.3	2.0	2.1	0.8	27.7%	15.2	10.9	12.0	13.3	13.3	1.3	5.1%
Governmental Affairs	1.0	1.2	1.2	1.2	1.2	0.0	0.8%	8.5	8.8	10.1	11.0	11.0	0.8	4.0%
Subtotal	58.5	64.4	71.0	75.0	76.3	5.2	3.6%	348.1	370.5	367.3	405.2	412.1	44.9	5.9%
Other A&G Costs														
IT: Direct & Allocated	10.2	11.3	12.1	11.0	13.4	1.3	5.3%	234.8	234.8	272.4	309.3	324.2	51.8	9.1%
Corporate Cost Reductions	-	-	-	(3.6)	(3.6)	(3.6)	N/A				(34.7)	(33.7)	(33.7)	#DIV/0!
Other Membership Costs	2.4	2.9	3.1	3.3	3.6	0.5	7.4%							
Incentives	21.2	20.9	21.6	28.2	12.6	(9.0)	-23.6%							
Severance	0.0	(0.1)	1.6	1.3	1.3	(0.3)	-9.3%							
Regulatory Fees	5.9	6.4	6.7	6.9	8.7	2.0	13.9%							
General Plant Maint.	2.3	2.6	2.6	2.6	2.9	0.3	5.3%							
Total PTO to A&G	5.3	5.9	4.4	5.9	6.3	2.0	20.6%							
Total Labor Loadings to A&G	-	(0.0)	0.0	(0.0)	0.0	-	0.0%							
Benefits (net of capital allocs.)	53.0	54.3	51.8	58.1	57.7	5.9	5.5%							
Corp Allocations	(4.5)	(3.8)	(5.7)	(7.5)	(8.7)	(3.0)	23.2%							
Revolver Fees, Margin Net Int., & Broker fees	2.5	3.0	1.9	1.9	1.8	(0.1)	-3.2%							
Subtotal	98.4	103.2	99.9	108.0	95.8	(4.1)	-2.1%							
TOTAL A&G	156.9	167.6	170.9	183.0	172.1	1.2	0.3%	582.9	605.3	639.7	679.8	702.7	63.0	4.8%

PGE's Insurance Policies

Insurance Policy	Description
All Risk Property	PGE's main All-Risk property insurance program is led by FM Global and insures PGE's property such as power plants, substations, office buildings, etc. from "all-risks" of direct physical loss or damage (including boiler and machinery), subject to policy exclusions, caused by perils such as fire, explosion, lightning, wind, ice, hail, flood, earthquake, and certain acts of terrorism. This policy specifically excludes coverage for PGE's transmission and distribution property as well as PGE's renewable projects. Under this program PGE maintains coverage limits of $1 billion with a $2.5 million deductible.
Renewable Property	The All-Risk property insurance program for PGE's renewable assets is currently placed in the London market. Operational All-Risk coverage for these assets, including both wind and solar, are insured to their combined full replacement value of $1.8 billion and carry a $0.15 million deductible
Director's and Officer's Insurance	Directors and Officers ("D&O") Liability Insurance shields PGE's directors and officers against the normal risks associated with managing the business. The insurance premiums requested in this case are reasonable expenses that are necessary to attract and maintain qualified and competent directors and officers and they provide a direct benefit to PGE's customers. Currently PGE purchases $140 million in D&O insurance limits with $.75 million deductible. No deductible applies to Side A, or individual coverage. The limits purchased are reasonable, necessary and consistent with the standard practice of the utility industry. The lack of an appropriate level of D&O insurance would make it difficult for PGE to hire qualified and competent people for positions at the director and officer level. In addition, lack of appropriate D&O limits would provide a significant motivation for our experienced directors and officers to seek employment elsewhere. Subjecting the Company to the potential of such adverse outcomes is not in the best interest of PGE's ratepayers.
General & Auto Liability	General and Auto Liability insurance covers PGE's legal liability from claims resulting from bodily injury or property damage arising out of PGE's operations, including the use of company vehicles. Given PGE's contact with its customer's premises and the dangerous nature of its operations, this insurance is of paramount importance. PGE maintains coverage limits of $160 million with a $2 million self-insured retention.
Nuclear	PGE is required by the United States Nuclear Regulatory Commission to maintain Nuclear Liability coverage for the on-site storage of its spent fuel until such time that the radioactive materials have been removed from the Trojan site. The coverage consists of three policies: (1) The Facility Form insuring PGE's legal responsibility for damages because of bodily injury, property damage, or covered environmental clean-up costs caused by the Nuclear Energy Hazard during the policy period and reported within ten years of the policy termination date. (2) Master Worker insuring PGE's legal obligation to pay as damages because of bodily injury sustained by a "worker" and caused by the nuclear energy hazard. "Worker" refers to a person who is or was engaged in nuclear related employment; (3) Suppliers and Transporters covering incidents caused by radioactive waste materials stored either temporarily or permanently at off-site locations not owned/operated by the insured.
Fiduciary	Fiduciary Liability insurance provides protection for officers and employees for both breach of fiduciary duties and other wrongful acts in the administration of employee benefits programs. This program is made up of total limits of $50 million with a $0.25 million self-insured retention.
Aviation	This policy insures the helicopter's hull value from physical damage and provides $20 million of liability coverage in operating the aircrafts during PGE's aerial patrol operations.
Cyber	The policy has several insuring agreements, providing coverage for: (1) damages and claims expenses due to theft, loss or unauthorized disclosure of personally identifiable non-public information or third party corporate information, (2) costs incurred to comply with a breach notification law, and (3) claims expenses and penalties in the form of a regulatory proceeding resulting from the violation of a privacy law such as HIPPA or FTC. PGE purchases a limit of $10 million with a $.25 million self-insured retention.
Fidelity & Crime	Insures losses incurred by PGE or its employee benefit plans as a result of the dishonest acts of employees, including embezzlement, forgery or the theft of money or securities. The policy has a $10 million limit and $0.5 million deductible. This coverage is typically excluded under most All-Risk Property policies and must therefore be purchased under separate cover.
Workers' Compensation	The State of Oregon requires PGE to maintain excess coverage to protect itself from catastrophic losses to employees arising out of and in the course of employment. This coverage sits above PGE's self-insured Workers' Compensation program.
Surety Bonds	In the course of doing business PGE must procure and maintain a number of Surety bonds throughout the year. These bonds allow PGE to do work for various state and city governments and agencies and are a requirement for maintaining a form of collateral for self-insuring PGE's Workers' Compensation obligations.

EXHIBIT 603C

Confidential

PGE 2018 R&D Proposed Projects
Brief Descriptions

The below R&D projects will be brought before PGE's Research and Development Committee for consideration and prioritization in 2017. PGE expects most of these projects will be continued through 2018. Due to the fluid nature of research projects, funding ratios are subject to change.

These projects primarily relate to the below topics of application:

SG	Smart Grid
SR	System Reliability
RP	Renewable Power
OE	Operational Efficiency
ES	Energy Storage
SY	System Resiliency

PGE R&D Projects for 2018		
Brief Description	**Topic**	**2018 $**
1. Joule Bank System (JBS) This is a continuation of a project started October 1, 2014 on the design and early prototyping of the Joule Bank System which involves a flexible, highly efficient, residential heating and cooling system based on heat pumps and thermal storage. Extensive collaboration has evolved to ensure arms-length, third-party assessment. Collaborating institutions include Harvey Mudd School of Engineering for thermodynamic assessment and modelling and Portland State University for initial prototype design and development. Because of the thermal storage and utility control features, it is estimated that 90% of peak demand can be eliminated and the energy storage can be "filled" mostly at PGE's discretion. In 2015, PGE concluded theoretical and prototype development; in 2016 – a bench scale "production" model was tested under real-world conditions. In 2017/2018 PGE will work with a manufacturer to evolve a field prototype.	SG	40,000
2. PSU – Battery Backup Filed Demo; Residential and Grid As electric utilities experience increasing penetration of distributed renewable power generation (wind and solar) resources at the distribution feeder level, there is heightened awareness for the need to ensure acceptable power quality from both safety and reliability perspectives. Energy storage devices will be needed to store energy when it is abundant and to release it when needed.. Development of the energy storage devices will enable the grid to respond with demand side controls and limit peak power demand. If available in sufficient capacity, energy storage devices will help resolve the present "non-dispatchability" of wind and solar power assets which currently dominate the renewable power generation resource stack mix. This development will advance the incorporation of more of these types of renewable power in response to carbon emission reduction policies through the promotion of renewable energy standards (RPS).[1] To accomplish this on a more distributed basis requires that PGE take steps similar those described above for incorporation of renewable power sources such as wind and solar. This can also be done using energy storage alone on a distributed basis. PGE has collaborated with Portland State University's Electrical and Computer Engineering (ECE) Department to take steps in the placement of battery energy storage devices at residential locations. This collaboration will allow the testing and use of a very safe aqueous ion battery that has more energy density than power density, and more suitable for household use. The vision is that PGE would own and maintain the 7 to 8 KW inverter and the nominal 50 kWhr battery as investment assets so that: • PGE through, an agreement with the premise owner, can use the battery • Controls for the battery would enable demand response, wind firming, etc. • Upon loss of utility power a disconnect allows the battery to power the home • Upon re-gaining utility power the inverter will allow automatic grid re-synching • The inverter will also monitor and control for islanding conditions • The meter for the system will track energy for home and grid separately • The meter also supports circuitry to facilitate telemetry, command and control PGE expects the battery will serve PGE's purposes for the vast majority of the time. For the home owner, the battery-inverter will provide the peace of mind of having back up power for that short period of time that loss of power is experienced on PGE's grid. The home owner knows that the battery will be supporting the increased penetration of renewable power such as	ES	40,000

[1] Oregon is one of 29 states with a renewable portfolio standard requirement. In Oregon this translates to major investor owned utilities and larger consumer or municipal owned electric utilities needing to account for 20% of power sales via renewable power resources by 2020; 27% by 2025 and 50% by 2040. This is above a baseline of the present renewable hydropower resources for these utilities meaning that these are entirely new and thus incremental to that baseline.

PGE R&D Projects for 2018		
Brief Description	**Topic**	**2018 $**
wind and solar.		
3. OSU - Cascadia Lifelines Research The Cascadia Lifelines Program will provide essential and unique engineering solutions including cost-effective retrofit strategies for infrastructure subjected to long-duration shaking resulting from a Cascadia Subduction Zone event. The project will provide improved prediction of ground-shaking specific to Oregon conditions, predicted seismic behavior of soils unique to the Willamette Valley, including the liquefaction potential, and system optimization of interdependent lifelines. The impact of this research will help assess cost-effective approaches to increased resilience, resulting in saved lives and improved business continuity for western Oregon and PGE's service territory. In joining this program effort headed by Oregon State University ("OSU"), PGE continues taking a pro-active approach in minimizing the impact of the next devastating earthquake on its customers, and doing its part in improving Oregon's ability to bounce back from such an event. As a secondary benefit, teaming with OSU on this research gives PGE ready access to the team of seismic hazard mitigation experts at the university. R&D funding is $50,000 per year for a 5-year commitment or $250,000 over five years; PGE occupies a seat on the management board that guides the OSU research priorities. The dollar commitment on behalf of PGE customers is substantially matched from other utility and related infrastructure providers (e.g., BPA, ODOT, NW Natural, EWEB, Port of Portland and others) yielding a match of five to 10 fold.	SR	50,000
4. CEA-2045 EPRI demo of "Smart" Water Heaters & EVSE (PEV 240V Chargers) EPRI has convened a group of utilities, e.g. Duke, Southern Company, AEP, BPA, TVA, appliance manufacturers; for PGE: water heaters and electric vehicle supply equipment (EVSEs) and communication device makers to conduct field demonstrations targeting 10 units of each type of appliance; mostly at PGE employee homes. The goal is to advance end-to-end capability of demand response (DR) using the CEA-2045 communication interface (also known as the appliance socket.) This is a three phase effort beginning with project planning in 2013. Projected field deployment and demonstration starts between mid-2014 to early-2015. Non-EPRI program follow up and evaluation in 2016. With this proposal PGE intends to test demand response (DR) with hot water heaters and EVSEs as demand response tools into 2017 and 2018. Expected benefits to PGE include: (1) Influence the demand responsive behavior of appliances (by providing requirements to manufacturers thru EPRI); (2) Advance efforts that PGE proposed it would pursue as part of PGE's Integrated Resource Plan (IRP) and in PGE Smart Grid reports to OPUC and finally, (3) Advance or otherwise support PGE's Retail Market Strategy to provide innovative solutions for PGE customers.	SG	40,000
5. Transmission and Distribution Analytics Pilot Over a period of 3 years, initially proposed for 2014 - 2017, PGE's Transmission and Distribution (T&D) Asset Management group has initiated research into a detailed analytics effort involving meter and other T&D data. This has been a long planned effort with initial scoping in 2014 that has involved looking for adequate software and vendors to provide the "big data" analytics capability and long-term support. Asset Management is close to concluding best options and thus desires to proceed. This initial pilot will drive PGE's grid optimization efforts in support of a smarter grid (integrated grid) and will be very economic based on initial cost assessments. It is also consistent with PGE's Smart Grid Roadmap. If all goes as planned, 2018 will be the year where PGE will commit capital funding bringing this effort out of the R&D stage to full implementation.	SR	0
6. Dispatchable Standby Generation (DSG) Non-Emergency Emissions Conversion PGE's DSG Department will continue to continue to develop a testing and monitoring protocol that will meet newly enacted US EPA requirements in a cost effective manner. This would require PGE to equip an existing DSG site that has multiple generators with real time monitoring and information logging using a unique method of gathering values from pressure	SR	0

PGE R&D Projects for 2018		
Brief Description	**Topic**	**2018 $**
transducers, thermocouples, and data logging equipment to interface to existing DSG communications infrastructure. This research will validate the new exhaust monitoring equipment and interface to an onsite data logger integrated in existing PQ meters. If successful, DSG can roll out the technology to other DSG sites and enhance the usefulness of DSG beyond 50 hours/year. If successful, the allowed use of DSG generators will change from a limited number of hours/year (by EPA) to an unlimited number of hours. This will allow PGE to utilize the DSG generators for a variety of reasons that are not allowed now, such as peak power, demand response, economic dispatch, etc. The increased potential of the DSG generators is very valuable to PGE. If the creation of 'non-emergency' DSG machines is feasible, we will move forward with converting more machines, and increase the value of the DSG program.		
7. <u>Exportable Power Demonstration using EVs</u> PGE will monitor the deployment of fleet electric vehicles (EV) capable of exporting power to the grid (e.g. Via pickup truck or equivalent) to determine effectiveness, total cost of ownership, and exportable power capabilities. This would be done in the context routine (e.g., battery support when replacing a residential transformer) and resiliency applications (e.g., powering communications hubs). The project will also assess user sentiment when compared to using existing internal combustion engine vehicles in PGE's fleet for the same purposes. This project will also explore a vehicle to grid (V2G) demonstration involving Nissan Leaf EVs and the Princeton Energy Systems bidirectional charger/inverter. This project will allow the purchase and installation of two bidirectional charger/inverters for two used Nissan Leafs and allows control of the flow of electricity to and from the vehicle to the grid. Nissan North America has the ability to modify the 2013 and newer Nissan Leaf model SL or SV to perform Vehicle to Grid Functions and is interested in working with PGE to conduct a trial in PGE service area. Nissan will provide project support and vehicle modification at no charge. Princeton Energy Systems (PES) has created a V2G Inverter/Charger that connects to a modified Nissan Leaf that can allow bi-directional flow of electricity to and from the Nissan Leaf. Control of the power flow is through an interface with the PES device and can allow increasing/decreasing the charge rate or increasing/decreasing the export of power to the grid. This device is close to being approved for use in the US. PGE would like to effect this demonstration in a fairly high visibility location to ensure public access and educational opportunities.	ES	0
8. <u>PGE Employee EV Charging Behavior Research</u> With the increased penetration of electric vehicles (EV) and supporting infrastructure -- PGE needs to research various concerns as this use ramps up – for example: • charging and driving habits of EV customers • battery life & degradation as it relates to a driver's charging & driving habits • impact of TOU rate schedule on EV charging • commuting habits of EV drivers PGE has pursued this research via studying the driving habits and usage of PGE employees as part of this R&D project.	SG	0
9. <u>**EPRI** Program 62 – Occupational Health and Safety</u> The Electric Power Research Institute's (EPRI) Program 62 (P62) provides members with research relevant to current and anticipated occupational health and safety (OH&S) issues. The deliverables derived from PGE's engagement will be used to build, update, and sustain our occupational health and safety program. P62 also provides the ability to guide future Oregon Health& Science University ("OHSU") research for the industry while leveraging the experience, ideas, and funding of other electric utility companies. Deliverables relate directly to the influence of worker protective clothing (heat/cold stress); economic evaluation of ergonomic interventions; economic safety metrics/indicators; development of an exposure database; and SF6 decomposition by-products. Additional deliverables include monthly safety webcasts (recorded), a technical workshop, and access to EPRI's technical staff. By utilizing EPRI PGE has an information resource that will allow for better short- and long-term safety	OE	50,000

PGE R&D Projects for 2018		
Brief Description	**Topic**	**2018 $**
planning and strategizing. The program is designed to address both current issues and anticipate those of tomorrow.		
10. **EPR**I Program 180 – Distribution Systems Distribution system owners need to continually improve the efficiency and reliability of the distribution system, to accommodate a higher penetration of distributed energy resources (DER), and to maximize utilization of existing distribution assets without compromising safety and established operating constraints. Significant changes to distribution design and operating practices are needed to accommodate these new requirements. At the same time, utilities will continue to grapple with the ongoing challenges of an aging infrastructure, increasing customer expectations, increasing competition for resources, and an aging workforce. Recent experience with major storm events has also revealed a need to re-examine practices for designing, maintaining, and operating the distribution system to improve its overall resiliency. EPRI's Distribution Systems Program has been structured to provide members with research and application knowledge to support planning and management of the grid today and the transition to a modern integrated grid. The Program delivers a portfolio of tools and technologies to increase overall distribution reliability and resiliency; understand the expected performance for specific components throughout its life cycle; assess methods for evaluating the condition of system components; and develop and test new technologies. The program delivers a blend of short-term tools such reference guides and industry practices as well as longer-term research such as component-aging characteristics and the development of new inspection technologies. Overall, the Program includes research that supports grid modernization and provides tools for planning, design, construction, maintenance, operation, and analysis of the distribution system.	OE	170,000
11. Inspection and Correction – Below Grade Corrosion PGE is very interested in developing an inspection and correction program that facilitates learning more about below grade corrosion for its galvanized lattice towers, galvanized tubular steel poles and weathering steel tubular steel poles. The research should also include a survey of industry best practices. Presently, the Company has very little experience with evaluating the below grade condition of its steel structures. PGE will employ the services of a competent vendor or OSU, to research different techniques to evaluate below grade corrosion as well as devise and kick off a pilot program to begin looking at a sampling of its transmission towers. Early discussions between PGE and OSU note that existing corrosion rate monitoring techniques were mainly developed for measuring corrosion rate of metals with accessible measurement surfaces. For metals embedded in soils, the locations and sizes of the corroding surfaces are unknown because embedded steel surface in soil is inaccessible for direct measurements due to the presence of the thick soil cover which is electrically resistive. This limitation yields existing corrosion rate measurement techniques inaccurate, unreliable, and in most cases, unusable in field applications. The main hypothesis of the proposed research is that half-cell potentials on the soil surface can be used to identify the locations and sizes of anodic (positively charged) and cathodic (negatively charged) sites on the embedded metallic surfaces. The idea is similar to the concept of half-cell potential mapping for reinforcement corrosion in concrete, but with considerably different challenges. The soil cover has significant differences from concrete cover in chemical composition, thickness, porosity and microstructure. In addition, corrosion patterns of metals in soils are not the same as the patterns in concrete. Therefore, feasibility and applicability of half-cell potential mapping process need to be investigated. The proposed research is a multi-year effort with the following objectives: Year 1: Experimental investigation of the feasibility of half-cell potential mapping technique to identify corrosion of metals embedded in soils and identification of critical parameters affecting measurement accuracy. Year 2: Development of testing protocols to use half-cell potential mapping technique as part of regular field inspections by PGE.	SR	0

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Research will include assessing how well the technique works as well as correction methods including: below grade coatings, ground sleeves, grounding techniques, and cathodic protection. PGE has been in discussions with Oregon State University School of Engineering to craft a potential research agenda and attendant scope of work. It is likely that BPA will also find this research valuable and may also contribute funds to expand the work (e.g., different soil types, tower designs, etc.)		
12. <u>Battery Backup Demonstration with a Public or MUSH Facility</u> This project builds on a PGE field demonstration using a battery implemented in June 2016 at a PGE employee's residence. This project would create a customer or utility centric design that can be repeated at scale. This project is similar to the project crafted in Oct 2015 as part of PGE's submittal to the ODOE RFP for energy storage demonstration. The objective would be very similar to that project inasmuch as it involves a "battery-vault-on-the-feeder" design. Such a scalable design would have application at many public institutions facilities such as found at municipalities, universities, schools and hospitals (hence the term: "MUSH"). At scale, the design concept could also be supportive of non-wires solutions to regional transmission congestion.	ES	100,000
13. <u>EV Behavior for Battery State of Charge (SOC) Research Non-PGE Customer Employees</u> With the increased penetration of electric vehicles (EV) and supporting infrastructure -- PGE needs to research various concerns as this use ramps up; in particular attempt to understand; • charging and driving habits of EV customers • battery life & degradation as it relates to a driver's charging & driving habits • impact of TOU rate schedule on EV charging • commuting habits of EV drivers PGE has pursued this research via studying the driving habits and usage of PGE employees. This project utilizes a transponder device that delivers useful data sufficient to assess the above – this time using PGE employees who do not live in PGE's service territory.	SG	30,000
14. <u>NuScale Modular Reactor Study Group</u> PGE has the opportunity to assess the development and potential commercialization of the NuScale small modular reactor technology. PGE staff will do this by being part of a regional study and advisory group that has been assembled to periodically review developments regarding technical and licensing advances. This early look will help PGE assess whether, how and if this technology can advance to the point of being a cost-effective power generation solution for PGE customers and evaluation through its Integrated Resource Plan.	SR	5,000
15. <u>Biomass Supply Chain Development in Support of Boardman Conversion</u> Since 2009, PGE has investigated the potential to use torrefied biogenic biomass to displace coal at its Boardman Power Plant. This has been coupled to the need to pre-process the biomass through torrefaction in order to make the fuel sufficiently friable (crispy) so that it can be ground to a fine powder in the Boardman pulverizers. PGE has done early exploration in partnership with OSU Extension into a biomass supply chain via energy grass agronomy especially for Arundo and Sorghum. In 2016, PGE worked with Oregon Torrefaction, LLC to explore the availability of woody biomass derived in part, from USFS Forest Stewardship contracts out the Malheur National Forest. As Boardman gets closer to its commitment to cease use of coal at the end of 2020; PGE will need to firm its views of what will be the potential biomass supply chain components sufficient to fire the Plant at 30% to 40% capacity.	RP	110,000
16. <u>OSU Wave Energy Support</u> PGE continues its support of OSU to develop and test intermediate/full scale wave energy generation devices in the Wallace Energy Systems and Renewables Facility (WESRF) Lab (linear test bed), Hinsdale wave flume, and/or Northwest National Marine Renewable Energy	RP	30,000

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Center (NNMREC) open ocean test berth – Pacific Marine Energy Center (PMEC). This will demonstrate and expand the available renewable resources for PGE customers. In 2017/2018 PGE will continue its support of OSU research into specific component including mooring design, energy extraction and other critical equipment.		
17. <u>PSU-PGE Smart House Design; Streetlights; Smart City Research</u> PGE in collaboration with PSU will, through an interdisciplinary competition or incentive, attempt to create broad-perspective solutions for grid/renewable friendly "smart" homes. Focus will be on solutions for homes that have the ability to use and/or store renewable energy when over generation occurs as wind and solar generation approaches 50% in California and later in WECC. This is more commonly referred to as the "duck curve" when solar over generation will be evident especially in California due to its very aggressive renewable portfolio standard.	SG	10,000
18. <u>U of O, Regional Solar Radiation Data Center Project</u> This project supports the University of Oregon's ("U of O") longstanding collection and storage of regional solar energy data and the maintenance of calibration equipment. This data is supplied to the U. S. Department of Energy's National Renewable Energy Laboratory (NREL) and made available to all utilities for siting of utility scale solar projects. The calibrated solar instrumentation can also be used to validate PGE's present and future distributed solar photovoltaic (PV) resources performance; ancillary meteorological data will be used to estimate effects of wind on distributed PV solar resources. Supporting these local solar sensing stations provides PGE customers with more granular solar data useful for optimal siting of solar photovoltaic devices.	RP	10,000
19. <u>Portland State University ("PSU") – Investigate Wake Effects on Biglow Canyon Phase 3 Production</u> This project proposes research to optimize the blade length and rotor rotation for the Siemens wind turbines at Biglow Canyon Wind Farm. This will increase the performance/output at PGE's Biglow Canyon Wind plant and thus its overall power output with potentially only small capital outlay. The optimization research and resulting power modelling validation would utilize the wind tunnel available at PSU.	RP	20,000
20. <u>OSU – Real-time Load Modelling OSU's S-Phasor Network, Microgrid Reliability</u> The goal of this project is to better understand load models in order to advance grid protection of the next generation (integrated grid) power transmission and distribution infrastructure. With assistance from the growing PMU network at OSU, a composite dynamic load model can be estimated in real time and provide useful insight into the design of microgrid protection schemes. This will address challenges such as reverse flows, automatic reclosing, or delayed relay tripping. This project will provide PGE and its customers with insights about the benefits of deploying phasor measurement units (PMUs) at the distribution level yielding improved analysis of anomalies from modern, non-traditional loads, as well as synchronization between transmission and distribution level sensing.	SG	35,000
21. <u>OIT – Second Life Battery Research</u> This project allows PGE in collaboration with Oregon Institute of Technology (OIT), to learn about and implement uses of second life batteries. In particular, there is a desire to better understand the comparative life cycles of Li-Ion, Zinc-Bromide, and Sodium-Sulfur batteries as it applies to grid level storage/islanding applications. The approach would be to obtain multiple types of batteries that are candidates for the second life study: (1) Perform SOC (%), (2) capacity, (3) life cycle, and efficiency, (4) charging-discharging, and reaction time analysis of candidate electro chemistries. This project will deliver a formal, evaluated report with the comparison data. These results would allow PGE to be better positioned to understand how 2^{nd} life uses of long-lived batteries can be cost-effectively applied to other applications that will benefit its customers. These tests will be conducted at Oregon Renewable Energy Center	ES	35,000

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(OREC) under a controlled environment.		
22. <u>OIT – Comparative Studies of Energy Storage: CAES, Batteries, Super Caps</u> PGE and OIT propose collaborative research to simulate proposed, new energy storage systems in combination with design and testing of small scale energy generation/storage devices at the Oregon Renewable Energy Center (OREC). The simulation would generate data to determine, for various applications, the optimal storage systems for PGE. These simulations would help PGE and its customers understand: • Compressed air energy storage systems: efficiency, feasibility, capacity, and geological requirements/impact studies • Ultra-Capacitors: Graphene and Carbon Nanotubes, Charging & Discharging Characteristics • Hybrid Li-ion & Ultra Capacitor Systems: reaction time, cost • Cost of implementation, Peak load applications, long term applications	ES	35,000
23. <u>Torrefied Biomass Fuel Test Burns for Multiple Days - Proof of Concept</u> Since 2010, PGE has embarked formally on a large R&D effort to assess the feasibility of displacing coal at its Boardman pulverized coal plant with torrefied biomass. This project extends that effort with work to fine tune both the production and the use of the new fuel in the Plant's boiler. The project will also support evolution of new fuel handling, processing and safety procedures associated with both green and torrefied biomass. The project will also closely monitor torrefied fuel performance and emissions in both co-fire, as a transition, and 100% torrefied biomass applications. This project specifically evolves support and techniques to safely and cost-effectively apply torrefied biomass as fuel to displace coal at the Boardman Power Plant.	RP	300,000
24. <u>**EPRI** P60 EMF and RF Health Assessment & Safety (3-year)</u> The Electric Power Research Institute's (EPRI) Program 60 addresses electric and magnetic field (EMF) and radio-frequency (RF) exposures and health issues. Planning and building new transmission and distribution (T&D) projects takes on heightened importance as the power grid is upgraded and modernized by increased asset capacity and integration of smart grid technology and remotely-located renewable energy resources. New T&D construction and capacity upgrades to T&D lines and substations, building electric vehicle (EV) charging infrastructure, and expansion of smart grid technology's reliance on two-way wireless communication, can create public concerns about possible human health risks from EMF and RF exposures. Such concerns can lead to lengthy delays and regulatory decisions affecting project schedules and costs. Program 60 provides PGE with research, analyses, and expertise to better inform public dialogue and regulatory oversight. It is comprised of two project sets, P60A: Community and Residential Studies and P60B: Occupational Studies. These deliver timely, reliable EMF and RF research results, including communication materials, relevant background information, and analyses of key external studies. Program 60 research, combined with EPRI staff expertise, contributes to EMF and RF scientific knowledge, better enabling objective health risk evaluations and exposure guideline development aimed at reducing uncertainties for PGE customers and PGE workers	SR	146,000
25. <u>**EPRI** P64 Boiler and Turbine Steam & Cycle Chemistry</u> Safety and availability loss due to failures are two key issues driving R&D on major fossil power plant components, especially in older plants. Operators need to minimize major causes of lost availability and associated maintenance costs related to corrosion and inadequate cycle chemistry, and prevent boiler tube and turbine blade/disc failures and flow-accelerated corrosion (FAC). Generation assets are experiencing increasing demands for greater operating flexibility, low-load operation, and more frequent unit shutdowns and cycling. These demands are raising	SR	30,000

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additional key issues, including the dynamic impacts on plant systems and the preservation of equipment. Operators need to minimize and mitigate the increased risk of corrosion damage and component failures presented by these special operating regimes. EPRI's Boiler and Turbine Steam and Cycle Chemistry Program offers guidelines, technology, and training materials to help plant operators manage water/steam cycle chemistry, reduce unplanned outages and operations and maintenance (O&M) costs, and improve unit efficiency, as well as address chemistry requirements of flexible operation and proper equipment storage. The industry needs to balance risks & costs of the most costly equipment by using proven technologies to create solutions. By using the results of the R&D in this program, members can: • Improve overall unit availability and flexibility: Losses due to improper chemistry have a 1% or more effect on unit availability • Reduce steam turbine efficiency losses: Chemical and metallic oxide deposits reduce turbine efficiencies by up to 2%		
26. **EPRI** P68 Instrumentation, Controls and Automation Instrumentation and control (I&C) systems affect all areas of plant operation. Every component, process, system, and person relies on instrumentation and controls to identify, communicate, and control process data to ensure the safe, reliable, efficient and cost-effective operation of the plant. As older plants continue to age and new plants are built, instrumentation and control systems become increasingly more vital in helping a power generator meet its strategic mission of capacity, efficiency, and reliability. EPRI's Instrumentation Controls, and Automation program identifies, develops, and demonstrates state-of-the-art sensing, monitoring, diagnostics, and control system technologies that improve equipment condition assessment and plant performance, and help accurately measure critical plant parameters. This program focuses on providing integrated instrumentation and control solutions that enhance processes, technologies, and operations and maintenance, which can enable program members to: • Reduce costs through greater automation in tuning of process controls and operating point transitions. • Improve reliability through integrated anomaly detection, diagnostics, and prognostics. • Improve reliability through more effective equipment monitoring, made possible through collaborative R&D.	SR	47,000
27. **EPRI** P69 Maintenance Management & Technology The Electric Power Research Institute's (EPRI's) Maintenance Management & Technology program helps power generation plant owners and operators address common industry challenges related to maintenance program structure and functionality. EPRI works with top-performing organizations to collaboratively research and develop maintenance processes and technologies that help improve the safety, reliability, and performance of plant equipment and organizations. Research projects include efforts to identify potential causes of equipment failures, effectively monitor and assess the condition of equipment, and proactively plan for equipment maintenance. A significant part of these research efforts involves the management and communication of data and information necessary for monitoring and maintaining power plant assets. This program helps its members transition to, and sustain, the most efficient and effective practices associated with plant maintenance. The key attributes of an optimized program are adoption of information management needed to support a condition-based approach to maintenance, and replacement of costly corrective maintenance with proactive preventive maintenance. Using the results of this program, members can: • Achieve operation and maintenance excellence through an integrated approach that includes process improvements, related technologies, and knowledge management • Address current issues associated with the need for flexible plant operations, asset retirement, and new reliability standards	SR	72,000

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• Better standardize O&M programs, processes, and procedures • Increase plant availability and reliability through improved maintenance management and staff performance		
28. **EPRI** P94 Energy Storage and Distributed Generation Energy storage and distributed generation technologies are attracting increasing interest from utilities and regulators as localized flexible grid assets. Storage can act as a buffer between electricity supply and demand, increasing the flexibility of the grid and allowing greater accommodation of variable renewable resources. Distributed generation (DG) entails the production of power at or near load centers, thereby augmenting or substituting electricity infrastructure with DG fuel infrastructure, where appropriate. Both storage and DG may provide temporary solutions for regional and local capacity shortages, and may provide relief to localized transmission and distribution congestion. Technology advances, as well as investment in production capacity, have resulted in significant cost reductions of energy storage and distributed generation. However, the economic use of these technologies still generally requires the user to take full advantage of multiple potential benefit streams ("stacked benefits"). The various applications that contribute to the value of distributed resources have different requirements, and the ways in which these requirements are coincident or competitive are still being explored. Technologies such as fuel cells, micro turbines and small reciprocating generators are still relatively expensive in terms of installed capital cost, but low fuel costs and opportunities offered by the application of combined-heat-and-power (CHP) architectures may make them increasingly cost-effective options in the future. It is important to understand the factors that may make storage and distributed generation technologies technically and economically viable in the future, whether the devices are owned and operated by utilities, by customers, or by third-parties. While storage and distributed generation options are rapidly maturing and are beginning to become practical in grid applications, there are still significant challenges to overcome.	SG	100,000
29. **EPRI** P104 Generation Maintenance Applications Center Power generators globally face chronic equipment problems in the more than 1,500 non-nuclear generating units that are up to 30 years old or older. Power generating companies are constantly seeking to reduce maintenance-related O&M costs for aging equipment while improving unit reliability through incremental component improvements, but are challenged by diminishing collective experience and knowledge and an urgent need to develop new maintenance and engineering staffs as the current workforce retires. The training and knowledge that are needed to educate and inform new staffs are not always readily available from vendors or equipment suppliers in a comprehensive format ready for use. New maintenance challenges are created by the addition of equipment to upgrade the performance and improve the emissions of these existing plants. In addition, new generation in the form of combined-cycle combustion turbines, bio-fuel boilers, and wind farms is adding to the need for innovative development guidance for the new types of balance-of-plant (BOP) components in these units that was not previously included in GenMAC's portfolio. EPRI's Generation Maintenance Applications Center GenMAC program provides practical information for improving plant maintenance-related operations and maintenance processes, reliability, and cost through collaboration with participating organizations. Materials can be used to transfer base knowledge to workers new to the organization and by experienced staff searching for reliability enhancements for maintenance tasks.	SR	40,000
30. **EPRI** P194 Heat Rate Improvement Program PGE always attempts to contain operating costs and this increases the need to improve plant heat rates. Heat rate improvements bear a direct relationship to tonnage releases of all air emissions, including CO_2. The integration of heat rate assessment capability into retrofits of operating	OE	0

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plants and new plant designs is critical to ensuring the optimal efficiency in plant operations. The focus of the Electric Power Research Institute's (EPRI's) Heat Rate Improvement program (Program 194) is to improve operating plant heat rate, independent of the fuel fired. The program will advance the state of the art, benefitting all power generating companies -- including those now starting performance improvement programs and those with vast experience and mature programs. The efforts behind improving heat rate require a broad understanding of power plant design, operation, maintenance, ambient conditions, thermal sciences, combustion, and the type of fuel fired. To be successful, many factors must be taken into account to ensure results are both cost-effective and do not create problems elsewhere in the plant. The Heat Rate Improvement program activities include research on thermodynamics, auxiliary power consumption, heat transfer, plant processes, controls, new hardware, fluid dynamics, measurement, and software, in addition to issues related to fuel quality and the combustion process. The Heat Rate Improvement program focuses on an approach that cost-effectively enhances power plant efficiency without creating side effects. Potential heat rate improvements include: • Significant savings in fuel costs and are by far the lowest-cost and a proven and commercially available method for reducing CO_2 emissions. • Overall combined-cycle plant performance, permitting those sites to reduce fuel costs per MW as their capacity factors increase. • Cost savings through improved boiler performance, regained capacity, and increased flexibility in fuel sourcing. • Revealing reliability related problems in the quest to identify performance or thermal efficiency problems, permitting timely maintenance and a reduction of generation costs. • Enhanced operational flexibility by improving plant performance at part and low load.		
31. **EPRI** P170 End-Use Energy Efficiency and Demand Response The electricity industry must meet customers' continuous demand for power as well as provide safe, reliable, affordable, and environmentally responsible service to customers. Utilities and policy makers in the United States and abroad are increasingly turning to energy efficiency as a resource to help address these challenges. Many U.S. states have enacted legislation that mandates specific energy-efficiency savings goals, and some explicitly require utilities to place energy efficiency as the first opportunity in their resource planning initiatives. Key to the realization of these goals is the development and adoption of emerging energy-efficient technologies and best practices. It is also important for utilities to characterize the grid impacts of customer interaction with emerging energy technologies, and to develop platforms for their integration as resources to enable an Integrated Power System. Interaction with the 'connected' customer that will provide both energy efficiency and demand response benefits to those customers that are crucial for the "utility of the future". This program is focused on the assessment, testing, demonstration, deployment, and technology transfer of energy-efficient and demand-responsive end-use technologies to accelerate their adoption into utility programs, influence the progress of codes and standards, and ultimately lead to market transformation. The program also develops analytical frameworks essential to utility application of energy efficiency and demand response (DR) in order to enable the Integrated Power System, with particular focus on end-use load research and data analytics.	SG	5,000
32. **EPRI** P173 Bulk Power System Integration of Variable Generation There has been a significant increase in the implementation of renewable energy, due to state mandated policy decisions on renewable energy standards and federal air and water standards, along with improved economic viability for these resources. Much of the estimated development of renewables comprises variable resources as wind generation and solar photovoltaics (PV), which when integrated with the grid, create new challenges for maintaining reliable system operation. Future projections are that a more significant build-out of these variable renewable resources is likely at both the transmission and distribution levels. Power system planners and	SG	75,000

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operators will require new tools and resources to ensure a reliable, sustainable, and cost-effective supply of electricity to consumers. New tools needed include improved and/or new sources of system flexibility to respond to and accommodate the increase in energy variability and uncertainty, the development of additional transmission infrastructure to deliver energy from remote locations, and planning and operational methods and software to effectively plan and operate the bulk system with these new resources, many of which may be at the distribution level. This research program addresses these needs and directly supports EPRI's Research Imperatives #2 "Integration of Dynamic Customer Resources and Behavior" and #3 "Integrated Power System and Environmental Modeling Framework." Research is focused on -(1) The Bulk Power System Variable Generation Integration research program which provides variable generation integration analytics; (2) development of planning and protection methods, tools, and models; and (3) development of operator methods and tools to reliably and economically integrate wind and solar PV generation.		
33. **EPRI** P174 Integration of Distributed Energy Resources Increased amounts of distributed energy resources (DER) in the electric grid bring a number of challenges for the electric industry. Utilities face large numbers of interconnection requests; distributed generation on some circuits will exceed the load; and many operating challenges involving feeder voltage regulation, hosting capacity limits, inverter grid support and grounding options are involved. Furthermore, providing reliable service as DER penetrations increase and electricity sales diminish can also add economic and business challenges to the technical ones. This Program addresses these challenges with project sets that assess feeder impacts, inverter interface electronics, and integration analytics. The Program evaluates case study experiences and strategies related to future business impacts. It also evaluates leading industry practices for effective interconnection and integration with distribution operations. Many of these activities support EPRI's "The Integrated Grid" initiative. This Program includes lab and field evaluations and demonstrations of improved DER power management and communications. A primary objective of the work in the field is to expand utility hands-on knowledge for managing distributed energy resources—without reducing distribution safety, reliability, or asset utilization effectiveness. Moreover, the optimal integration of distributed energy resources, like solar photovoltaic (PV) generation, has the potential for significant public benefits. These include reduced climate impact of overall electric power generation, potential for more efficient and optimum operation of the electric system through efficient generation closer to the load and even improved resiliency with local generation to provide power during major events on the grid. Achievement requires making these distributed resources a part of the planning and operation process inherent to an Integrated Grid.	SG	40,000
34. **EPRI** P183 Cyber Security This program develops an analysis framework to correlate cyber, physical, and power system events including: • Development of security event scenarios that utilities can adapt to their operational environment • Identification of operational and asset condition data sources to support event detection; and • Results and lessons learned from testing and demonstrating scenario detection in EPRI's lab as well as utility host sites. Utility enterprises are evaluating cyber security threats to their communication networks in a way that integrates that information with other traditional information about equipment health status and power system status. It is now time to integrate this information into a comprehensive and consistent picture, for use by power system operators and communication system operators, in order to provide a system-wide view and to improve coordination of operator responses. This project intends to focus the "Analysis" component of the Integrated Threat Analysis Framework (ITAF) by developing and testing broadly applied use cases and potential data analysis methods to determine when a malicious event has taken place. While the aggregation of data from these	SR	95,000

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domains (Information Technology, Operations Technology, Physical, threat indictors, etc.) provides a view across the entire utility enterprise, determining how to use this information to make decisions will be very challenging. The operational environment will vary day-to-day due to changing conditions (weather, loading conditions, availability of variable resources, planned or unplanned maintenance, etc.) so the use cases must be dynamic and represent a growing knowledge base as opposed to a set of static scenarios. This challenge will require expertise in both cyber security and grid operations. This project coordinates activities of three EPRI research programs: Substations (P37), Grid Operations (P39), and Cyber Security (P183) in a way that is intended to provide broad power industry and public benefits, including better communication between diverse utility personnel and public service personnel.		
35. **EPRI** P199 Electrification for Customer Productivity PGE's industrial and commercial customers are constantly striving to increase productivity and enhance their competitiveness in the global marketplace. In many cases, electrification – i.e., the application of novel, energy-efficient electric technologies as alternatives to fossil-fueled or non-energized processes – can boost utility productivity and enhance the quality of service to these customers. Electricity offers inherent advantages of controllability, precision, versatility, efficiency, and environmental benefits compared to fossil-fueled alternatives in many applications. A lack of familiarity and experience with emerging technologies, however, impedes many customers, particularly small- to medium-sized businesses and civil institutions, from pursuing electrification measures that can improve the productivity and efficiency of operations. Such enterprises would benefit from information and support from PGE. However, electric utilities themselves face obstacles to serving as effective utility partners in this regard. Identifying and measuring the prime opportunities for electrification in a given service territory can be difficult. One of these is the lack of an analytical framework for quantifying the net benefits of electrification strategies – from the customer, utility and societal perspectives. The P199 research program aims to address gaps like this by developing and refining analytical tools and an objective knowledge base of technologies, applications, and markets and facilitating stakeholder networks to help utilities evaluate and pursue electrification opportunities in partnership with their customers.	SG	0
36. **EPRI** Power Quality Knowledge Development and Transfer Deregulation has been made even more difficult for utility management of electrical power quality issues. It has grown even more difficult with deregulation, reregulation, increasingly scarce technical and strategic tools, and a conspicuous lack of unbiased resources for information, collaboration, advice, and problem solving. Moreover, with the ever-increasing use of sensitive digital and electronic equipment in today's economy, PGE's end-use customers are not only demanding higher quality power, but also are calling upon it to help resolve PQ problems within customer facilities. This EPRI supplemental project offers a number of benefits, including: access to EPRI experts and industry peers, access to high-impact resources, such as documents covering a wide range of PQ topics, and access to MyPQ.epri.com, a comprehensive electronic PQ resource providing 24/7 access to more than 500 PQ case studies, PQ technical documents, PQ standards references, indexes, conference presentations, and a wealth of other resources.	OE	30,000
37. Salem Smart Power Center (SSPC) Use Case Testing & Validation PGE has implemented the Salem Smart Power Project (SSPP) delivering five assets that were funded as part of the US DOE's 5-year, $178 million Pacific NW Smart Grid Demonstration Project. The SSPP effort expended $25 million of which 50% of the cost was covered by US DOE stimulus funding beginning in 2010. The remaining 50% was 50-50 cost shared between PGE and its principal vendors: Enerdel, Eaton and Alstom. PGE's overall cost was $6.5 million and yielded the Salem Smart Power Center (SSPC) which showcases a 5 MW, 1.25 MW-hr lithium ion battery-inverter system (BIS) and related assets – all of which have been capable of	SG	0

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responding to a transactive control signal. The facility is located at PGE's Oxford substation in Salem Oregon and is grid-tied via the 12.4 kV Rural Feeder line. Sixteen use cases have been identified of which 9 have either been validated or discarded for potential autonomous single use. Below are the remaining cases PGE should continue to pursue. After single use validation, optimized concurrent use for multiple use cases will be attempted. • 400 kW of Demand Response Benefit (DR) • 1.3 MWh of Energy Shift from on-Peak Costs to Off-Peak Costs • 2 to 4 MW of Real-time Voltage Support for System Operations • ≈ 1.2 MWh of Off-Peak ability to Absorb Excess Wind Power • Distribution Automation Using Advanced, Intelligent Switches • Adaptive (Dynamic) Conservation Voltage Reduction • Using the SSPP as a Dispatchable Standby Generation Resource		
38. <u>Develop & Assess Model to Gauge DSG Program Target Capacity</u> PGE's dispatchable standby generation (DSG) program is unique and currently possesses 107 MW of dispatchable power largely in the form of diesel fueled gen-sets at over 60 customer sites. The DSG program has unparalleled capability to supply non-spinning reserve and has been a remarkable addition to PGE's non-central station power generation mix. This research proposes an effort to model and then understand the possible upper limit of the DSG effort and most importantly – discern the governing, if not principal limiting factors. This assessment will allow PGE to best deploy its resources to optimizing the program on behalf and for the benefit of all its customers.	SG	0
39. <u>Behind the Meter Use of Energy Storage & Solar PV – Customer Behavior</u> As noted by the US DOE, energy storage applications can be closely coupled to smaller scale applications. Commonly mentioned applications include: • Demand Response Programs for peak shifting • Integration with Electric Vehicle Infrastructure for energy storage and peak shifting • Commercial Building integration to optimize energy use; support Peak Energy Shift • Integration with Residential Use cycle(s) for peak shifting With this background, PGE proposes explore to opportunities to engage customers in buying or contracting for energy storage at their buildings, for both residential and small commercial. The behind-the-meter (BTM) storage market is still nascent, with two leading companies Sonnen and Tesla PowerWall, the former with almost 1,000 systems deployed in the US and the later starting to ship product. Utility programs offering these types of systems are also new; existing programs provide a platform where customers can buy or lease the battery/inverter system (BIS) to provide backup power to the home during an outage and used by the utility for utility services during other times. There is still a lot of work needed including to determine ownership structures, the value of the BIS to both the customer and the utility, and proving distributed energy resources can be controlled and used for utility services. PGE believes, however, that these systems are coming and that PGE, on behalf of its customers, needs to gain experience in installing and operating the systems as well as to develop a strong partnership with the vendors. Therefore this project will 1) install a Sonnen Battery system at an employee's house and 2) install a Tesla Powerwall at Portland State University. As a result, PGE on behalf of its customers, expects to: • Develop a partnership with each vendor • Learn about the procurement and installation process	SG	75,000

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• Collect and analyze BIS operational data: o Round trip efficiency – quantify lifespan degradation over time o Analyze outage information – how long did the battery hold up the house? o Charge/discharge rates o Noise o Response time o Demonstrate local integration of renewable generation • Demonstrate control of distributed storage for utility applications • Obtain employee feedback on implementation, operation during outages, ways to improve service and terms of service, effect on lifestyle, peace of mind, etc. • Demonstrate the reduced cost of storage for utility applications by capturing the value for customer reliability (reduced outage time) • Determine the value of local renewable integration • Validate 10% capacity credit, as compared to central generation For the PowerWall option assess the safety of the system for residential applications		
40. **EPRI** Computer Based Training Modules for Sulfur Hexafluoride (SF6) Handling EPRI's SF6 (Sulfur Hexafluoride) Computer-Based Training (CBT) Modules consist of five sub-modules that each provide approximately one hour of instruction to users on SF6 topics. A browser interface helps the user navigate through the interactive training. As the user moves through the module, it provides instruction and assessment. At the end of the module, the user receives a final scored assessment and a pass/fail result. Five SF6 sub-modules are included in the package: Safety, Handling, Analysis, Detection and Environmental Impact. These computer-based training modules are maintained as part of "Program 37: Substations", The program and the CBT provide updated and efficient training covering a large amount of SF6 knowledge in a highly usable format. SF6 is used in electrical switchgear as an insulating gas and has both industrial hygiene and greenhouse gas concerns if handled inadequately. Training materials will be used primarily for transmission and distribution (T&D) personnel and as new or better practices evolve – this EPRI program will allow PGE to stay current with best practices.	OE	10,000
41. **EPRI** P87 Fossil Materials and Repair PGE's fossil power plants are increasingly tasked with flexible operations, pushing for maximum output during peak price periods, transitioning to low-load and multi-shift operation, and frequent fuel switching to take advantage of spot market opportunities on behalf of its customers. These practices can accelerate material damage in major power block components due to frequent cycling of operations, i.e., increased "wear and tear". New materials are being introduced for replacement of components in aging plants, in the building of higher-efficiency power plants, and in the construction of components with thinner walls for improved operational flexibility. Regulations on air and water quality have resulted in construction of new pollution control equipment and water management technologies that are more demanding on materials than older systems. Improved knowledge of materials behavior in this environment allows for accurate prediction of remaining life, proper choice of repair strategies, and optimized material selection, fabrication, and repair. To address these needs, PGE proposes to participate in EPRI's Fossil Materials and Repair program (Program 87) which provides integrated materials selection guidance, repair and welding technologies, and corrosion mitigation methods to improve equipment performance, reliability, and safety on behalf of its customers. Research is conducted in all areas of the fossil power plant, including the major power block (boilers, HRSGs, steam turbines, gas turbines, etc.) and the balance of plant. Goals of this program include: • Increase availability through better understanding of plant materials. • Minimize or eliminate -- repeat failures and equipment damage, and reduce outage frequency and duration by using improved knowledge of damage mechanisms and tools	SR	50,000

PGE R&D Projects for 2018		
Brief Description	**Topic**	**2018 $**
for life-assessment methods. • Reduce failures from high- and low-temperature corrosion. • Obtain in-depth knowledge of advanced ferritic and austenitic alloys and processes used to fabricate and join these alloys. • Select appropriate weld filler metals and processes for construction and repair. • Reduce outage time and manage maintenance costs through implementation of innovative repair techniques. • Maximize component life through improved materials selection guidance and procurement specifications.		
42. Multi-Family Energy Management (2-year project) The goal of this project is to evaluate smart energy management technology for energy efficiency and demand response benefits in the multifamily sector. Study partners include: EQL Energy, Portland State University, IOTAS, Energex, and College Housing North. The Study proposes to include two vendors' suite of products, at 4 sites (3 using Iotas, 1 using Energex), and will examine energy savings that comes from controlling HVAC equipment based on sensor data, occupancy, consumer behavior, and control features. The two vendors have distinct differences in experience, target customers, platform cost and functionality. This study will be able the collection of data and evaluation of many of the energy saving variables associated with multifamily energy use, e.g., landlord and tenant behavior, environmental and energy use feedback, and effectiveness of sensor and control technology. This study will examine savings information only to Information, sensors plus enabled controls (smart). The principal deliverable will be to quantify the amount of energy and capacity savings improvement when users can employ smart sensors and control, versus the information only scenarios. This research addresses use of smart technology to increase energy efficiency of multi-family structures and to the extent it proves itself – will allow PGE to recommend to customers – technologies to lower their energy costs.	SG	60,000
43. **EPRI** P88 Combined Cycle HRSG and Balance of Plant (3-year) This research will use work performed by EPRI to improve the design and operation of the heat recovery steam generators (HRSGs) at PGE. This work can be utilized by plant operation and maintenance teams and the corporate engineering group for the design of new plants, and the project engineering group when it comes to new upgrades/improvement projects to ensure that the new projects take into account the latest and best practices are included in the new design. The research information included in program 88 will provide training material for PGE employees, and keep best practices available so that PGE works proactively in identifying issues and addressing them, before these issues can become a safety concern or impact plant reliability. Joining Program 88 will also allow PGE to have input on the projects that will be evaluated by EPRI and participating industries that are not electric utilities. This will benefit PGE by having EPRI work on projects that are specific to PGE. PGE can also benefit by utilizing the EPRI team as a resource when it comes to evaluating design of new projects or other evaluations related to program 88. PGE currently owns 3 HRSGs not including Beaver or Coyote 2 unit. Some of the plants are around 10 years old and it will be very important for PGE to stay at the forefront of the new research s and apply the latest technology to our HRSGs. This may be even more important as PGE prepares to enter the Energy Imbalance Market (EIM).	SR	68,000
44. Utility Demonstration Projects & Pilots – Best Practices; Lessons Learned PGE conducts many demonstration and pilot efforts to better serve its customers. This project will help improve our process related to the development of all pilots and technology demonstrations by understanding what we do particularly well and where we can learn from other utilities successes and failures. This collaboration will focus on distilling lessons learned from recent utilities (see below) and customer experiences. Rather than providing specific technical support for particular projects, the emphasis of this research is to identify broad best	OE	30,000

PGE R&D Projects for 2018		
Brief Description	**Topic**	**2018 $**
practices in the design, structure, and execution of pilot and demonstration projects. It provides the first attempt to benchmark PGE's pilot and R&D approach against other utilities. Past and present participants include: Rocky Mountain Institute (convener), ConEd, Avista, APS, (confirmed) and other utilities (possibly SCE, SMUD, Duke, Xcel, National Grid, PSE, and Entergy). PGE will use these learnings to revise and improve our process and approaches to pilot development and design.		
45. <u>Oregon BEST – NW Energy Experience Prize Participation</u> In 2015 and 2016, PGE has participated in the NW Energy Experience Prize (NW Energy XP) program. The effort fosters and leverages collaboration between several universities, along with subject matter experts from regional utility and power companies. The program gives students hands-on experience and knowledge that cannot be learned in the classroom. In return, utility staff gets in-depth research on selected topics / problems facing today's power and utility industry. Participating universities include PSU, OSU, OIT, UP, and WSU-Vancouver. Past topics of interest to PGE include: use of drones for high tower inspections; impact of demand response penetration; impact of distributed renewable power penetration into PGE's service territory. Topics anticipated for 2017 consideration include demand response, renewable biomass use and smart city topics. If any of these are selected it will be likely that PGE will commit funding in either 2017 or 2018 to pursue a partnership with the sponsoring universities and their research team(s) as part of this program.	SG	0
46. <u>Non-Wires Solutions to Transmission Congestion</u> PGE in collaboration with PSU proposes a competent and authoritative research paper to set context and to analyze the possibility of using recent energy storage advances to alleviate grid congestion. . The Pacific Northwest transmission grid is congested, and especially true of east-west electricity movement, including localized areas. The congestion has grown over the years due to load center growth on the west side of the Cascade Mountains and the proliferation of wind power plants on the east side of the mountains. As BPA controls 75% of the region's transmission system this is a top concern of PGE and its customers, since PGE has a heavy reliance (as do virtually all electric utilities in the region) on the BPA system. In southwest Washington and Multnomah County, Oregon where the population has more than doubled there has been no transmission line upgrade or expansion for forty years. This led the BPA in 2011 to propose the "I-5 Corridor Transmission Reinforcement Project" to construct new transmission to help relieve congestion for Cowlitz, Clark and Multnomah Counties. This is roughly a 70 mile run extending from Longview Washington to Troutdale Oregon with construction alternatives being evaluated on the Washington side of the Columbia River. The ability to construct new transmission lines is expensive, daunting and given recent experience might not be possible at any price. The advent of large grid-scale energy storage systems of which PGE's Salem Smart Power Center is an example suggests the possibility of a non-wires option to help relieve transmission congestion. Energy storage can effectively serve as a "wide spot" in the pipe and with a sufficient number of installations could eventually widen the pipe entirely and be a viable solution to the congestion issue.	AR	25,000
47. <u>Resiliency Applications of EVs in Post Seismic Events or Equivalent (V2G)</u> The use of electric vehicles (EV) to support recovery efforts after a natural disaster is of growing interest to emergency planners. From their perspective, electric vehicles are more than just cars - they are also mobile batteries that can provide back-up power to homes, pop-up clinics, and shelters, and offer a more reliable source of transportation than gasoline-dependent vehicles. Perhaps the most notable example to date of electric vehicles being used in emergency response occurred within just two years of the first models coming onto the market in 2010. After a massive tsunami and earthquake hit Japan in 2011, the Nissan LEAF, Mitsubishi i-MiEV, and other electric cars <u>were used as generators and a reliable mode of transportation</u>, demonstrating the technology's advantages. This project will explore this emerging topic – to include looking at the benefits as well as the challenges of using electric vehicles to support recovery efforts after a	SY	25,000

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Brief Description	**Topic**	**2018 $**
hurricane, earthquake, or other disasters. The research will also review strategies for incorporating electric vehicles into an emergency response plan. The research will address the central question -- if electric vehicles are considered an asset, how can planners and government leaders prepare their organizations and their communities to fully take advantage of them?		
48. <u>Exploring Bidding the SSPC Battery Inverter System Capacity into the EIM</u> PGE understands that its 5 MW, 1.25 MW-hr grid-connected lithium ion battery inverter system (BIS) located at the Salem Smart Power Center has the potential to participate in the nascent energy imbalance market. Should this transpire, controls and control software will need to be researched and implemented. This would be accomplished in the context of eventually optimizing the BIS use against other competing use cases such as the present highest value use which is frequency support. Inasmuch as bidding the SSPC battery into the EIM would be a first attempt – PGE will need to explore the best methods to do this in collaboration with PGE Power Operations either on a manual or automated basis. Doing this successfully would bring intellectual capability to PGE engineers and software programmers that will be well placed as even more batteries or other types of energy storage devices connect to the grid and also have a role in the EIM.	OE	15,000
49. <u>Analytical Pilot Study - Demand Impact Forecasting & Validation Technology</u> This project is an analytical pilot study and reporting of estimates related to precision and applicability of demand impact forecasting and validation technology within the PGE service territory for each individual customer with the aggregate program at an hourly resolution. The effort will also include historical cross-validation and back-casting (purposefully challenging a model with real data and a known outcome to see how well the model predicts the outcome) to measure the expected performance of the models. If successful, PGE will be equipped to decide on the viability of consumer-level forecasting for the purposes of using residential DR programs as a reliable peak load reduction and shifting option, and on the viability of performance-based individualized compensation measures. PGE will research how best to securely share interval data with TROVE Data Science of DR participating customers, specifically those involved in the Residential Pricing Pilot. TROVE will use this data as well as their own third-party attribute data to build predictive models at the customer-level to measure demand impacts for each historical event and future events for the upcoming year.	OE	125,000
50. <u>WSU – Power Engineering Energy Innovation (ESI) Center Data Access</u> Washington State University's ESI Center brings together research faculty, business leaders, and governmental organizations to address the technological challenges inherent in the demand for renewable, clean and reliable energy. The center consists of more than 30 WSU faculty members. Thirteen are in the core areas of power, energy, and computer science. More than twenty are in sociology, economics, psychology, communication, and public policy - helping bridge the gap between science and society. The center also collaborates with a wide range of government and industry partners. The center's focus areas include renewable energy; social and economic incentives; information collection, delivery, and analysis; decision support; efficient use of right-of-way and associated economic issues; and cyber security of the smart grid. Many of these topics are of interest to PGE especially in light of Oregon's SB 1547 mandate for PGE to achieve 50% renewable power by 2040. PGE participation in ESI can lead not to just data and information access but also to collaborative research that is co-funded by larger granting institutions such as the US DOE. PGE believes that participation in this opportunity will better position its staff to implement smart grid applications with special emphasis on renewable power penetration into the Pacific Northwest grid. This combination would benefit PGE's overall customer base.	SG	25,000
51. <u>Collaboration with BPA Innovation Technology Program (up to 15 Topics)</u> PGE staff has long been aware of Bonneville Power Administration's (BPA) extensive research capabilities and funding as part of its Innovation Technology Program. In recent years, BPA	SG	100,000

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management has invited PGE staff to sit in on annual reviews of the entire program. PGE staff have also participated on joint BPA-PGE research projects to ensure mutual leverage of strengths via the partnership. With this partnering foundation set in place, this research project seeks to identify PGE interest in BPA research projects where PGE would increase its presence on select topics to provide knowledge and funding on specific projects to BPA staff and in return, PGE would leverage, on behalf of its customers BPA's much larger R&D budget as embodied in its Innovation Technology Program. At present, PGE staff have identified up to 15 topics where such mutual leverage will likely be useful. Examples of potential collaboration areas include: Home Battery Systems; MW Scale Battery Energy; Demand Response; Cold Spray – Hydroelectric Turbines and Advanced Wind Generation Forecast Error.		
52. Low Income, City of Portland Multi-Family Heat Pump Water Heater Demo PGE and the City of Portland will participate in a collaborative demonstration to assess the ability to incorporate highly efficient heat pump water heaters in multi-family buildings that cater to the low-income segment of our customer base. This project will assess the logistics of helping foster a higher penetration of this equipment as well as provide objective costs and resulting benefits that derive for the residential and commercial customers of PGE's low-income segment	SG	30,000
53. Exploring Digital Personal Assistants to Lower Utility Transaction Cost The advent and penetration of the internet of things (IoT) is increasing and more often than not can find potential cost savings for PGE customers in their use. Example of technologies includes Digital Personal Assistants: o Google Home o Amazon Echo The objective of this research is to develop a system that enables a digital personal assistant to report-out on routinely-requested transactional data, for example: o Train the Personal Assistant to develop skill so that customers can pay a bill or ask a routine question via a personal assistant o Explore how personal assistants may be used to decrease costs of transactional requests via PGE's CSO organization Partners for this effort include o Technology vendor (e.g., Google, Amazon) o Programming support (e.g., Accenture) o PGE Corporate planning and IT teams o Eventually PGE's CSO organization	SG	40,300
54. Exploring Use of Non-Intrusive Customer Load Monitoring Devices (3-years) This project seeks to explore the "metering of the future and (non) intrusive load monitoring": Examples of technologies: o MIT gadget that disaggregates energy use at household level o Sense gadget that does the same thing o Neurio home energy monitor o Others likely to be discovered at CES 2017 The research objective(s) are divided into two timeframes: o Near term: ▪ Compare results of data against PGE AMI data ▪ Test customer interface and engagement platform ▪ Install technology that could be used in future Hackathons o Longer term: ▪ Determine if/how these types of devices may supplant need for AMI ▪ Consider if/how these data may be used instead of modeled data via Energy Tracker	DG	40,000

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Brief Description	**Topic**	**2018 $**
• Match results of data with customer engagement/programs • To create tailored recommendations based on *empirical* (as opposed to modeled) results o Target partners for this research include: ▪ Technology vendor ▪ Evaluation firm (if not PGE internal staff) ▪ Customer/employee ▪ PGE Meter Team, others		
55. <u>Load Shifting at small scale using HVAC with Ice Storage Capability</u> This project will investigate integrating energy storage using ice with HVAC. Examples of recent technologies derived from market monitoring include: o Ice Energy has a storage integrated HVAC Solution o Another more recent article on Ice Cub The research objective(s): o Explore new technology (ease of installation, quality, cost, experience, value) o Determine savings to be realized, if any, under TOU and/or if net metering were evolved to RVOS o Identify target household, if any, within PGE Service Area for demonstration Expected partners for this project include: o Technology vendor o Evaluation firm o Customer/employee ▪ Ideally a home with solar ▪ Maybe also small business? o PGE or Consultant or University partner as subject matter expert o HVAC installation vendor?	SG	60,000
56. <u>Practicality of 100% Solar Roofing Material in the Pacific Northwest</u> Solar photovoltaic (PV) applications continue to increase in penetration and decrease in cost. Thus, PGE, on behalf of its customers will explore leading edge offerings in this market to ensure the Company and its customers have good knowledge and understanding. An example of a recent PV application technology was announced by Tesla (https://www.tesla.com/solar) where it will be offering a whole roof solar product. The objective(s) of this research include: o Assessing cost effectiveness compared to usual & customary roofing o Assess physical durability o Need for maintenance and to what extent o Safety issues, if any o Customer and market acceptance	RP	40,000
57. <u>Support & Participation in Updating End Use Load Research Studies</u> The Pacific Northwest – as a region has been a notable national leader in energy efficiency for the last four decades. Much of this work has been based on consumer uses of electricity and the devices that convert electricity to modern conveniences such as lighting, refrigeration, consumer appliances of all types, HVAC, to name just a few. For the Pacific NW, the formal research database for consumer data end use loads is now easily 30 years old and very dated. Consumer behavior in electricity use and the electrical devices/appliances/gadgets that use electricity to deliver the end use or convenience, has evolved. This project allows PGE to engage with regional players such as utilities, consumer groups, NGOs and other stakeholders to share the costly proposition that supports updating of regional End Use Load Research Studies. PGE customers will benefit due to the funding leverage whereby PGE's contribution will be combined with joint funding from other regional utilities and related institutions.	SG	120,000
58. <u>Pre-Feasibility Study – Low Head Hydrokinetic Device</u>	RP	25,000

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Brief Description	**Topic**	**2018 $**
PGE has done preliminary due diligence on a potentially viable low head hydrokinetic power generator. The unit under consideration comes in two power capacity sizes, requires at least 15 feet of depth and on the order of 1.5 meters/sec of water velocity. PGE has interest in the unit capable of 400 kW of power generation. The manufacturer is a Canadian Company, whose technology has been licensed by Boeing in an exclusive 25 year arrangement to market, sell and deliver turnkey hydrokinetic energy farms deriving power from the flow velocity of a river. The device under consideration for testing and demonstration has been emplaced in the St. Lawrence River for four years with two of the years under power generating conditions and the remaining two years "free-wheeling" to assess wear and tear. In this demonstration, it appears that migrating fish species actively avoid the unit and survive interaction. This project seeks to characterize a possible location for demonstrating this device (or equivalent) as part of PGE's power generating infrastructure. PGE believes a location just downstream of Pelton Dam appears adequate. This project will produce definitive bathymetric (underwater topography) measurements as well as the vertical and horizontal velocity profiles of the Deschutes River bank to bank cross-section at the location of interest. It is possible to also use the cooling canal at the Boardman Power Plant for this same purpose. It is likely that over a two period there will be significant licensing work and other impact analyses to accommodate use of this device in either a riverine or canal setting.		
Total		**$2,753,300**