Portland General Electric Company
121 SW Salmon Street • 1WTC0306 • Portland, OR 97204
portlandgeneral.com

August 4, 2022

Via Electronic Filing

Public Utility Commission of Oregon
Attention: Filing Center
P.O. Box 1088
Salem, OR 97308-1088

Re: **PGE UE 294 2021 Retrospective Research & Development Projects**

Filing Center:

Enclosed, pursuant to OPUC Commission Order No. 15-356, is Portland General Electric Company's annual retrospective look at Research and Development Projects for 2021.

Thank you for your assistance in this matter. If you have any questions or require further information, please call me at (503) 464-7488.

Please direct all formal correspondence, questions, or requests to the following e-mail address: pge.opuc.filings@pgn.com.

Sincerely,

/s/ *Jaki Ferchland*

Jaki Ferchland
Manager, Revenue Requirement

JF/dm
Enclosure

Research & Development
Program / Project End Year Summary

Date: 7/7/2022

R&D Program/Project Name: Utilizing DER for Advanced Distribution Resiliency

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Darren Murtaugh **Project Team (external):** EPRI Staff **Project Description:** The increasing quantities and diverse types of Distributed Energy Resources (DER) being deployed on distribution systems provides an opportunity for distribution utilities to offer new modes of operation leveraging these resources. The goal is to produce systems that are more resilient during natural disasters, for example hurricanes, tropical storms, wildfire risks and Public Safety Power Shutoff (PSPS) events. During times of crisis or system disruption, new modes of distribution control and grid-forming capabilities of DER could be activated to provide power to some or all customers in affected areas. EPRI is leading a project through the U.S. Department of Energy (DOE) that is developing and demonstrating the pre-event analysis process, DMS/DERMS controls, and local DER device capabilities needed to support this capability. Resilience solution approaches include customer-sited, community-connected, and feeder-level distribution reinforcements. The solution being developed through this project, the “Solar Critical Infrastructure Energization System,” could provide grid operators facing system disruptions with the ability to call on diverse available generation resources to keep critical infrastructure online throughout a crisis. The proposed system joins and augments existing systems and equipment through five core components	**PGE Budget/Actual:** FY21: $30,000 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.

Benefit to PGE: Project Benefits: • New planning methodologies for resilient emergency modes of operation with customer sited, community-connected, and distribution reinforced approaches\ • Next-generation DMS/DERMS functionality and requirements that add new capabilities to distribution systems • Understanding of the cybersecurity technology and architecture requirements needed to support local systems during large-scale disruption • Laboratory and field implementation and evaluation of the proposed technologies **Customer Benefit:** Helps PGE build systems that use customer DER's more effectively, increasing the benefits to customers.	**Strategic Alignment:** Efficient Operations Electrification/Decarbonization

Value

PGE Participation: Participation in Advisory meetings to gain insight and influence supplemental research direction. Receipt of base research performed as outlined in Value Derived	Value Derived: • A T&D resiliency planning assessment method that identifies grid regions that can be viably and reliably isolated and operated by utilizing DERs as restoration resources to resilience zones, community centers, or critical infrastructures in high-risk areas. • New control system functionality to form and operate these regions, making energy pathways through the grid that route solar and storage energy to areas and loads of greatest need.

	• A proactive load curtailment method that operates at circuit, facility, and device levels – clearing the energy path to serve the greatest energy needs. Grid-forming inverters for solar photovoltaics (PV) and storage, including decentralized controls with capabilities to start and regulate voltage and frequency. • Cyber-secure technology and architecture for resilient communication systems that can support regional emergency operations. The project will implement the new capabilities in a commercial DMS/DERMS, and the demonstration will apply the products, methods and system in a field environment. Validation includes computer-modeled application to several distribution system scenarios.

Research & Development
Program / Project End Year Summary

Date: 7/8/2022

R&D Program/Project Name: Modeling Grid-Enabled Residential Loads in Distribution Systems

Project Status:

☒ Complete

☐ Will Continue Next Year

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Mani Obi **Project Team (external):** PSU Electrical Engineering faculty and students **Project Description:** We are in a critical state of building a global journey to a greener world, which means abandoning our dependency on fossil fuels and making the transition to cleaner forms of energy. This will mean large increases in the electrification of vehicles and with that, more electric vehicles will mean higher electricity bills for customers and increased demand on the grid. By 2030, the projected number of electric vehicles on the road in the United States is 18 million, which translates to about 44 TWh. Much of managing the anticipated growth of electric vehicle impacts relies heavily on building models that test innovative ideas for elective dynamic energy coordination among end-uses in the residential sector. This capstone project, Modeling Grid-Enabled Residential Loads sponsored by Portland General Electric, is a segment of several interconnected efforts which ultimately result in understanding whether residential grade smart switching devices help reduce peak loading of a feeder grid. The team focused efforts on gathering real-time current data from a smart switching device to analyze loaded switching characteristic	**PGE Budget/Actual:** FY21: $39,156 **Cost Share Total:** (if applicable) **Cost Share Percent:** N/A

behavior. The results of the data analysis are used to model the device for use in a residential simulation environment. To understand the impacts the device has on the grid, the team used simulation findings of the loaded switching behavior on a 13-node test feeder composed of 960 single family household loads.	
Benefit to PGE: The benefits are capture in the following conclusion: The purpose of this project is to analyze the impacts of customer adoption of a residential smart switching device at deferent levels of a distribution feeder. The team focused on the NeoCharge device for our simulation and analysis of smart switching behavior and its impacts on the residential distribution feeder. In order to analyze the impacts of the device on a distribution feeder, the device was characterized and successfully modeled where it was successfully applied to various simulations. The distribution feeder simulation environment, GridLAB-D, had some unexpected limitations, but the models our team developed were detailed and adaptable. As a result, the simulation results were realistic and simple to verify at every step in building each model. **At the branch level, the NeoCharge device reduces peak power for a branch circuit by load shifting. This result has considerable benefits for the customer because the need to install an additional 240 V circuit is not needed, thereby lowering the overall cost of EV adoption**. At the service level, the device generally reduces peak power by a small amount except in rare cases where peak power is increased. The fact that overall, the peak power is generally reduced provides an added benefit to the customer	**Strategic Alignment:** Electrification/Decarbonization

through utility programs like time of use rates, peak time rebates and so on. We believe the utility could benefit from this peak reduction characteristic if there is very large adoption of the NeoCharge or similar devices. The peak power values observed at the service level was at or above 80 % of a 100 A rated panel, including the Worst Case scenario. **The team concludes that customers do not need a panel upgrade when adopting one electric vehicle if the panel is rated for 100 A and above.** At the feeder level, the device did not have any significant impacts at 50% electric vehicle penetration compared to 100% NeoCharge adoption for every electric vehicle in the model. The overall peak power reduction was minimal, and the transformer overloading events were almost identical whether the NeoCharge was not a factor or 100% NeoCharge adoption for every electric vehicle. On the larger scale, the service and feeder analysis indicates the NeoCharge would have little impact on the utility as a whole even with mass adoption. **Customer Benefit:** Analysis provides insight into use of devices that can lower the cost of EV adoption.	

Value

PGE Participation: PGE engineering participated in providing data and feedback to the research	Value Derived: Data and analysis that can drive EV strategy at PGE.

Research & Development
Program / Project End Year Summary

Date: 7/8/2022

R&D Program/Project Name: Modeling High-power Electric Vehicle Distribution Impacts

Project Status:

☒ Complete

☐ Will Continue Next Year

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Mani Obi **Project Team (external):** PSU Electrical Engineering faculty and students **Project Description:** The Portland State University (PSU) Power Engineering Group has completed a series of studies to understand the potential impacts of medium-duty Electric Vehicle (EV) charging within the Portland General Electric (PGE) Swan Island distribution system. PGE expects medium-duty EV loading within this service area to grow significantly in coming years; the substation will eventually host numerous Electric Vehicle Charging Locations (EVCLs) where these vehicles will charge. Each of these EVCLs will host one or more Electric Vehicle Service Equipment (EVSE), which themselves range in capacity from small units supporting personal employee vehicles to high-power EVSE charging units for both industrial and commercial fleet use. PGE expects Swan Island will eventually host eight EVCLs. The PSU team analyzed several of these planned installations. When considering the impact of these EVCLs, both the number of EVs and the deferent loading characteristics from each charging level were considered over multiple forecast periods. Assets of particular	**PGE Budget/Actual:** FY21: $41,169 **Cost Share Total:** (if applicable) **Cost Share Percent:** N/A

interest were identified for analysis to determine where the system was overloaded by the addition of medium-duty EV charging events. Loading on the two substation transformers was analyzed, as was loading on transformers and conductors near the largest three EVCLs. Feeder conductors between each EVCL and the substation were also analyzed to determine if they presented a possible bottleneck within the distribution system. The team also considered whether EV charging that was incentivized to time-shift by Time-of-Use (ToU) pricing could reduce loading of these assets. Additionally, the PSU team analyzed Battery Energy Storage System (BESS) placement in order to consider how BESS could be used to defer EVSE loading away from peak demand periods as well as reduce customer electricity costs. This analysis considered the power and energy capacities of BESS that would be required to achieve demand curtailment. The team also analyzed how BESS can be used to reduce loading of municipal electric busses operating within a fixed route and using an in-route charger. These analyses show how EVSE loading may be regulated through proper placement and control of BESS.	
Benefit to PGE: PSU studied PGE's Swan Island study in order to identify distribution system impacts from EVCLs serving medium-duty vehicles. The Swan Island substation serves a large industrial customer base, which PGE expects will adopt medium-duty EVs in large numbers over the coming years. PSU conducted analysis of hosting capacities, ToU load shifting, and BESS placement within the Swan Island study in order to understand how wide-scale adoption of medium-duty EVs could impact distribution system assets and how BESS	**Strategic Alignment:** Efficient Operations Electrification/Decarbonization

could be used to provide non-wire solutions to these impacts. By identifying potential problems and possible solutions, PGE distribution planners can proactively take steps to prepare for large-scale medium-duty EV adoption, not only within the Swan Island service area, but throughout PGE's service territory. **Customer Benefit:** Helps PGE build systems that can accommodate customer EV's/DER's more effectively, increasing the benefits to customers.	

Value

PGE Participation: PGE engineering participated in providing data and feedback to the research	Value Derived: Analysis done for multiple scenarios and control methodologies will guide PGE planning teams on the needed infrastructure to support large scale adoption of EV's across the service territory.

Research & Development
Program / Project End Year Summary

Date: 7/8/2022

R&D Program/Project Name: Primary Frequency Response Detection and Archiving System

Project Status:

☒ Complete

☐ Will Continue Next Year

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Mani Obi **Project Team (external):** PSU Electrical Engineering faculty and students **Project Description:** Power system balancing authorities are routinely affected by sudden frequency oscillations. These frequency events can initiate cascading outages and cause damage to both customer-owned and utility equipment. For this project, the Portland State University capstone team developed a regression-based algorithm that is capable of detecting frequency events within a short period of time after the onset of an event. This frequency detection algorithm rapidly detects frequency events and generates flags, which can then be used to actuate response assets. The algorithm has three parameters that can be adjusted, making it highly tunable. The team also developed an Algorithm Evaluation Environment, which the team used to evaluate the algorithm and quantify its efficacy using a suite of evaluation metrics. Within this report, the team demonstrates how to use the Algorithm Evaluation Environment to tune the algorithm parameters in order to best align results with industry expert opinions. Engineers can use this evaluation environment to tune the detection algorithm to best match the definition of a	**PGE Budget/Actual:** FY21: $18,581 **Cost Share Total:** (if applicable) **Cost Share Percent:** N/A

frequency event, as defined by their own experts, prior to implementing the frequency response algorithm within their balancing area.	
Benefit to PGE: This capstone team has developed a process for evaluating the ability of an algorithm to detect frequency events. The Algorithm Evaluation Environment (AEE) uses an event archive consisting of 135 PMU data sets to quantify the ability of an algorithm to reproduce the observations of industry experts. Because of its speed, sensitivity, and tuneability, this algorithm shows significant promise and will be implemented in the PSU real-time frequency event detection system in Summer 2021. In addition to developing the AEE and the regression algorithm, the team also achieved the following: • Developed a visualization tool for stored PMU data to plot frequency and slew rate over time. • Compiled a Frequency Event Archive of 135 frequency events, near-events, and non-events of PMU data. • Developed a GUI-based analysis tool for event classification. • Created an online survey for classifying events that can be easily sent to industry experts. • Developed an automated program that compares algorithm output to industry expert assessment. **Customer Benefit:** Greater situational awareness for detecting frequency events translates into more reliable operations and reliability for customers.	**Strategic Alignment:** Efficient Operations

Value

PGE Participation:	Value Derived:
PGE engineering participated in providing data and feedback to the research	Tools and algorithms that can be implemented by PGE system operations.

Research & Development
Program / Project End Year Summary

Date: 6/30/2022

R&D Program/Project Name: EPRI P198 Strategic Sustainability Science

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: Ongoing

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Kristen Sheeran **Project Team (external):** EPRI Staff **Project Description:** EPRI's Strategic Sustainability Science program identifies and develops tools, models, and analyses that utilities need in order to integrate a sustainability mindset throughout their organizations and throughout the communities they serve. Expectations regarding sustainability commitments and performance are rising as customers, investors, employees, and other industry stakeholders become more committed to achieving an energy transition that benefits everyone, and also underpins ambitious economy-wide decarbonization targets. Corporate strategies are advancing beyond regulatory compliance to a more comprehensive focus on driving value through economic, environmental, and social responsibility. As a result, electric power companies need ways to embed sustainable practices into day-to-day operations and strategic long-range planning. To address these expectations, the program explores how a commitment to sustainability throughout electricity generation, delivery, and utilization can support a sustainable economy.	**PGE Budget/Actual:** FY21: 44,729 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.

This program serves as a resource nexus to bring sustainability thought leaders together and propel progressive scientific research and analysis.

In addition, the program's research and expertise are applied outside of this annual research portfolio via various supplemental and custom application projects for a holistic approach for tackling myriad sustainability issues. Examples include the Equitable Decarbonization Interest Group and member-customized Sustainability Assessments. Program members benefit from the non-proprietary, real-world learning that is continually brought back to inform the annual portfolio.

Benefit to PGE:

PGE can leverage industry peers and research from this program to guide our plans to decarbonize the electric delivery fleet. Key activities to support PGE in this journey include:

- Sustainability Optimization: Leveraging Value Exploration (SOLVE) V3
- Next Generation Metrics: Context, Impact, Social, and Leading Sustainability Metrics
- Supply Chain Workshop development
- Enhancing Stakeholder Engagement Engineering and Design
- Annual Sustainable Electricity Research Summit

Customer Benefit:

This project further enables us to learn from our utility peers in the areas of sustainability, decarbonization

Strategic Alignment:

PGE's participation in this program provides us the tools and resources we need to execute on all three of our strategic imperatives (decarbonize, electrify, and perform) as well as our purpose and climate goals.

and ESG to better meet our customers' ever-increasing expectations in this area.	

Value

PGE Participation:	Value Derived:
1. Sustainability value to the business and how to capitalize on that value in service to our decarbonization imperative and roadmap. 2. By joining P198, we will gain insights into how we may more-proactively engage our customers in the sustainability dialogue. 3. Previous sustainability projects/initiatives follow up for updates and context (including the 2014 Maturity Model for GHG (2018 EPRI Tech Transfer Award Winner) and the 2016 Priority Issues/Materiality Assessment)	The Strategic Sustainability Science program seeks to provide the following benefits: • Establishes a focal point for the present and future of sustainability-related research for the energy industry. • Enhances utilities' ability to operate more efficiently, better mitigate risk, and meet growing expectations of customers and other stakeholders. • Enables utilities to enhance strategic planning, risk management, value analysis, and communications processes by engaging colleagues in these areas directly and developing tools to help root sustainability into these functions. • Enriches the two-way interaction and dialogue on sustainability issues and solutions between various internal and external stakeholders, which drives timely, proactive engagement and improved understanding. • Empowers better-informed utility decision making on a broad range of strategic topics by incorporating sustainability dimensions. • Equips utilities to increase the maturity of their sustainability approach, thus demonstrating sustainability leadership. • Supports strategic activity, but also informs day-to-day decision making, for example, through metrics research to inform sustainability reporting. • Ultimately helps in achieving the broad societal, economic, and environmental benefits associated with more sustainable companies and communities.

Research & Development
Program / Project End Year Summary

Date: 2/2/2022

R&D Program/Project Name: EPRI Supplemental Project: Alternative Technologies for Recloser Backup Power

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
TITLE OF THE PROJECT	PROGRAM MANAGER	$ 0	$ 15,000	$ 15,000

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor: James Bledsoe

Sponsoring Department: Distribution Automation (RC227)

Project Team (internal): James Bledsoe, Distribution Automation Engineer

Project Team (external): Jason Anderson, EPRI

Project Description:

This project provides PGE an opportunity to research and develop alternative backup battery power for 651R recloser controller units. Currently, all new recloser units that will be installed between 2020 and 2024 will have lead acid batteries, and battery maintenance represents possibly the largest O&M expense related to recloser asset management. Recent EPRI research concluded that these batteries are required to be replaced every 4 to 5 years. By 2024, PGE plans to install a total of 400 reclosers throughout the service territory. The objective of this project is to investigate suitable alternative energy storage technologies that could provide backup power for the 651R recloser control unit. These new technologies would possibly reduce the O&M expenses through more cost-effective maintenance for control backup power systems and by reducing the frequency of battery replacements.

PGE Budget/Actual:

FY20: $0

FY21: $15,000/$15,000

Cost Share Total: The OPUC prefers for PGE to leverage R&D funds from other organizations to increase the value of PGE's R&D budget. Please identify any leveraged or matching funds associated with this project.

Cost Share Percent:

50%

Benefit to PGE: PGE will benefit from this research by reducing O&M expenses through more cost-effective maintenance for control backup power systems and by reducing the number of battery replacements. **Customer Benefit:** Our customers will benefit through enhanced reliability and wider scale deployments of reliability-enhancing technologies.	**Strategic Alignment:** Deliver operational excellence and competitive financial returns. The proposed project will support operational performance by reducing O&M expenses through more cost-effective maintenance and increase system health by implementing reliable technologies. This project will give insight on how to affordably increase efficiency on the distribution system.

Value

PGE Participation: An important part of PGE's participation in EPRI is active participation in EPRI advisory council meetings. Participation can influence the direction of EPRI's research to create added value for PGE's customers. This supplemental project is associated with meetings regarding P180.003 Distribution Systems.	**Value Derived**: Research evaluations of battery alternative technology and backup power function for current recloser controllers. This includes further understanding of controller's power supply charge and discharge cycles for different battery technologies. Controller charge modes are being researched further and how Constant Current, Fast Charge, Float Charge, and Discharge modes pair with LiFePo4 batteries. Further field information is also being gathered regarding control enclosure and its effects on battery life with alternative battery technologies.

Research & Development
Program / Project End Year Summary

Date: 7/7/2022

R&D Program/Project Name: Arc Flash Testing of 480-V Bypass Meter Socket

Project Status:

☒ Complete

☐ Will Continue Next Year

☐ Discontinued (reason) _____

Project Sponsor: Bill Messner **Sponsoring Department**: Safety **Project Team (internal):** Dan Loomis, Jonathan Wilson **Project Team (external):** Tom Short (EPRI) **Project Description:** The operation of distribution circuits exposes workers and the public to hazards, including contact to energized objects (shock), arc flash from a system fault (burns), and step and touch voltages. This project aims to focus on these risks through research on: • Grounding and personnel protection • Arc flash analysis and protection • Detection and reduction of live, downed conductors • Stray and contact voltage • Manhole events • Evaluation and use of protective equipment • Technologies to improve worker safety	**PGE Budget/Actual:** FY21: $20,000 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.
Benefit to PGE: These research tasks can help utilities improve safety for the public and utility workers. Specifically, the research results could help utilities: • Improve grounding approaches • Improve public and worker safety through leading approaches for downed conductor detection • Reduce hazards to workers from arc flash • Better use protective cover-up	**Strategic Alignment:** Safe & Efficient Operations

• Protect workers from contact to energized lines by enabling technology to reinforce better practices for line coverings • Effectively implement voltage-detection technologies to warn of hazards **Customer Benefit:** Safer operations translates into lower overall costs to customers	

Value

PGE Participation:	**Value Derived**:
PGE operations personnel and safety staff	Results will affect current operating standards

Date: 7/7/2022

Project Name: CEATI Stations Equipment Program (SEP)

Project Status:

☐ Complete

☒ Will Continue Next Year

- Engagement is on an annual basis and was renewed for 2022

☐ Discontinued (reason) _____

Project Sponsor: Alex Banicki **Sponsoring Department**: Asset Mgmt Engineering **Project Team (internal):** Various **Project Team (external):** CEATI Staff **Project Description:** The mission of CEATI's Station Equipment Program (SEP) is to address shared experiences and lessons learned regarding the lifecycle management of station assets – including purchasing (specifications, quality control, etc.), design, installing, commissioning, maintaining, and operating – as well as disposal and planning for future changes and trends in the utilities industry. The group assists in maximizing the safety, reliability, and efficiency of station assets while also minimizing costs, complying with applicable regulations/ laws/industry standards, and producing required reporting for applicable authorities.	**PGE Budget/Actual:** FY21: $89,565 (Budget for both SEP and Hydro) **Cost Share Total:** (if applicable) **Cost Share Percent:** Varies by program Costs are shared among the 145+ utility members and vary by program and project. Typically projects are supported by multiple utilities so costs would be less than 20% of the total project budget.
Benefit to PGE: The CEATI program model provides electric utilities with a cost-effective vehicle for sharing experiences and addressing issues pertinent to their day-to-day operations, maintenance, and planning. In addition to serving as a strong technical resource tool, CEATI programs include project collaboration opportunities yielding practical deliverables which organizations can use to leverage their expenditures. **Customer Benefit:**	**Strategic Alignment:** Perform

Customers benefit by PGE Implementing and maintaining the electrical grid more efficiently and reliably.	

Value

PGE Participation:	**Value Derived**:
PGE's Substation Maintenance Engineering personnel are involved and access information on the CEATI portal	Technical information and peer utility benchmarking

Date: 7/7/2022

Project Name: CEATI Generation Interest Groups

Project Status:

☐ Complete

☒ Will Continue Next Year

- Engagement is on an annual basis and was renewed for 2022 for the Dam Safety, Hydraulic Plant Life, Asset Management Generation, and Thermal Generation programs

☐ Discontinued (reason):

Project Sponsor: Maria Ouellette **Sponsoring Department**: Engineering Services **Project Team (internal):** Various **Project Team (external):** CEATI Staff **Project Description:** **Dam Safety(DSIG):** Composed of dam owners who jointly sponsor research & development projects designed to help assess and improve the safety of dams. Research is required for the development and evaluation of new diagnostic monitoring tools and techniques in order to assess the stability and safety of existing dams. New repair materials and techniques can reduce the cost of required dam safety improvements. **Hydraulic Plant Life (HPLIG):** Focuses on required capital investments in equipment and parts replacement to ensure outage times and cost for equipment repair and maintenance are optimized. **Asset Management Generation (AMIG):** Covers all aspects of Asset Management, from development of policies and strategies, to risk frameworks, asset management plans, and investment management to achieve strategic objectives. **Thermal Generation Programs (TGIG):** Objective is to identify immediate design, operational, and	**PGE Budget/Actual:** FY21: $89,565 (Budget for both SEP and Hydro) **Cost Share Total:** (if applicable) **Cost Share Percent:** Varies by program Costs are shared among the 145+ utility members and vary by program and project. Typically projects are supported by multiple utilities so costs would be less than 20% of the total project budget.

maintenance issues, and to monitor and develop emerging thermal technologies.	
Benefit to PGE: The PGE Dam Safety (Civil) Engineering team actively collaborates with the CEATI Dam Safety Interest Group (DSIG). PGE has engineers who participate in various task force groups, project development teams, and general business needs. These groups include Gates Task Force, Penstock Working Group, Seismic Working Group, and Dam Safety Maturity Matrix development and implementation. As a group, the DSIG works with our domestic peer organizations to collaborate and advocate for the industry by bringing together expertise and providing a coordinated effort to provide the FERC comment on new initiatives and regulation. From the lens of professional network, PGE is able to share and benefit through collaboration with peers from around the world. West Side Hydro has taken advantage of the HPLIG partnership in recent months from benchmarking, notably for Outage Management regarding runner maintenance. Through the 2021 spring conference, WSH presented focused questions to better understand industry peer, maintenance durations. Resulting from that discussion, WSH has moved runner inspections, runner clearance inspections and wicket gate pinch from 1-yr to 3-yr inspections. This allows better use of the “Tech Model”, leading to cost effectiveness and better equipment reliability. For HPLIG, TGIG, and AMIG PGE has submitted multiple surveys to pulse utilities around the world related to maintenance optimization, vibration, lubrication, whole life cycle cost models, and general Asset Management Strategy and Risk assessment initiatives. PGE acts as project monitors for multiple projects related to lubrication and vibration programs for thermal, wind, and hydro for the TGIG. For AMIG specifically, as PGE implements elements of Asset Management this membership has benefited the company by allowing us to access information and reports on best practices at other utilities. The most recent example includes Project 0601- Enterprise Risk Management which details the process of determining	**Strategic Alignment:** Perform

risk for hydro assets and contains failure data from five peer utilities. There have also been discussions facilitated with subject matter experts at other companies (i.e. - BPA, Tacoma Power, Manitoba Hydro) on their Asset Management processes which means that we don't have to create processes from scratch. In general, the CEATI program model provides electric utilities with a cost-effective vehicle for sharing experiences and addressing issues pertinent to their day-to-day operations, maintenance, and planning. In addition to serving as a strong technical resource tool, CEATI programs include project collaboration opportunities yielding practical deliverables which organizations can use to leverage their expenditures. **Customer Benefit:** Customers benefit by PGE Implementing and maintaining power generation more efficiently and reliably.	

Value

PGE Participation:	**Value Derived**:
PGE's Generation Operations and Design and Asset Management engineering personnel are involved and access information on the CEATI portal	Technical information and peer utility benchmarking

Research & Development
Program / Project End Year Summary

Date:

R&D Program/Project Name:

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
Pulsed Power DC Microgrid for Remote Area Highway Fast Charging Stations	PROGRAM MANAGER	$	$ 26,731	$20,000

- Year to be Completed: 2024

☐ Discontinued (reason) _____

Project Sponsor: Andy Eiden & Ian Beil

Sponsoring Department: Distributed Resource Planning & Grid Edge Solutions

Project Team (internal): Andy, Ian, Matthew McCormick, Hannah Fischer, Elizabeth Turnbull, Coreen Henry, Timothy Treadwell

Project Team (external): Nadav Enbar (EPRI), Ben Sigrin (NREL)

Project Description:

This three-year project leverages federal funding from the U.S. Department of Energy (DOE) to identify customer DER coadoption preferences by conducting national surveys that employ the discrete choice experimentation method. The survey designs will be informed by a DER technology value map that identifies cost efficiencies and barriers to coadoption as well as input from project funders on technology and customer attributes of interest. To augment customer stated preferences from the surveys, EPRI plans to use data-driven algorithms to analyze existing co-adopter trends and usage patterns from utility-provided interconnection and metering data. EPRI also anticipates integrating a choice model (developed from survey responses) into NREL's opensource DER adoption tool—the Distribute Generation Market Demand (dGen) model—to create co-adoption forecasts

PGE Budget/Actual:

FY20: -

FY21: $26,731k (SDF)

Cost Share Total: DOE provided a $2.0M cost share

Cost Share Percent: 20%

Benefit to PGE:

Strategic Alignment:

This project will develop a customer survey that is presented to customers that have adopted at least one DER (an electric vehicle, rooftop solar, or a battery) in order to determine the thought process that went into that decision and why they might or might not adopt other DERs. **Customer Benefit:** The work will benefit a broad group of customers by better understanding the decisions that early adopters make, and applying the lessons learned to future product development.	The internal team consists of member from a range of customer-facing roles as well as technical contributors. It is expected that this group with bring a variety of perspectives to the table. The work is also being closely monitored by Legal and by Customer Services to make sure it aligns with all applicable PGE standards for interactions with customers.

Value

PGE Participation: This project involved coordination between DOE, NREL, EPRI, and the participating utilities. The 2021 year was spent crafting the legal and technical documents that will guide the work. These documents were presented to PGE in February 2022, and thus the 2021 year involved the initial framing of the project. The bulk of the work is anticipated for late 2022 and throughout 2023.	**Value Derived**: Once the customer surveys are designed, distributed, and the data is accumulated, they will provide valuable information in terms of customer desires for a range of new DER technologies, and how PGE can better craft a message and design policies to support these investments.

Research & Development
Program / Project End Year Summary

Date: 6/22/2022

R&D Program/Project Name: Construction Safety Research Alliance (CSRA)

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2021	Cost 2022
CSRA	PROGRAM MANAGER	$ 15,000	$ 15,000

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor: Alden Strealy

Sponsoring Department: Health & Safety

Project Team (internal): Alden Strealy & Safety Staff

Project Team (external):

University of Colorado staff and member utility/construction companies

Project Description:

CSRA is an alliance of industry leaders and experienced scientists who are focused on transformative construction safety research.

The CSRA is a forum where we:

• Propose and test new safety ideas and innovations

• Invite industry members to actively participate in safety research

• Explore the efficacy of new safety technologies

• Network and share best practices

• Shape the next generation of safety researchers and practitioners

PGE Budget/Actual:

FY21: $15,000

Cost Share Total: $45,000

Cost Share Percent: Total project budget varies with number of participants. For 2021 our cost share was about 1.5%.

Benefit to PGE:

The rate of serious injuries and fatalities has plateaued in the construction industry for nearly 20 years. The mission of the CSRA is to assemble industry leaders and worldclass researchers to conduct collaborative research that eliminates these unacceptable life-changing events.

Strategic Alignment:

Perform – Delivering operational excellence

Customer Benefit: Having access to the latest collaborative processes and technologies to reduce work related injuries and safety incidents will support PGE's mission of providing safe and reliable power to our customers.	

Value

PGE Participation: PGE personnel have access to all research and technologies that are supported by the alliance. PGE can also participate in research and share safety data with other entities to provide a richer data set for analysis.	**Value Derived**: Given the large participation from utilities and construction companies across the US (68 as of 2021), PGE will have access to the latest up to date research on safety protocols for electric utilities and contractors for a fraction of the actual research cost.

Research & Development
Project Summary

Date: 07/08/2022

Project Name:

Customer Flexible Load Resource at Scale

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: Expenditure of R&D funding ended in 2021, operation of water heaters and use of SGTB funding will continue into 2022.

☐ Discontinued (reason) _____

Project Sponsor: Tim Treadwell

Sponsoring Department: Grid Products and Integration

Project Team (internal): Tim Treadwell, Manny Obi

Project Team (external):

Project Description:

Opportunity to understand the flexible load capabilities and benefits or value streams of grid enabled water heaters at scale while also testing and validating the operational sustainability of various device communication approaches; LAN (Wi-Fi), LTE and NAN. (Water heaters are a major resource in our decarb plan). Opportunity to understand the role and capabilities of PGE's NAN and vet the stability of LAN and LTE to communicate and utilize an at scale flexible resource. The project will leverage ETO and PGE HPWH incentives to offer at lowest possible cost purchase and installation of HPWH to single family home customers. Lessons to be learned: (1) Communication infrastructure usability and stability. (most BTM devices will be LAN likely aggregated and orchestrated through third party) (2) Distribution operation impacts of a concentrated flexible load asset; (3) Benefits and value streams to the local distribution network; (4) Communication and dispatch issues when attempting to integrate such resources into our NAN; (5) Energy services and values identification; (6) PGE's ability and operational gaps when operating such a resource; (7) How to engage single family households around flexible load (not entirely equal to DR); (8) How to successfully electrify water heating loads.

PGE Budget/Actual:

FY20: $105,000/$92,000
FY21 :$45,000/ $44,920

Cost Share Total: $150,000

Cost Share Percent: 55%

Benefit to PGE:

This is in part an effort to develop and understand a positive customer experience and journey when we deploy and seek to acquire significant amount of flexible load. The concentration of a grid enabled customer resource (flexible load) will help us better understand the challenges of making our integrated grid interoperable. We'll also learn through in-field testing the value and costs of operating a flexible resource "at scale" on the distribution system. By coordinating internally and externally we demonstrate to all internal and external stakeholders our pursuit for excellence in our work. This is an opportunity to vet our FAN and ADMS for DER optimization.

Customer Benefit:

Customers within the project will receive at significantly reduced cost a smart grid enabled energy efficient water heater. The project will benefit all customers by advancing our understand of the value of such a resource and its ability to offset the need to build a more traditional supply side natural gas asset. This will help us understand the challenges of using water heater as balancing resources or as a resource to address local distribution operations such as voltage and frequency. The project will lend insight into peak demand reductions employed in concert with the additive service of renewable integration. The project will enable us to learn more about utilizing our FAN and ADMS for the purpose of making operational DERs for various gird services. This is an internal communications project which should help us identify operational shortcomings, if any, of our FAN and ADMS for DER operations. This approach should save ratepayer investment.

Strategic Alignment:

☒Deliver exceptional customer experience

☒Invest in a reliable and clean energy future

☒Build and operate a smarter, more resilient grid

☒Pursue excellence in our work

Summary

Synopsis of Project as Implemented:

The project has experienced a number of challenges and setbacks since implementation began. Most notably is the impact of COVID, which has limited our ability to effectively engage and recruit customers, as well as the global chip shortage which has extended timelines and delivery dates for manufacturing of the universal communications module (UCM) hardware. Despite these issues, the project has been steadily progressing.

The project team contracted with Apricity for the design and manufacture of 50 LTE-based CTA-2045 UCMs and another 30 mesh-based units, which allow for utility dispatch commands to be passed from the DERMS to participating water heaters. The team also contracted with VirtualPeaker (VP) to complete integrations into their DER controls platform. L+G was engaged to design and install an RF mesh network in the N. Portland portion of the SGTB. All systems are now fully operational allowing for end-to-end control of water heaters across all three communication pathways.

Final participation in the study has been less successful than planned. When recruitment for the project ended the study included 4 wifi, 10 mesh, and 7 LTE water heaters. The units were divided into two groups for dispatch and observation.

Performance Against Objectives/Deliverables:

Project objectives and deliverables are primarily focused on the testing of communications and equipment performance. The project's progress, after numerous delays and setbacks, is now allowing that process to occur, albeit on a smaller scale that originally anticipated. In addition to the communications and DR performance-based outcomes, the project has also provided valuable insights into customer recruitment strategies, issues with existing wifi product offerings from water heater OEMs, and hardware/software challenges that will face any fullscale implementation of a single-family water heater DR program.

Decisions to be Made:

The project is now in a control and observation phase, there are no more major implementation decisions to be made on the project.

Next Steps:

Collection of data is ongoing and will continue through at least the end of Q3 2022, at which point PGE will analyze the data and generate a report summarizing findings.

Research & Development
Program / Project End Year Summary

Date: 1/28/2022

R&D Program/Project Name: EPRI DCOI Assessment

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
TITLE OF THE PROJECT	PROGRAM MANAGER	$ 0	$ 40,000	$ 40,000

- Year to be Completed: 2023

☐ Discontinued (reason) _____

Project Sponsor: Jacob Leeney **Sponsoring Department**: **RC 311** **Project Team (internal): Standards** **Project Team (external): EPRI** **Project Description:** To aid the widespread adoption of DCOI as an alternative pole treatment to Penta, EPRI will be testing DCOI-treated poles over the next three years. The testing will be focused on understanding DCOI's effectiveness in preventing pole decay, maintenance requirements, effect on pole strength, necessary inspection period, environmental risks, and proper disposal methods.	**PGE Budget/Actual:** FY21: $40,000 /$40,000 FY22: $40,000 **Cost Share Total: N/A** **Cost Share Percent: N/A**
Benefit to PGE: PGE benefits from this study by better understanding how to own and maintain wood poles treated with DCOI, a wood preservative that is replacing Penta. **Customer Benefit:** Increased reliability driven by proper maintenance on DCOI poles	**Strategic Alignment:** Customer Focus, Increased Reliability

Value

PGE Participation: Direct information sharing with EPRI on the new preservative and how to best maintain poles treated with DCOI. Other studies on DCOI that are available to PGE are very limited in scope, and do not provide a comprehensive review of the new preservative.	**Value Derived**: Pole treatment and maintenance work practices that are appropriate for DCOI, the new wood pole preservative that is replacing Pentachlorophenol.

Research & Development
Program / Project End Year Summary

Date: 7/8/2022

R&D Program/Project Name: EPRI DER-VET User Group

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: Multiyear continuing commitment with EPRI due to ongoing and emerging opportunities with DER's on distribution systems

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Darren Murtaugh, Ian Beil, PGE Engineering teams **Project Team (external):** EPRI Researchers **Project Description:** Distributed energy resources (DER), such as, energy storage (ES), electric vehicles (EV), demand response (DR), and microgrids, are highly flexible assets that are growing in popularity. Energy storage (ES) systems, in particular, have the potential to be leveraged for multiple distribution, transmission, market, and customer services. The flexibility of DER potentially allows stacking multiple services to capture more value. However, stacked services require complex site specific analysis to manage conflicting and competing requirements. The Distributed Energy Resource Value Estimation Tool (DERVET™) provides a platform for calculating, understanding, and optimizing the value of DERs based on their technical merits and constraints. DER-VET supports site-specific assessments of energy storage and additional DER technologies—including solar, wind, demand response, electric vehicle charging, internal combustion engines, and combined heat and power—in different configurations, such as microgrids. It uses load and other data to	**PGE Budget/Actual:** FY21: $11,250 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.

determine optimal size, duration, and other characteristics for maximizing benefits based on site conditions and the value that can be extracted from targeted use cases. Customers, developers, utilities, and regulators across the industry can apply this tool to inform project-level decisions based on sound technical understanding and unbiased cost/performance data.	
Benefit to PGE: The User Group will bring together utility planners and other DER stakeholders in a forum to train and support members, share experience, socialize reference case studies, and identify and prioritize new DER-VET enhancements and improvements. User Group interaction will be facilitated through training, webcasts, and meetings, which include: • Personalized Training Sessions: Two half-day personalized training sessions per year for each member • Annual Meetings and Quarterly Webinars: Share case studies, user experiences, feedback, and tool enhancement and improvement activities • Training and software support for using the tool through the venues listed above. • Access to the latest User Group version of DER-VET, including any enhancements and improvements that occur during each funding year. These enhancements and improvements will be exclusive to User Group members for the three-year duration of the User Group. **Customer Benefit:** Improved experience when implementing DER's on the PGE distribution system.	**Strategic Alignment:** Perform/Operational Efficiency Electrify

Value

PGE Participation: Participation in user group meetings to gain insight and influence base and supplemental research direction.	**Value Derived**: The User Group provides the following key benefits: • Training and support for using DER-VET • Forum for exchange of information on how DER-VET can be applied effectively for DER decision-making

	• Early and exclusive access to enhancements and improvements of DER-VET guided by members.

Research & Development
Program / Project End Year Summary

Date: 6/30/2022

R&D Program/Project Name: EPRI Energy Sustainability Interest Group

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: Ongoing

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Kristen Sheeran **Project Team (external):** EPRI Staff **Project Description:** This project enables our strategically aligned sustainability work related to the decarbonization roadmap by increasing the learnings, research and tools associated with reducing the greenhouse gas emissions of both our business operations and power supply. By striving to decarbonize with sustainability in mind, this group also helps to balance these efforts with the performance of our businesses both operationally and financially.	**PGE Budget/Actual:** FY21: $25,000 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.
Benefit to PGE: Through this project we gather best practices from other utilities that are leaders in the sustainability and decarbonization space including Excel, Duke Energy, APS, Salt River Project, and others. By gathering best practices, we are better able to implement sustainability and decarbonization projects and initiatives that move our decarbonization roadmap forward while also benefitting our customers, community, employees and shareholders. **Customer Benefit:** This project further enables us to learn from our utility peers in the areas of sustainability, decarbonization	**Strategic Alignment:** Aligns with both decarbonization and operational excellence imperatives as well as our newly release climate goals and purpose

and ESG to better meet our customers' ever-increasing expectations in this area.	

Value

PGE Participation:	**Value Derived**:
1. Embedding sustainability to drive strategic outcomes 2. Reporting on sustainability to align with stakeholder interests and uses (including investors and customers) 3. Sustainability metrics learnings	• Learning from peers directly applied to defining and releasing our new Climate Goals which directly inform our strategic plan and reporting

Research & Development
EPRI Program Summary

Date: 06/24/2021

EPRI Program/Project Name: EPRI Fleet Electrification Planning & Assessment

Project Status:

☐ Complete

☒ Will Continue Next Year

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Dale Clark, PGE EV Staff **Project Team (external):** EPRI Staff **Project Description:** The transition towards electrified transportation is underway, with increasing numbers of new electric vehicle sales each year. Freight and delivery companies, bus and taxi operators, service stations, and many other fleet entities have the potential to rapidly introduce fleet charging. Although distribution utilities are aware that fleet electrification is imminent, there is still significant uncertainty on where demand on the grid for fleet charging will be, what their needs will be, and how a utility can proactively prepare to support its customers and the grid. To support this need, EPRI's Electric Transportation and Distribution Operations and Planning R&D programs have developed new processes and analytical capabilities to enable utilities to efficiently plan and design cost-effective solutions for fleet electric vehicle (EV) charging infrastructure. This project seeks to apply these new resources to help utilities evaluate vehicle and charging, characterize fleet travel patterns and technology needs, predict future fleet locations and sizes, quantify grid capacity to accommodate fleet electrification, and identify cost-effective integration solutions.	**PGE Budget/Actual:** FY21: $110,000 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.
Benefit to PGE:	**Strategic Alignment:**

Gain new insights, analysis, and tools to help predict future EV fleet impacts. **Customer Benefit:** PGE will have the capability to enable customers EV fleet strategies and use these new vehicle resources to benefit the grid.	Perform/Operational efficiency Electrify

Value

PGE Participation: PGE SME's responsible for fleet electrification will attend technical webinars and advisory meetings with EPRI.	**Value Derived**: Leveraged collaboration will enhance the speed and depth of knowledge gained.

Research & Development
Program / Project End Year Summary

Date: 2/1/2022

R&D Program/Project Name:

Project Status:

☒ Complete

☐ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
EPRI: Battery Energy Storage Fire Prevention and Mitigation	Jim Riehl	$30,000	$30,000	$0

- Year to be Completed: 2021

☐ Discontinued (reason) _____

Project Sponsor: Darren Murtaugh

Sponsoring Department: 509

Project Team (internal): Jim Riehl

Project Team (external): Dirk Long (EPRI) + other EPRI member utilities and BESS vendors participating

Project Description:

The objective of this project is to apply a holistic hazard analysis approach to evaluate battery fire threats, consequences, and mitigation options in specific instances. The project will drive collaboration between funding participants and subject matter experts to advance system level understanding of battery storage fire hazards and develop a prioritized framework for subsequent data collection, testing, and analysis.

PGE Budget/Actual:

FY20: $30,000
FY21: $30,000
FY22: $0

Cost Share Total: (if applicable)

Cost Share Percent:

N/A

Benefit to PGE: PGE benefits include improved understanding of risks with energy storage assets to support development of internal safety guidelines, project design specifications, and education of stakeholders who may interact with these systems.

Customer Benefit: This project has provided necessary information to support owners, operators, and developers of energy storage to proactively design, build, operate, and maintain these systems to minimize the risk of fire. The investigations identify, assess, and address battery storage fire safety issues so as to aid in avoidance of safety incidents and loss

Strategic Alignment:

WIG 2: Clean, integrated customer solutions

of property - a major challenge to the widespread deployment of energy storage. This may increase system reliability and penetration of renewable energy and reduce costs to electricity customers.	

Value

PGE Participation:	**Value Derived**:
PGE participated in this effort as a collaborator and funded EPRI to engage with this collaborative implementation project to identify research gaps, gather available data, and provide guidance to support safe system design and operations.	The non-proprietary results of this work were incorporated into EPRI's Energy Storage and Distributed Generation, Environmental Aspects of Fueled Distributed Generation and Energy Storage R&D programs and made available to both Collaborators and Site Hosts and eventually to the public for purchase, or otherwise. 1. Bi-monthly Updates (2020) EPRI hosted quarterly webinars to discuss research priorities and review progress of studies in addition to any available interim lessons learned concerning fire hazard analysis, prevention and mitigation technologies, and leading practices. 2. Battery Storage Safety Summary Report (2020) The non-confidential lessons learned and aggregate findings from the site-specific evaluations were documented in a single summary report provided to hosts and collaborators. This included review of common findings, explicit list of open questions, and details of any available quantitative evaluation approaches to inform industry stakeholders. Additionally, the report contained a set of recommendations summarizing guidance for future modeling and test procedures and criteria. 3. Knowledge Transfer Workshop (2020) EPRI hosted a workshop convening funding participants and advisors to transfer site-specific investigation results and discuss next steps. The workshop occurred in summer 2020. 4. Site Evaluations and Roundtable Q&A (2021) EPRI hosted a close out session for phase 1 of the Battery Energy Storage Fire Protection and Mitigation project in March of 2021. This included a final status update on phase 1 of this project and a useful round table discussion on explosion prevention and

	mitigation. This also included presentations on the participant site evaluations of Hazard Mitigation Analysis (HMA) reports and design study reviews and how those items can apply to other BESS projects.

Research & Development
Program / Project End Year Summary

Date: 06/20/2022

R&D Program/Project Name: Low Carbon Resources Initiative (LCRI)

Project Status:

☐ Complete

☒ Will Continue Next Year

	Cost 2021	Cost 2022	Cost 2023	Cost 2024
LCRI	$ 150,000	$ 150,000	$ 328,878	$ 328,878

- Year to be Completed: 2024

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom

Sponsoring Department: R&D

Project Team (internal):

Darren Murtaugh

Project Team (external):

EPRI Researchers

Project Description:

The Electric Power Research Institute (EPRI) and GTI Energy have created the Low-Carbon Resources Initiative (LCRI) to accelerate the deployment of low- and zero-carbon energy technologies required for deep decarbonization. LCRI is specifically targeting advances in the production, distribution, and application of low-carbon, alternative energy carriers and the cross-cutting technologies that enable their integration at scale. These energy carriers—which include hydrogen, ammonia, synthetic fuels, and biofuels—are needed to enable affordable pathways to achieve deep carbon reductions across the energy economy. The LCRI is focused on technologies that can be developed and deployed beyond 2030 to support the achievement of a net zero emission economy by 2050.

PGE Budget/Actual:

FY21: $150,000

Cost Share Total: (if applicable)

Cost Share Percent:

Typically EPRI programs have an average of 40 times cost leverage. **This initiative is highly leveraged at nearly 100 times**.

Benefit to PGE:

- Determine the potential role of renewable fuels to contribute to deep decarbonization across the energy economy by mid-century.
- Identify opportunities, constraints, and risks (research, development and

Strategic Alignment:

Perform/Operational Efficiency

Electrify

demonstration activities, policy impacts, market impacts, etc.) for facilitating increased renewable fuels utilization in a low-carbon future. • Pursue research and demonstrations to support key renewable fuels technologies. **Customer Benefit:** Greater carbon-free energy from their electric supply	

Value

PGE Participation:	**Value Derived**:
Participation in Advisory meetings to gain insight and influence research direction. Gain insight into zero carbon fuels technology to inform resource direction	• Structure performance testing. Full-scale laboratory testing of new overhead structure designs to assess performance during tree-strike events and improve resiliency. • Pole inspection technologies. Assessed the performance of nondestructive pole inspection technologies by comparing it to actual remaining pole strength. • Sensor performance testing results. Laboratory testing of line sensors provided data that utilities can use to enhance specifications. • Development of pole sensors. Development and field tests of sensors to detect pole angle and condition in real time. • Understanding of grounding configurations for vehicles. Laboratory testing of energized trucks informs grounding and safety practices. • Assessment of resiliency approaches and technologies. Field, laboratory, and computer tools to help utilities understand effectiveness and prioritize options to improve resiliency. • Collection and curation of industry practices around underground infrastructure. A robust repository of industry practices helps utilities identify areas for improvement of inspection, maintenance, and safety practices. • Network training. Developed and implemented an online training curriculum in low-voltage meshed network systems; available through EPRI-U. • Investigation of high-impedance faults and mitigation methods. Research into downed conductor and high-impedance faults helps utilities understand the risk and phenomena

	as well as the options to detect downed conductors and mitigate risks. • Testing of underground switches. Development of new industry intelligence on switch aging and performance in underground systems. • Laboratory testing of manhole events and restraint systems. Controlled laboratory testing of manhole events provides real-world performance information about restraint and mitigation systems.

Research & Development
EPRI Program Summary

Date: 3/19/2021

EPRI Program/Project Name: Power Quality

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed:

☐ Discontinued (reason) _____

Project Sponsor: Joey Baranski **Sponsoring Department**: Distribution Operations Engineering **Project Team (internal):** Ken Spencer is the lead and other engineers provide additional support as needed. **Project Team (external):** EPRI staff, utility peers, and others **Project Description:** Power Quality has evolved to become a critical enabler of operation and economic excellence for modern electric utilities. Electric utilities worldwide consistently report that power quality (PQ) is a fundamental component of three key utility business performance metrics: grid system performance, utility economic performance, and customer satisfaction. A resurgence of interest in electric power quality performance is being driven by the need to increase the economic performance of existing infrastructure, reduce the cost of grid operations and repairs, manage and respond to increasing grid complexity, and retain existing and attract new load with excellent PQ performance and related customer support. Key among these are R&D imperatives to use PQ expertise and knowledge to improve utility performance and management, maximize the proactive value of PQ data, and address increasing PQ issues that are inevitable with increasing edge-of-grid complexity.	**PGE Budget/Actual:** FY18: $123,447/$123,447 FY19: $126,002/$126,002 FY20: $113,502/ $113,502 FY21:$90,134/ $90,134 **Cost Share Total:** (if applicable) **Cost Share Percent:** (if applicable)
Benefit to PGE: The Power Quality research program offers fundamental insights on electrical grid power quality and compatibility to improve the value of electricity service for society. It may also contribute to	**Strategic Alignment:** This project aligns with all three strategic imperatives.

the overall public benefit of reliably supporting and integrating increasing levels of DER. **Customer Benefit:** The Power Quality research program offers fundamental insights on electrical grid power quality and compatibility to improve the value of electricity service for customers. It may also contribute to the overall customer benefit of reliably supporting and integrating increasing levels of DER.	Distribution Operations Engineering is the first-call for technical quality analysis, by partners in the Special Tester group who measure service anomalies. We continue to learn from hands-on experience as and from industry technical resources to grow and expand our expertise. The EPRI Power Quality program has been critical to developing this expertise, and will be a more critical resource as PGE expand bi-directional power flow, non-linear sources and loads on the distribution system (e.g. distributed solar, distributed batteries, DERMs, transportation electrification, VPPs, V2G, etc.), and other reliability and resiliency initiatives (VVO, CVO, CMI reduction, etc.).

Value

PGE Participation: Provides access to PQ expertise.	**Value Derived**: Access to expert PQ knowledge

Research & Development
Program / Project End Year Summary

Date: 7/7/2022

R&D Program/Project Name: P18 G133 – Foundational Elements for XFC DCaaS

Project Status:

☒ Complete

☐ Will Continue Next Year

☐ Discontinued (reason) _____

Project Sponsor: Darren Murtaugh

Sponsoring Department: RC 509 Grid Edge Solutions

Project Team (internal):

- Luke Whittemore
- Joe Colett

Project Team (selected external participants):

- Watson Collins, EPRI
- Carl Miller, EPRI
- Krish Tomatom, EPRI
- Vijay Bhavaraju, Eaton
- James Kennedy, Tritium

Project Description:

An industry consensus has emerged that DC power is the preferable means of delivering higher power to vehicles. The U.S. Department of Energy has recently coined the term Extreme Fast Charging (XFC) for 350 kW and above DC charging. This project will establish the foundational, technical transfer activities with leading utilities to: identify the technical and packaging requirements for the DC power distribution and grid connection; identify the standards needs for the DC portion of this XFC system; advance the development of technical requirements for regulatory support; and evaluate the economic implications of this XFC approach. Successfully establishing these foundational elements is expected to further efforts to achieve the grid integration of XFC in an interoperable, modular, and scalable manner. It could also create a novel technology pathway that could enable DC as a service and other renewable integration approaches.

PGE Budget/Actual:

FY21: $40,000 (Budget) / $40,000 (Actual)

Cost Share Total:

For this supplemental project, PGE joins Southern California Edison and Seattle City & Light to leverage our total investment through EPRI's research in collaboration with NREL.

Cost Share Percent:

Typically EPRI programs have an average of 40 times cost leverage.

Benefit to PGE: This research guides PGE's exploration of DC as a service and extreme fast charging for electric vehicles. **Customer Benefit:** PGE's participation in this focus area will enhance customer service by allowing us to design better informed products and services.	**Strategic Alignment:** The project supports PGE's corporate imperative of increasing electricity to 50% of total energy use by 2050.

Value

PGE Participation: PGE attended research and design meetings and provided input on preferred utility interconnection methodologies for primary metered extreme fast charging infrastructure. PGE has also had exploratory conversations with EPRI about hosting a prototype extreme fast charger at Electric Island.	**Value Derived**: PGE's participation has helped PGE anticipate the utility interconnection needs and pre-commercial technology pipeline of extreme fast charging and DC as a service.

Research & Development
Program / Project End Year Summary

Date: 07/6/2022

R&D Program/Project Name: P34 Transmission Asset Management Analytics

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: Multiyear continuing commitment with EPRI

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom

Sponsoring Department: R&D

Project Team (internal):

Jay Landstrom, Rob Weik

Project Team (external):

EPRI Researchers

Project Description:

The Transmission Asset Management Analytics program performs research to bridge this gap by developing analytics, methodologies, and asset knowledge enablers, such as failure rates and asset health assessment algorithms, to help utilities make better transmission equipment and component life-cycle management decisions. The results of this research provide utilities with new knowledge, algorithms, and data vital for effective equipment asset management. Research results are transferred to members through scientific reports, easy-to-use software and analytical methodologies, reference guides, webcasts, and workshops.

Specific research activities include:

- Develop data models that guide utilities on identifying data important for asset management analytics, such as developing failure rates, quantifying present condition (health) of in-service assets, prioritizing assets that need attention, formulating

PGE Budget/Actual:

FY21: $28,034

Cost Share Total: (if applicable)

Cost Share Percent:

Typically EPRI programs have an average of 40 times cost leverage.

spares policies, and better managing asset fleets.
- Collect and analyze industrywide failure and performance data for transmission assets to develop new metrics and analytics.
- Develop novel approaches to curate and query data sets to enhance their value.
- Develop analytics using various data sources to uncover asset characteristics and insights to support maintenance and capital planning strategies.
- Develop asset health assessment algorithms and risk mitigation strategies (for example, spares policies and equipment risk assessments).
- Develop an approach for a consistent analytical basis for making capital and O&M decisions.
- Produce reference books, guidelines, and technology transfer webcasts and workshops.
- Provide collaborative forums for sharing lessons learned and best practices.

Benefit to PGE:

The primary values provided by this research are:

- A sound technical basis for consistent and efficient decision-making
- More effective use of existing infrastructure and data
- Early identification of type issues, reducing unplanned outages
- Improved reliability and availability using analyses based on actual asset health and risk to determine maintenance actions
- Reduced reliance on time-based maintenance
- Improved capital planning decisions based on industrywide equipment performance and failure data
- Reduced unplanned expenses and increased benefits and value of planned work
- Improved reliability of electric service

Strategic Alignment:

Perform/Operational Efficiency

• Managed life-cycle costs and risks that contribute to keeping electric rates affordable • Help in assessing and managing risks **Customer Benefit:** Improved and more efficient operations, increased reliability, and increased safety.	

Value

PGE Participation:	**Value Derived**:
Participation in Advisory meetings to gain insight and influence base and supplemental research direction. Receipt of base research performed. Participation in supplemental research areas, such as arc EPRI University for Transmission. Participation in combining utility data to use with AI to gain better insights.	• New Metrics and Analytical Approaches Based on Analysis of Industrywide Circuit Breaker Performance Data: Provides definitions for new circuit breaker performance metrics and example analyses that utilize these newly developed metrics and industrywide data to illustrate novel ways to assess the performance of various circuit breakers that can support improved asset management decisions. New metrics have been developed to better quantify and analyze circuit breaker maintenance requirements. New analytical approaches have been developed to better understand relationships between corrective and preventive maintenance, circuit breaker replacement rates as a function of age, and relative performance among breaker models and types. These analyses provide new insights and visualizations of circuit breaker maintenance requirements. • Circuit Breaker Maintenance and Replacement Ranking Framework: A suite of applications that utilities can apply and adapt to their own needs for maintenance triggering, replacement, or maintenance ranking. The framework uses readily available data and analytics that enable trigger-driven condition and risk-based maintenance or replacement. Implemented

	as a spreadsheet-based approach, the framework provides utilities with default values that a utility expert can adjust and readily apply. • Power Delivery Asset Management Guideline: Comprehensive collection of reference information that documents asset management principles and provides guidelines for developing asset management processes and instituting formal asset management programs. • Power Transformer Expert System (PTX) for Condition Assessment : Power transformers are vital components of the power delivery system, and their operation impacts economic performance and reliability. Hence, accurately and efficiently assessing transformer condition is important for asset and risk management. EPRI developed expert fleet assessment methodologies for power transformers using readily available data. The automated tool emulates the thought processes of industry experts and provides individual unit and complete fleet assessments and suggested actions. • Protection and Control Asset Management Analytics : Introduces the basis for understanding, developing, and applying a set of practical, condition-based risk models for protection system equipment. Presents a process for developing protection equipment risk models and assessment tools and the development of data models, supporting industrywide data collection and analytics. • Assessment and Application of Advanced Analytics to Improve Substation Asset Management: Provides lessons learned about the application of natural language processing (NLP) to extract information from text records generated by utility maintenance and operations activities based on research work utilizing maintenance records supplied by several utilities covering a variety of substation equipment. • Overhead Conductor and Wood Pole Condition Assessment Analytics : A

	process for the review, extraction, and transformation of conductor and wood pole inspection and condition assessment data was developed and used to select data subsets suitable for further analyses and the development of models that relate pole and conductor age to the likelihood of being in a condition warranting maintenance or replacement actions. These models can be applied to the installed fleet and, using a Monte Carlo simulation, a series of yearly estimates of the expected number of poles or lengths of conductor that would be rejected if assessed can be calculated. Analysis results from several utilities were combined and compared to yield broader insights.

Research & Development
Program / Project End Year Summary

Date: 07/6/2022

R&D Program/Project Name: P37 Substations

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: Multiyear continuing commitment with EPRI

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom

Sponsoring Department: R&D

Project Team (internal):

Jay Landstrom, Rob Weik

Project Team (external):

EPRI Researchers

Project Description:

This research and development (R&D) program provides industry value through development of tools, techniques, and methodologies to help utilities improve substation equipment inspection, assessment, maintenance, and risk-based asset management. The information provided through the collection of projects in this program can provide members with knowledge that can help them in the following ways:

- Develop a technical basis for maintenance programs, including for new apparatuses such as resin-impregnated polymer (RIP) and resin-impregnated synthetic (RIS) bushings.
- Provide valuable data sets from the assessment of new and emerging monitoring technologies (for example, online DGA, online bushing monitoring, and online partial discharge detection).
- Extend equipment life by using maintenance guidelines.

PGE Budget/Actual:

FY21: $97,765

Cost Share Total: (if applicable)

Cost Share Percent:

Typically EPRI programs have an average of 40 times cost leverage.

- Reduce maintenance times and costs via condition-based maintenance.
- Assess SF_6 replacements and improve SF_6 management.
- Implement predictive maintenance practices to help reduce outages.
- Improve the specification and maintenance of protection and control apparatuses.
- Enhance decision-making on selection of HVDC and flexible alternating-current transmission system (FACTS) devices.
- Effective knowledge transfer through training webinars, reference guides, and field guides.

Benefit to PGE:

The primary values provided by this research are:

- Development of equipment aging assessment tools—failure modes, degradation mechanisms, and diagnostics.
- Assessment of the effectiveness of various diagnostic tools (online dissolved gas analysis [DGA] and online bushing and partial discharge monitoring).
- Assessment of new materials (such as SF_6 alternatives and new insulation fluids).
- Development of maintenance, inspection, and assessment guidelines.
- Guidelines for relay configuration and settings management.
- Development of webinars to transfer knowledge.
- Publishing of reference books, guidelines, videos, and field guides.
- Collaborative environments for sharing lessons learned and best practices.

Customer Benefit:

Improved and more efficient operations, increased reliability, and increased safety.

Strategic Alignment:

Perform/Operational Efficiency

Value

PGE Participation:	Value Derived:
Participation in Advisory meetings to gain insight and influence base and supplemental research direction. Receipt of base research performed. Participation in supplemental research areas, such as arc EPRI University for Transmission, Pandemic-Resilient and Sustainable Transmission and Distribution (T&D) Systems, Research and Testing of Alternatives to SF6 Participation in combining utility data to use with AI to gain better insights.	The Substations program has delivered many highly valuable reports, guides, and tools that have helped its members increase the reliability and efficiency of electric power delivery. Examples include: • **Reference guides**: EPRI provides a comprehensive collection of reference information that provides the technical basis to design and execute comprehensive maintenance, condition assessment, and life extension programs for substation equipment. These reports include *Power Transformer Guidebook: The Copper Book* (2021 version: 3002021342), *Switching Safety and Reliability, Fault Current Management* (1023060), *Bushing Reference Guidebook* (3002012859), *Increased Power Flow Guidebook* (2019 update: 3002015685), *Circuit Breaker Guide Book* (3002021359), an arrester selection reference guide (3002015688), and the updated *HVDC Reference Book* (3002021811). • **Pocket field guides**: The guides provide readily accessible information to increase the quality and consistency of daily activities. A set of seven pocket field guides is presently available: S*ubstation Infrared Monitoring* (3002003799), *Circuit Breaker Mechanism Maintenance Guides* (3002021360), *Circuit Breaker Pump and Compressor Maintenance* (3002007765), *Transformer Root Cause Analysis and Failure Investigation* (1024199), *Smart Ground Meter* (1020400), *Field Guide for Site Severity Assessment* (3002015707), and *Field Guide for Switching Personnel* (3002010019). • **Online monitor evaluations**: Within the EPRI laboratory, multiple online DGA, online bushing, and online partial discharge technologies are deployed and evaluated against a well-defined and repeatable test protocol. The data sets form a valuable part of

	utility decision-making on selection, application, and interpretation (2021 update: 30020201344). • **SF6 Leak Sealing**: The report documents a test plan and results of small-scale lab tests for sealing leaks from breaker/GIS components that are at ground potential (threaded fittings, bus-flanges, and porous welds on bus-work). It identifies promising materials, repair techniques for full-scale laboratory and the results from controlled field testing (2021 update: 3002021355). • **Ground Grid Protection Methods**: This task identifies corrosion control measures and evaluates which are most appropriate for each initiation mechanism (3002021372). The research is developing accelerated aging protocols for copper and has assessed the impact of conductor geometry on conductor corrosion. The research has also expanded the valuable soil corrosion library. • **Configuration Management for Protection and Control Systems—Application Guide for Relay Setting, Firmware Management, and Effect Practices**: Configuration management guiding principles and processes to protection and control systems for effective management of relay settings and relay firmware changes are introduced (2021 update: 3002021363) and (3002021364). • **Alternatives to Sulfur Hexafluoride (SF6) for Gas Insulated Substations (GIS) and Lines (GIL)**: The report provides a summary of GIS condition monitoring tools and the latest on SF_6 replacements worldwide (3002015690). • **Computer Based Training Modules for SF6—2021 Update**: This latest update is hosted on EPRI-U, and there are additional improvements for better distance education and new content, including the latest EPRI research (2021 update: 3002021387). • **Best Practices for Operation, Maintenance, and Refurbishment of FACTS Controllers**: Many FACTS installations are approaching or exceeding 30 years of service, and components are aging. Utilities need to make repair/replace decisions. This report provides best utility practices for operation,

	maintenance, and life extension strategies for existing FACTS controllers (3002021404). • **Transformer Inspection Robot Evaluations**: EPRI has conducted laboratory and field evaluations of new robotic systems to inspect the inside of a power transformer without having to lower the oil level. This research has identified and evaluated potential technologies that could be used, then demonstrated the most promising option in laboratory and substation environments. This has led to improved guidance on options for internal transformer inspections (2019 update: 3002015700). • **Novel Transformer Dehydration**: EPRI membrane technology for continuous transformer dehydration was moved from the lab to field trials with successful patenting and licensing (3002021340). • **Contamination Performance of Insulators**: The updated practical maintenance guide (3002021394) provides guidance to maintenance personnel on how to evaluate contaminated external insulation and determine the best approach to reduce risk of flashover. The research has also produced valuable guides for remedial measures (3002021391). • **Circuit Breaker Lubrication (Mobile Application)**: EPRI has completed laboratory testing on a wide range of greases to assess compatibility, aging, and degradation characteristics, and the results are readily accessible in a mobile application. This tool provides the technical basis for selecting the most suitable grease depending on breaker type, maintenance frequency, and environment (2019 version: 3002015675). • **138-kV Research Substation, 110/13-kV Research Transformer, and Salt Fog Chamber**: EPRI (with help from utility donations) has commissioned these three facilities. The added capabilities are greatly expanding the breadth of research tasks that can be rapidly and cost-effectively executed.

Research & Development
Program / Project End Year Summary

Date: 07/6/2022

R&D Program/Project Name: P40 Transmission Planning

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: Multiyear continuing commitment with EPRI

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Jennifer Galaway, Ian Beil **Project Team (external):** EPRI Researchers **Project Description:** Traditional power system planning methods and tools are increasingly challenged in today's power system environment as utilities embark on de-carbonization pathways and prepare for climate change related impacts. Transmission owners and operators not only need to plan for future demand growth and increasingly uncertain generation portfolios, but also to provide transmission services for scenarios with vast amount of distributed resources and central generation resources that include significant portions of variable generation (VG) technologies that are often remote from load centers and have significantly different behavior from synchronous generation. The challenge of meeting reliability and resilience requirements with the changing landscape and increasing levels of uncertainty may necessitate adjusting and enhancing transmission planning criteria and methods, and may require new tools and models for transmission planners. Some of the areas for	**PGE Budget/Actual:** FY21: $97,765 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.

significant research that will help planners to deal with challenges moving forward are:

1. Generic, easy to use models of emerging generation and transmission technologies that can be validated periodically for planning studies
2. Efficient approaches to generate and screen contingencies for stability concerns to reduce resource and time burden
3. Practical framework to plan the system to withstand extreme events such as the impacts of geomagnetic disturbances, electromagnetic pulses, natural events, and various physical security attacks on system resilience
4. Consideration of impact of extreme weather events on transmission resilience
5. Consideration of impact of climate change along with other policy goals on long-term planning
6. Application of risk-based reliability approaches for optimal investment decision for long-term transmission reliability
7. Use of high-performance computing (HPC) architecture along with machine learning (ML) and artificial intelligence (AI) for planning studies
8. Use of node-breaker models for reliability studies
9. Integration of power electronic-interfaced transmission assets such as HVDC, FACTS, grid enhancing technologies (GETs), energy storage, and distributed resources in transmission planning
10. Voltage and reactive power management with higher integration of inverter-based resources (IBR)
11. Study methods and tools for more specialized topics like sub-synchronous resonance, control interactions, transmission power quality, electromagnetic studies (EMT) etc.
12. Finally, protection consideration to keep up with the changing grid specifically including efficient tools to check protection settings for changing system conditions, tools for proactively identifying

protection mis-operations and near-misses from a large data repository, validating short-circuit models based on event data, and incorporating protection models in planning studies for higher accuracy in certain cases	
Benefit to PGE: The primary values provided by this research are: • Innovative methods and tools for reliable and economic integration of new energy resources and end-use loads • Tools, methods, key insights to transmission planners to save time, mitigate risks, and reduce costs while maintaining reliability and resilience • Engagement with various stakeholders including regulatory agencies, industry standard groups, and government agencies to advance state-of-the-art transmission planning to benefit public at large and reduce risk for grid operators • Forum for members to collaborate among each other, expert researchers, and technology specialists to solve near-term issues as well as identify and prioritize long-term research needs that collaborative research should address **Customer Benefit:** Improved and more efficient operations, increased reliability, and increased safety. Grid operational and analysis enhancements that increase DER implementation.	**Strategic Alignment:** Perform/Operational Efficiency Electrify

Value

PGE Participation:	**Value Derived**:
Participation in Advisory meetings to gain insight and influence base and supplemental research direction. Receipt of base research performed.	The Transmission Planning program delivers valuable information that helps its members, other electric power stakeholders, and society in

Participation in supplemental research areas, such as arc EPRI University for Transmission, Pandemic-Resilient and Sustainable Transmission and Distribution (T&D) Systems,	numerous ways. Some examples include the following: • ***Protection Settings Evaluation Tool (PSET) (3002018182, 3002020178):*** These deliverables provide macros that integrate into commercial short circuit analysis software tools to allow the user to configure aspects of a system-wide short circuit study and then execute the simulations and report on the results. Based on the configuration from the user, the tool identifies protection systems which may mis-operate allowing the user to identify potentially incorrect relay settings prior to mis-operation occurring. • ***Power Plant Parameter Derivation (PPPD) Version 14.0 (3002022342):*** The PPPD software tool is a simulation program that can be used for validating and parameter estimation of models for synchronous generator power plant, wind and PV power plants, and static var systems. The tool uses measured generation equipment responses to system disturbances to validate the generator, excitation system, and governor control system transient stability models. This tool allows generation owners to perform ongoing model validation as system disturbances occur to support system reliability and to comply with emerging North American Electric Reliability Corp. (NERC) requirements to periodically validate the generator models. • ***Load Component Export Tool (LCET) 4.1 (3002022343):*** The LCET simplifies the process of calculating composite load model parameters and exporting them to file formats used by simulation tools Siemens PTI PSS®E and GE PSLF™. Users can export load model parameters for multiple areas/zones in a planning case. • ***Automated Contingency Generation Tool (ACGT), Version 6.0.1 Beta (3002021522):*** The ACGT software automatically generates contingencies using node-breaker topology for steady-state as well as dynamic studies. The

	contingencies generated cover a wide gamut ranging from N-1 to G-1-1, N-1-1, bus faults, breaker failure, stuck breaker, and common-mode as defined in the NERC planning standard TPL-001-4. This tool can potentially result in a significant saving in amount of time and labor required for assessing system reliability. Also, this approach is much less error prone as opposed to manually generating contingencies. • ***Contingency Screening & Ranking Tool (CSRT) - Transient Stability Module V1.0 Beta (3002021530):*** This software was developed to screen a large number of contingencies and rank them in order of severity from transient stability perspective. • ***Contingency Screening & Ranking Tool (CSRT) - Dynamic Voltage Module V2.0 Beta (3002021528):*** The tool analyzes the post-contingency voltage performance at the local and global level to rank contingencies based upon the nature of the post-contingency voltage according to a set of pre-defined voltage performance metrics • ***Protection in Planning Studies Tool (PIPS), Version 4.0 Beta (3002021886)*** The purpose of this tool is to create appropriate protection relay models on particular grid equipment and populate the device models with conservative setting assumptions. The tool can then be tested on real grids to assess if these generic protection relay models can successfully identify credible protection issues. • ***Risk-Based Planning Scenario Builder Tool (3002021757):*** This software considers uncertainties in system load, renewable generation, hydro generation, demand-side resources, and economic growth to generate power flow scenarios that can capture a wide range of possible system states. In addition, the tool also generates contingencies for each power flow case based on historical performance of generator and transmission components.

	• ***Transient Recovery Voltage (TRV) Screening Tool (3002021354):*** This tool is developed on EMTP-RV platform to perform simulations to screen TRV results against available circuit breaker capability. The tool performs breaker TRV analysis with predefined circuit configurations for easy setup and quick initial assessment. Planners can use this tool to determine if a detailed TRV analysis is needed. • ***Categorizing Line TOV Values for Determining Minimum Approach Distances (3002004444):*** This report documents a technical basis for characterizing transient overvoltage values (TOV) that drive the minimum approach distances for conducting live-line work. The report summarizes the maximum TOV magnitudes expected for various line characteristics and associated operational practices • ***Controlled Transmission Expansion Planning (CPLANET) (3002021766):*** CPLANET explores various mathematical modeling and numerical optimization approaches for transmission expansion planning considering power flow control devices such as phase-shifting transformers (PSTs) • ***GICharm (3002021347):*** This tool is designed to study GMD-related harmonics • ***Coordinated Expansion Planning JHSMINE Tool V1.0 and V2.0 (3002021771, 3002021770):*** The coordinated expansion planning (CEP) - Johns Hopkins Stochastic Multi-Stage Integrated Network Expansion (JHSMINE) is a planning software based on stochastic optimization to perform long-term generation and network expansion planning under uncertainties.

Research & Development
Program / Project End Year Summary

Date: 06/20/2022

R&D Program/Project Name: P180 Distribution System Research

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2021	Cost 2022	
P180 – Distribution System Research	PROGRAM MANAGER	$ 58,998	$ 60535	

- Year to be Completed: Multiyear continuing commitment with EPRI due to ongoing and emerging issues on distribution

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom

Sponsoring Department: R&D

Project Team (internal):

Jay Landstrom, Alex Konopka

Project Team (external):

EPRI Researchers

Project Description:

EPRI's research regarding T&D Environmental Issues (P51) is designed to inform utilities managing the environmental aspects of T&D across a wide value spectrum by conducting research on protecting resources, managing environmental impacts, protecting human health, and informing permitting, regulatory compliance, corporate strategy, and social responsibility.

PGE Budget/Actual:

FY21: $58,998

Cost Share Total: (if applicable)

Cost Share Percent:

Typically EPRI programs have an average of 40 times cost leverage.

Benefit to PGE:

- Reduced costs for ROW maintenance; utility pole and other asset management; mineral oil spill and other risk management; and spill prevention, control, and countermeasure compliance.
- Improved power system reliability by decreasing the potential for T&D outages from avian/animal interactions, applying enhanced and emerging vegetation management best practices, and reducing

Strategic Alignment:

Perform/Operational Efficiency

vulnerabilities and risks to substation reliability. • Reduced ecological and human health risks along T&D ROWs through vegetation management, by preventing avian and other wildlife impacts, and by remediating soil and water contamination at T&D facilities. • Enhanced T&D line permitting and regulatory compliance along T&D ROWs and at substations. **Customer Benefit:** Improved and more efficient operations, increased reliability, and increased safety. Participation in this program allows PGE to leverage over $2.5 million worth of research activities for a low cost.	

Value

PGE Participation:	**Value Derived**:
Participation in Advisory meetings to gain insight and influence base and supplemental research direction.	• Cleanup endpoints for substations contaminated with dielectric fluids or arsenic. • Data and tools that informed substation retrofit plans acceptable to regulators and that minimize risk and reduce costs. • "Immediate" estimates of potential oil losses in failure events. • Research that helped inform the designation of out-of-service wood poles as nonhazardous. • Bird strike indicator/animal activity monitor deployment/avian collision avoidance at utility sites to clarify operational impacts and reduce liabilities from avian and wildlife interactions with facilities. • Criteria defining cost-effective, sustainable performance standards for integrated vegetation management. • Data to inform the power industry's use of integrated vegetation management as a strategy compatible with North American Electric Reliability Corporation (NAERC) standards.

	• Guidance and information to enhance pollinator habitat and address invasive species on T&D ROWs. • Data on costs of deferring vegetation management. • Animal caused outages mitigation product evaluations. • Stormwater management along ROWs.

Research & Development
Program / Project End Year Summary

Date: 07/6/2022

R&D Program/Project Name: P173 Bulk Renewables and DER Integration

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: Multiyear continuing commitment with EPRI

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom

Sponsoring Department: R&D

Project Team (internal):

Jennifer Galaway, Ian Beil

Project Team (external):

EPRI Researchers

Project Description:

Installed capacity of renewable and distributed energy resources has increased significantly in the past fifteen years due to policy decisions such as state-mandated renewable energy standards and federal air and water standards, along with cost reductions, and customer preferences. Bulk power system planners and operators require new tools and resources to provide a reliable, sustainable, and cost-effective supply of electricity to consumers as renewable and distributed resources increase in penetration. EPRI's Bulk System Renewables and Distributed Energy Resources Integration research program (P173) addresses these research needs and provides members integrating increased levels of renewables important information to ensure reliability and economic efficiency of the changing power system.

Tools to aid in meeting these objectives include:

PGE Budget/Actual:

FY21: $63,655

Cost Share Total: (if applicable)

Cost Share Percent:

Typically EPRI programs have an average of 40 times cost leverage.

(1) improved and/or new sources of system flexibility to respond to and accommodate the increase in energy variability and uncertainty

(2) the development of additional transmission infrastructure to deliver energy from remote locations

(3) 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.

Recent announcements at federal, state and utility level demonstrate significant ambitions to increase clean energy, including renewables and battery storage, to meet decarbonization goals has increased the need to study higher penetrations of renewables, in some cases up to 100%. Much of the expected development of renewables comprises variable and/or distributed energy resources (VER/DER) such as onshore and offshore wind generation and solar photovoltaics (PV), which when integrated with the grid, create new challenges for maintaining reliable system operation. Emerging technologies such as battery energy storage, demand response and increased energy system integration are also expected to support these new resources. Studying and operating these systems requires new techniques and tools, which is the focus of this program.

Benefit to PGE:

The primary values provided by this research are:

- Providing innovative planning, operational and protection methods, tools and models as well as integration analytics that help utilities and system operators reliably and economically integrate emerging resources into the grid
- Supporting and advancing the development of integrated energy systems with more renewable, sustainable resources for the benefit of society
- Providing actionable insights, tools, and collaborative opportunities to increase

Strategic Alignment:

Perform/Operational Efficiency

Electrify

resource adequacy and reliability for a decarbonized future **Customer Benefit:** Improved and more efficient operations, increased reliability, and increased safety. Grid operational and analysis enhancements that increase DER implementation.	

Value

PGE Participation:	**Value Derived**:
Participation in Advisory meetings to gain insight and influence base and supplemental research direction. Receipt of base research performed. Participation in supplemental research areas, such as arc EPRI University for Transmission, Pandemic-Resilient and Sustainable Transmission and Distribution (T&D) Systems,	The Bulk System Renewables and Distributed Energy Resources Integration program has provided industry leadership and helped create valuable deliverables in areas such as modeling and transmission planning tools, system protection, operating reserves, frequency response and resource adequacy. Several highlights include: • Generic models and model validation for wind, solar PV, energy storage, and hybrid resources, where leadership from EPRI in industry forums, as well as the related model validation tools and studies has resulted in the inclusion of improved generic models in existing commercial software packages. • Novel system strength metrics and the associated Grid Strength Assessment Tool provides planners with information about potential instability in weak areas, and solutions for addressing these challenges. • Model development, validation and application for grid forming inverters to support the analysis required to understand the role such resources can play. • A screening-level tool, the Transmission Hosting Capacity Tool, that can assess the additional injection of VER that a portion of the network can accommodate under pre-defined conditions.

	• Electromagnetic transient type (EMT-type), time domain and associated frequency domain models of converter interfaced wind turbines, solar PV and batteries that can be used for short circuit studies to determine how they affect system protection, and development of associated guidelines. • Model parameterization tool for Voltage Control Current Source inverters in protection software. • Dynamic equivalent models for DER and modeling approaches for representing Active Distribution Systems in transmission models, and a software tool for developing aggregated DER models. • Approaches for procuring operating reserve to manage the variability and uncertainty of variable generation, and delivery of a software tool (DynADOR) to calculate operating reserve requirements. • Development of methods to size reserve to ensure contingency events can be managed under normal and extreme conditions, and delivery of a software tool (DynADeCR) that can support operators. • Ongoing assessment of the changing nature of frequency performance in systems with high penetration of VER and DER including studies on frequency performance with high VER. • A software tool (FRADT) that allows users calculate the available primary frequency response and inertia on their system for future time periods and can be to study frequency response sufficiency. • Software that allows for monitoring of inertia levels in the system at both system and regional levels. • A framework and set of metrics and tool (Inflexion) that can assist planners in assessing the system operational flexibility to meet increased ramping requirements associated with wind and PV. • Guidelines and studies to outline and study how resource adequacy methods may need to be adopted to the changing resource mix, and how different resources contribute to adequacy.

	• Methods to develop scenarios for resource adequacy studies that ensure both extreme and typical events are considered appropriately, together with risk modeling of resources on the system. • Modeling approaches to integrate DER, energy storage and hybrid plants can be included in resource adequacy studies. • Operator guidelines to support those new to renewable integration in getting up to speed with the most relevant material and issues for operating the system. • Various survey and overview documents, on issues such as DER in operations, ancillary services, low inertia operations and offshore wind integration.

Research & Development
Program / Project End Year Summary

Date: 3/15/22

R&D Program/Project Name: EPRI P174 DER Integration

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
EPRI P174 DER Integration	PROGRAM MANAGER	$ 75,288	$ 66,891	$

- Year to be Completed: 2025

☐ Discontinued (reason) _____

Project Sponsor: Frederick Harris

Sponsoring Department: 565

Project Team (internal):

Project Team (external):

Project Description:

This project is ongoing and is utilized primarily for information gathering, learning, and workshop participation. Participation in the EPRI Integration of DER research portfolio. Research covers tools and methods for planning and operating a more integrated distribution system in a changing landscape with increased penetration of Distributed Energy Resources (DER). Also included are valuation mechanisms for DERs and insights into utility interconnection practices and strategies related to future integration approaches.

PGE Budget/Actual:

FY19:
FY20: $75,288
FY21: $66,891/$66,891
FY22:

Cost Share Total: (if applicable)

Cost Share Percent:

Benefit to PGE:

Provides supporting documentation, workshops, and updates to analytical tools regarding managing interconnection requests, grid control applications, and integration of DER.

Customer Benefit:

Provide pathway for more transparent information to the customer regarding feeder DER, hosting capacity, etc. Will lead to a more visible and configurable system that will be analyzed through future ADMS.

Strategic Alignment:

Aligns strategies relating to hosting capacity via DRIVE. Will be key component in defining related Distributed Resource Planning (DRP) efforts. Addresses management of interconnection requests, and rules/regulations related to these requests. Reference documents provides insights relating to DER settings, operation, and protection.

Provides groundwork for future initiatives aimed at increasing system reliability.	

Value

PGE Participation: Participated in general overview meeting with EPRI and internal stakeholders. Will leverage P174 to better understand smart inverters and smart inverter settings. Will continue to leverage P174 to determine best practices when performing Hosting Capacity Analyses. Leveraging available resources provides guidance in decision making process relating to DER integration.	**Value Derived**: Hosting Capacity is a major topic of interest in the Distribution System Planning (DSP) docket. Participation in the DRIVE user group and active use of the DRIVE tool has been incorporated in the DSP Plan published in Q4, 2021. Materials provide insight regarding inverter patterns, expectations due to heavy PV penetration, and guidance relating to voltage regulation.

Research & Development
Program / Project End Year Summary

Date: 06/20/2022

R&D Program/Project Name: P180 Distribution System Research

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
P180 – Distribution System Research	PROGRAM MANAGER	$ 130,024	$ 115,109	$ 119,230

- Year to be Completed: Multiyear continuing commitment with EPRI due to ongoing and emerging issues on distribution

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom

Sponsoring Department: R&D

Project Team (internal):

Dan Loomis (Manager, Utility Standards Engineering)

Various Internal Stakeholders (Data Science, Distribution Engineering, UAM, Standards, etc…)

Project Team (external):

EPRI Researchers

Project Description:

Research addressing the full asset life-cycle is designed to improve utilities' ability to acquire, operate, maintain, and dispose of distribution assets. This research can produce results impacting specifications, inspection tools,

maintenance practices, fleet management, and other key aspects of distribution owners' responsibilities.

Examples of assets addressed in this program include wood poles, transformers, reclosers, cable terminations, and overhead conductor. Examples of industry issues include use of reliability metrics, fleet management approaches, safety, and resiliency.

PGE Budget/Actual:

FY21: $115,109

Cost Share Total: (if applicable)

Cost Share Percent:

Typically EPRI programs have an average of 40 times cost leverage.

Benefit to PGE:	Strategic Alignment:
• Enhance safety of utility workers and the public regarding distribution assets • Improve specifications for new assets • Develop maintenance practices based on a technical basis • Reduce maintenance costs • Proactively plan capital and maintenance budgets • Increase distribution system resiliency • Improve asset and system reliability **Customer Benefit:** Improved and more efficient operations, increased reliability, and increased safety. Participation in this program allows PGE to leverage over $5 million worth of research activities for a low cost.	Perform/Operational Efficiency Electrify

Value

PGE Participation:	Value Derived:
Participation in Advisory meetings to gain insight and influence base and supplemental research direction. Receipt of base research performed. Included information related to the performance of avian covers being used on PGE's system. Participation in supplemental research areas, such as arc fault modeling to help better align PGE work practices with best industry practices. Participation in combining utility data to use with AI to gain better insights.	• Structure performance testing. Full-scale laboratory testing of new overhead structure designs to assess performance during tree-strike events and improve resiliency. • Pole inspection technologies. Assessed the performance of nondestructive pole inspection technologies by comparing it to actual remaining pole strength. • Sensor performance testing results. Laboratory testing of line sensors provided data that utilities can use to enhance specifications. • Development of pole sensors. Development and field tests of sensors to detect pole angle and condition in real time. • Understanding of grounding configurations for vehicles. Laboratory testing of energized trucks informs grounding and safety practices. • Assessment of resiliency approaches and technologies. Field, laboratory, and computer tools to help utilities understand effectiveness and prioritize options to improve resiliency.

	• Collection and curation of industry practices around underground infrastructure. A robust repository of industry practices helps utilities identify areas for improvement of inspection, maintenance, and safety practices. • Network training. Developed and implemented an online training curriculum in low-voltage meshed network systems; available through EPRI-U. • Investigation of high-impedance faults and mitigation methods. Research into downed conductor and high-impedance faults helps utilities understand the risk and phenomena as well as the options to detect downed conductors and mitigate risks. • Testing of underground switches. Development of new industry intelligence on switch aging and performance in underground systems. • Laboratory testing of manhole events and restraint systems. Controlled laboratory testing of manhole events provides real-world performance information about restraint and mitigation systems.

Research & Development
Program / Project End Year Summary

Date:

R&D Program/Project Name: EPRI P180.004: Distribution Safety Research

Project Status:

☐ Complete

☐ Will Continue Next Year

TITLE OF THE PROJECT		Cost 2020	Cost 2021	Cost 2022
EPRI P180.004: Distribution Safety Research	PROGRAM MANAGER	$130,024	$ 115,109	$

- Year to be Completed: 202X

☐ Discontinued (reason) _____

Project Sponsor:

Sponsoring Department:

Project Team (internal): Dan Loomis, Jonathan Wilson

Project Team (external): Tom Short (EPRI)

Project Description:

The operation of distribution circuits exposes workers and the public to hazards, including contact to energized objects (shock), arc flash from a system fault (burns), and step and touch voltages. This project aims to focus on these risks through research on:

- Grounding and personnel protection
- Arc flash analysis and protection
- Detection and reduction of live, downed conductors
- Stray and contact voltage
- Manhole events
- Evaluation and use of protective equipment
- Technologies to improve worker safety

PGE Budget/Actual:

FY20: $130,024/$130,024

FY21: $115,109/ $115,109

Cost Share Total: (if applicable)

Cost Share Percent:

Benefit to PGE: These research tasks can help utilities improve safety for the public and utility workers. Specifically, the research results could help utilities: • Improve grounding approaches • Improve public and worker safety through leading approaches for downed conductor detection • Reduce hazards to workers from arc flash • Better use protective cover-up • Protect workers from contact to energized lines by enabling technology to reinforce better practices for line coverings • Effectively implement voltage-detection technologies to warn of hazards **Customer Benefit:**	**Strategic Alignment:**

Value

PGE Participation:	**Value Derived**:

Research & Development
Program / Project End Year Summary

Date:

R&D Program/Project Name:

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2021	
EPRI P200 Distribution Planning and Operations	PROGRAM MANAGER	$ 54,759	

- Year to be Completed: 2025

☐ Discontinued (reason) _____

Project Sponsor: Frederick Harris **Sponsoring Department**: 565 **Project Team (internal):** **Project Team (external):** **Project Description:** Participation in the EPRI Distribution Operations & Planning research portfolio has been key in laying foundational groundwork in updating practices and principles in Distribution Planning. EPRI's Distribution Operations and Planning research program equips distribution planners and operators with the means necessary to meet the challenges of today and tomorrow. This includes the supporting and development of new planning processes and frameworks, models, tools, reliability assessment analytics, as well as incorporation of new automation, protection, and control technologies that will be required to transform the current distribution system into an active distribution system that integrates and uses new distributed technologies.	**PGE Budget/Actual:** FY21: $54,759/$54,759 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.
Benefit to PGE: Developing tools will further inform equipment analytical processes, and will provide a standard, uniform approach which will ultimately increase system reliability. Approaches to P200 has informed PGE's future path regarding Distribution Resource Planning.	**Strategic Alignment:** Addresses PGE's Distribution Automation Initiative; will enhance the study process related to future installation of DA schemes. Will continue to inform Distributed Resource Planning (DRP) and related processes moving forward. Will be referenced to address DSP.

Customer Benefit: Tools produced from program provides additional efficiency within the planning process, ultimately leading to increased future system reliability.	

Value

PGE Participation: Participated in Distribution Operations and Planning Webinars. Distribution Automation (DA) switch/recloser placement tool continues to be a key analytical tool used by Planning Engineers. Leveraged reference documents. Provides guidance related to distribution system and DER modeling. Informs additional options analyses including non-wires alternatives. Provides some operational insight relating to ADMS.	**Value Derived**: Continues be leveraged to meet electrification and decarbonization goals. Tools and materials support scenario planning, and sensitivity assessments. Will add value regarding options analysis and decision making.

Research & Development
Program / Project End Year Summary

Date: 3/15/2022

R&D Program/Project Name: EPRI Pandemic-Resilient and Sustainable Transmission and Distribution (T&D) Systems

Project Status:

☐ Complete

☐ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
EPRI Pandemic-Resilient and Sustainable Transmission and Distribution Systems	Linda Keezer	$ 20,000	$ 20,000	$ 20,000

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor: Anthony Gomez

Sponsoring Department: Health & Safety

Project Team (internal): Linda Keezer

Project Team (external):

Annette Rohr, EPRI Project Manager

EPRI SME's and other utility funders

Project Description:

This project aims to assess the near- and long-term impacts of COVID-19 and provide a rigorous technical basis for future pandemic resilient and sustainable T&D operations.

Key project focuses of this project include:

• Evaluating the efficacy of existing and new protocols and technologies and developing new or improved processes for health, safety, and disinfection for T&D applications

• Developing new processes and tools that enhance control center and field crew operations and asset management under normal and pandemic conditions

• Forecasting near-term electricity demand and deferred capital and maintenance work impacts, identifying potential operational reliability challenges, and specifying associated mitigation options

• Assessing the long-term economic impact on system demand and sustainability strategies including impact to generation capacity factors, emissions and pollution, and renewables deployment and curtailment

PGE Budget/Actual:

FY20: $20,000/20,000

FY21: $20,000/$20,000

FY22: $20,000

Cost Share Total: $120,000

Cost Share Percent: Total project budget is about $7,000,000 which makes our cost share at 1.7%.

• Evaluate disinfectant processes, personal protective equipment (PPE), and health monitoring to enhance safe workspaces • Evaluate work processes and facility designs to enable safe, reliable, and efficient operations • Assess and prepare for future demand impacts and mitigate potential operating challenges. • Understand sustainability implications to decarbonization and renewable energy targets	
Benefit to PGE: Rarely do electric utilities around the world simultaneously face the same critical challenge as they are with the COVID-19 pandemic. This provides a unique opportunity to collaboratively develop a scientifically informed foundation for new T&D operations processes and technology applications that enable safe, reliable, affordable, and sustainable delivery of electricity under pandemic and non-pandemic circumstances. PGE is expected to receive the technical basis for evolving company-specific pandemic response plans and sustainability strategies to meet current and future needs. **Customer Benefit:** Having access to the latest collaborative processes and technologies to effectively operate in a pandemic environment will support PGE's mission of providing safe and reliable power to our customers.	**Strategic Alignment:** Perform – Delivering operational excellence

Value

PGE Participation: Participation in routine calls allows PGE health & safety personnel and operations staff to be involved with research on a deep technical level. Feedback from program participants is directly used to shape the content of ongoing research and provide input to our own plans.	**Value Derived**: Given the large participation from utilities across the globe, PGE will have access to the latest up to date research on COVID-19 protocols for electric utilities for a fraction of the actual research cost.

Research & Development
Program / Project End Year Summary

Date: 06/20/2022

R&D Program/Project Name: EPRI Incubatenergy (Pano AI)

Project Status:

☒ Complete

☐ Will Continue Next Year

- Year to be Completed: 2021

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Jay Landstrom, Dan Nunez Wildfire Mitigation and Resiliency **Project Team (external):** EPRI Researchers, Pano AI Developers/Managers **Project Description:** Through the EPRI Incubatenergy program, PGE funded a demonstration project along with PG&E to install new wildfire detection cameras from Pano AI in PGE's and PG&E's service territories. This new camera technology detects possible wildfires automatically using AI and machine learning to detect smoke. The platform then sends alerts to utilities and fire agencies to enable a quicker response to suppress the fires. PGE working with Pano AI to develop new capabilities to address utility specific use cases. These cameras were installed in partnership with the City of Portland Water Bureau	**PGE Budget/Actual:** FY21: $57900 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.
Benefit to PGE: • Greatly improve situational awareness for potential wildfires • Reduce the risk of catastrophic wildfires in PGE's service territory • Increase worker safety	**Strategic Alignment:** Perform/Operational Efficiency

Customer Benefit: • Reduce risk of wildfires for customers and communities • Increase customer safety • Increase fire agency situational awareness and lessen response time	

Value

PGE Participation:	**Value Derived**:
Participated on the deployment team to ascertain technology effectiveness. Worked with technology vendor to better align Pano development and roadmap to utility interests. Participated in final project demonstrations to industry professionals	• Direct insight into use of AI/machine learning to enhance wildfire detection • Low cost demonstration/pilot to assess the technology readiness for full scale deployment • Learnings from peer utilities on use of cameras for wildfire situational awareness • Direct connection with vendor through development to align PGE interests with technology

Research & Development
Program / Project End Year Summary

Date: 07/6/2022

R&D Program/Project Name: PQ Knowledge Development and Transfer

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: Multiyear continuing commitment with EPRI

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Kellie Cloud **Project Team (external):** EPRI Researchers **Project Description:** Power Quality offers a unique opportunity for improving utility economic performance, enhanced customer service, and operational excellence. Managing increased grid complexity coupled with more demanding and sophisticated end-use customers is of paramount importance. The ever-increasing use of sensitive digital and electronic equipment in today's economy, end-use customers are not only demanding higher quality power, but also are calling upon utilities to help resolve PQ problems within customer facilities	**PGE Budget/Actual:** FY21: $20,000 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.
Benefit to PGE: This project offers many potential benefits, including: • Provides extremely high value and high leverage to PQ managers, engineers, and technicians. • Provides access to EPRI experts and a network with industry peers both inside and outside the utility industry. • Provides a wealth of high-impact resources in a well designed, readable, and accessible format. Included among these are numerous documents covering a wide range of PQ	**Strategic Alignment:** Perform/Operational Efficiency

topics, written not only for use by busy PQ professionals, but also to be shared with important enduse customers and internal utility management. • Provides support and enhancement of the program's website. MyPQ.epri.com, a comprehensive electronic PQ resource, provides 24/7 access to more than 1000 PQ case studies, PQ technical documents, PQ standards references, indexes, conference presentations, and other PQ related resources. **Customer Benefit:** Access to critical Power Quality tools and data to help customers analyze their electrical system anomalies.	

Value

PGE Participation:	**Value Derived**:
This supplemental program offers access to a wealth of PQ knowledge and data.	This project offers many potential benefits, including: • Provides extremely high value and high leverage to PQ managers, engineers, and technicians. • Provides access to EPRI experts and a network with industry peers both inside and outside the utility industry. • Provides a wealth of high-impact resources in a well designed, readable, and accessible format. Included among these are numerous documents covering a wide range of PQ topics, written not only for use by busy PQ professionals, but also to be shared with important enduse customers and internal utility management. • Provides support and enhancement of the program's website. MyPQ.epri.com, a comprehensive electronic PQ resource, provides 24/7 access to more than 1000 PQ case studies, PQ technical documents, PQ standards references, indexes, conference

	presentations, and other PQ related resources.

Research & Development
Program / Project End Year Summary

Date: 7/8/2022

R&D Program/Project Name: EPRI Sustainability Program Review

Project Status:

☒ Complete

☐ Will Continue Next Year

- Year to be Completed:

☐ Discontinued (reason) _____

Project Sponsor: Brett Greene **Sponsoring Department**: Strategy **Project Team (internal):** Caitlin Horsley, McKena Miyashiro, Geoff Moore, Elysia Treanor, Peter Davis **Project Team (external):** EPRI Staff **Project Description:** While PGE has invested in the development of our sustainability program and disclosure, like many other companies we have not fully realized the opportunity to optimize company decisions, inform public and stakeholder priorities, and engage on future customer, city, state, and federal sustainability-related initiatives. These assessment services will help to build a best in class sustainability program and related priority/material sustainability issues to align with increasing stakeholder expectations and allow the successful execution of PGE's updated sustainability and decarbonization goals.	**PGE Budget/Actual:** FY21: 45,000 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.
Benefit to PGE: This work directly ties to PGE's decarbonization imperative and updated sustainability and decarbonization goals. PGE's customers have expectations around the sustainability of our business and many of them have sustainability commitments of their own. Participation in this program demonstrates our commitment to sustainability as we seek to build business value while simultaneously acting as environmental stewards and corporate citizens in the	**Strategic Alignment:** PGE's participation in this program provides us the tools and resources we need to execute on all three of our strategic imperatives (decarbonize, electrify, and perform) as well as our purpose and climate goals.

communities we serve. These services will provide us with tools and recommendations in order to execute on our updated sustainability and decarbonization commitments while also directly answering to investor requests (specifically the Sustainability Priority Issue Assessment). **Customer Benefit:** This project further enables us to learn from our utility peers in the areas of sustainability, decarbonization and ESG to better meet our customers' ever-increasing expectations in this area.	

Value

PGE Participation: 1. Investor requested Priority Sustainability Issues assessment will enable learnings for executing on our most priority issues while also communicating this important baseline work to our investors and other stakeholders. 2. The Sustainability Program assessment will enable us to set up a governance framework and other foundational elements to a program that is poised to successfully execute our sustainability and decarbonization commitments.	**Value Derived**: Assessments kicked off late 2020 with final reporting in 2021.

Research & Development
EPRI Program Summary

Date: 06/24/2021

EPRI Program/Project Name: EPRI University for Transmission (EU4T)

Project Status:

☐ Complete

☒ Will Continue Next Year

- Engagement is on an annual basis and was renewed for 2022

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Jay Landstrom **Project Team (external):** EPRI Staff **Project Description:** EPRI | U for Transmission provides high-quality, foundational technical training for utility engineers and other transmission/substation staff that work in assets, asset management, operations, and planning. The project includes a combination of training on demand, distance learning and face-to-face training geared toward engineers and technical staff.	**PGE Budget/Actual:** FY21: $10,000 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.
Benefit to PGE: Provides PGE engineering staff access to the latest training on various topics that are critical to the development and continuing education of the technical staff. Supplements training by seasoned engineers as this pool is diminishing. **Customer Benefit:** Customers benefit by PGE having a highly trained workforce to implement and maintain the electrical grid.	**Strategic Alignment:** Perform/Operational efficiency

Value

PGE Participation:	**Value Derived**:

Courses are a mixture of Computer based, On-demand and traditional classes. Employees sign up and attend through the EPRI LMS system	Training of new and seasoned engineers and technical professionals, NERC Operator certification training

Research & Development
Program / Project End Year Summary

Date: 07FEB2022

R&D Program/Project Name: EPRI Wind Reliability Database (WinNER)

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
EPRI P193B Wind Generation Annual Research Program	Alex Triplett	$ 0	$ 12,000	$ 12,000

- Year to be Completed: 2021

☐ Discontinued (reason) _____

Project Sponsor: Alex Triplett

Sponsoring Department: RC283

Project Team (internal): Alex Triplett, Greg Bingham, Scott Phares, Jesus Carrera, Ian Brook, Robin Berry

Project Team (external): Brandon Fitchett (EPRI), Raja Pulikollu (EPRI)

Project Description:

Access to the EPRI Wind Reliability Database, aka WinNER.

PGE Budget/Actual:

FY21: $12,000 SDF funding
FY22: $12,000

Cost Share Total: NA

Cost Share Percent: NA

Benefit to PGE:

The objective of this database is to better understand wind turbine component reliability throughout the life of a wind farm. This could lead to more predictable maintenance costs through data driven projections.

Customer Benefit:

Wind plays a major role in PGE's vision for a clean energy future. It is important to take actions to make our wind fleet a reliable and cost-effective renewable generating resource for our customers.

Strategic Alignment:

This program is in alignment with PGE's corporate imperatives to Decarbonize and Perform.

Value

PGE Participation:	Value Derived:
- Wind Innovators Network (WIN) meetings with EPRI and other wind operators. - Wind Component Reliability Database Webinars. - Numerous 1-on-1 interactions with EPRI staff to address opportunities specific to PGE	- Ongoing participation in wind component reliability database to better understand expected major component reliability over the life of a wind turbine. - Using knowledge from this project, Asset Mgmt Engineering will advocate for data driven budgeting of wind capital maintenance. - Using reliability database to project gearbox and generator failure rates in 2022 and beyond. - Standardized reliability data for 2 major PGE failure modes, compared to industry failure rates, and developed failure projections. - Provided PGE with Python template and training to self-perform reliability analysis. - EPRI provided failure rate projections for generator failures, which is a major cost of unplanned wind capital maintenance.

Research & Development
Program / Project End Year Summary

Date:

R&D Program/Project Name:

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
5G Comms Lab	PROGRAM MANAGER	$ 0	$ 14,720	$ 180000

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor: Larry Bekkedahl **Sponsoring Department**: Integrated grid **Project Team (internal):** Mohan Chidambaram **Project Team (external):** Expeto **Project Description:** A 5G comms lab, to try new comms and technology for the integrated grid.	**PGE Budget/Actual:** FY20: 0 FY21: $14,720/$14,720 **Cost Share Total:** (if applicable) **Cost Share Percent:**
Benefit to PGE: The goal of the Energy Lab is to provide the ability to demonstrate the operational efficiencies and benefits through these grid modernization and digital transformation use cases to accelerate and enable the “Connected Utility”. In some cases, these projects will be candidates for production and enter a process for commercial deployment at PGE. The scope of the Energy Lab includes the ability to manage the full lifecycle of network systems and cellular data capable devices organized into the following three (3) groups. ● Connected Worker ● Connected Customer ● Connected Field Device Achieving the “Connected Utility” goal will be driven through creating use cases and establishing foundational elements for the network and relevant data workflows. The Solution Framing Document defined in Section 5, will produce the specific use cases which will be driven through the	**Strategic Alignment:** As we move forward with our initiatives, one of the keys is telcoms to connect the various devices in the field, users and with customers. This lab tests these connections end to end (including PGE security requirements) to see what is feasible within a ”sandbox” environment

90-Day innovation cycle. These mutually agreed upon use cases will form the objectives of the Energy Lab and will relate to the three groups mentioned above. A known objective is the Wildfire Mitigation use cases that relate to the Connected Field Device group. The foundational elements include the current elements of PMN1 and PMN2 along with data analytic elements. Each PGE approved use case will be assessed and reported technically, qualitatively and economically. Technical results will be measured with predetermined and measurable acceptance criteria that are defined in the test plan for each use case. The qualitative assessment is focused on the "day in the life" feedback for the use case provided through transcribed/recorded interviews delivered to PGE at the conclusion of the trial. The 90-day cycle will conclude with a business case that includes the financial benefits as compared to a "business as usual" approach. This will result in a Go/No-Go/Modify decision to move the use case into production, revise it to complete additional testing, or other modifications including pausing the use for future consideration. **Customer Benefit:** 1. They tailor their solutions to fit PGE prior to going into a production environment 2. If anything fails, the customer gets a detailed understanding of why (e.g performance, ease of use etc)	

Value

PGE Participation:	**Value Derived**:
We are providing the locations, and in filed trial requirements for the lab	We have already identified more importantly use cases that don't work and what we need to do to make it work

Research & Development
EPRI Program Summary

Date: 06/20/2022

EPRI Program/Project Name: Educating a Digital Power Workforce to be GREAT with Data

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Jay Landstrom, Alex Banicki **Project Team (external):** EPRI Staff **Project Description:** The GREAT with Data initiative will develop and deliver T&E materials (both professional and university training) to address issues for merging Grid Operations Technology (OT) and Information Technology (IT). The central theme is to create necessary T&E activities for the next generation power engineers and data scientists, so they can design and develop the grid architecture and infrastructure to enable the integration of distributed energy resources (DER). The project will train, educate, and recruit qualified personnel into the electric utility industry through enhanced industry coordination and workforce readiness initiatives. New and revised university curricula will prepare incoming engineers and computer scientists for the newly evolving grid architecture and infrastructure. Further, this project will develop credentials for the training and education needed in the electric industry workplace to transform the grid.	**PGE Budget/Actual:** FY21: $10,000 FY22: $10,000 **Cost Share Total:** (if applicable) **Cost Share Percent:** Typically EPRI programs have an average of 40 times cost leverage.
Benefit to PGE: The GREAT with Data initiative will address T&E for workforce skills in five key technical areas: 1. Power system fundamentals;	**Strategic Alignment:** Decarbonize Electrify

2. Data science, including descriptive, prescriptive, and predictive analytics, and machine learning; 3. Cyber security; 4. Information and communication technologies (ICT) including increased grid interoperability and standardization; and 5. Integration of solar photovoltaic (PV) and other synergistic distributed energy resources (DER) such as energy storage, electric vehicles, demand response (DR), etc. Access to this training will help PGE up-level the skills of current and new employees to meet the challenges of the emerging grid. **Customer Benefit:** Customers benefit by PGE developing a smarter grid that will enable greater amounts of DER's.	

Value

PGE Participation:	**Value Derived**:
Attending advisory meetings in the Spring and Fall. Named affiliate universities to participate, PSU and OSU.	Affiliate universities gain access to all educational materials. PGE has access to all materials in addition to a limited number of free spots to attend training seminars on emerging smartgrid topics.

Research & Development
Program / Project End Year Summary

Date:

R&D Program/Project Name:

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
Heavy Duty Fleet Charging Infrastructure O&M Strategy and Training	PROGRAM MANAGER	$	$ 100k	$ 100k

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor: Ian Beil

Sponsoring Department: 509

Project Team (internal): Ian Beil, Joe Colett, Andy Eiden

Project Team (external): Tomoki Ito, Dexter Gauntlet, Brian Dillard (Panasonic)

Project Description: Explore

PGE Budget/Actual:

FY20: -

FY21: $100k / $19,100

Cost Share Total: Panasonic has dedicated a project engineer from their team to oversee the integration work, which is a significant in-kind cost share contribution.

Cost Share Percent: N/A

Benefit to PGE:

Creating of a grid-edge controller that is able to monitor and throttle the power of the chargers at Electric Island. This controller will provide a better understanding of the requirements for integrating electric vehicle chargers into PGE control systems

Customer Benefit: Allowing PGE to control EV loads will reduce the burden on associated distribution infrastructure, which in turn reduces interconnection costs for customers. These cost savings can spur additional EV purchases and reduce customer energy bills.

Strategic Alignment:

This work aligns with PGE's efforts to electrify the transportation sector. By better understanding the tools available to manage EV loads via the installed controller, PGE will be able to reduce EV loads at times of stress on the system, subsequently allowing for further adoption of EVs on a given distribution circuit.

Value

PGE Participation:	Value Derived:
PGE guided the work to install a controller at the electric island site, including procurement of a control cabinet, hiring of an electrician to build the controller and install at the site, and installation of fiber between the EV chargers at the site and the controller. PGE also coordinated discussions between various internal groups, Panasonic, and Daimler as the controller was designed and commissioned.	PGE derived value in this project in the form of expert advice provided by Panasonic, who is designing an "eFleetAggregator" product based on the learnings from the controller install funded by this R&D project. These insights allow PGE to make more informed decisions as it scales it managed EV charging programs and broader DERMS and ADMS investment decisions.

Research & Development
Program / Project End Year Summary

Date:

R&D Program/Project Name:

Project Status:

☒ Complete

☐ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
TITLE OF THE PROJECT	PROGRAM MANAGER	$	$ 75,000.00	$

- Year to be Completed: 2021

☐ Discontinued (reason) _____

Project Sponsor: Angela Long

Sponsoring Department: RC535 Distributed Resource Planning

Project Team (internal): Andy Eiden

Project Team (external):

Kevin Van Den Wymelenberg (UO)

Mark Fretz (UO)

Paul Ward (UO and then PAE)

Karina Hershberg (PAE)

Forest Tainier Gessner (PAE)

Linda Woodley, Diversifying Energy

Project Description:

University of Oregon developed indoor environmental quality (IEQ) risk assessment model for various risk factors related to exposure within multifamily apartment buildings, ranging from wildfire exposure to public health threats such as COVID-19 exposure and other common indoor air pollutants (e.g., volatile organic compounds resulting from on-site combustion of direct-use fossil fuels). UO team then researched and recommended 5 mitigation strategies to reduce the risk of exposure. PAE took the 5 recommended IEQ measures and paired them with a whole-building energy modeling of typical multifamily structure in order to make recommendations on the optimal trade-off between reducing IEQ risks and energy use,

PGE Budget/Actual:

FY20:

FY21: $75,000 / $75,000

Cost Share Total: N/A

Cost Share Percent: N/A

including impacts under different levels of energy efficiency and flexible loads to offset the added ventilation energy demands of the building. The project outcomes resulted in a case study of 4 pathways to mitigate IEQ exposure ranging from no/low-cost measures, to simple retrofits, and finally to new construction and major rehabilitation.	
Benefit to PGE: PGE continues to be recognized by leadership shown in this arena to promote cutting-edge research that aims to improve societal outcomes. At a time of heightened awareness on the need to account for multiple outcomes during extreme weather and/or wildfire events (e.g., occupant health and safety, GHG, grid reliability) these types of projects are critical to solidify PGE as a leader in providing the type of services and partnership our customers expect. The study outcomes are being circulated with a wide variety of external stakeholders, including in the University of Oregon's industry consortium (comprised of Nike, Swinerton, Condair, and others), PNNL's quarterly Healthy Buildings stakeholder group (comprised of PNNL, US DOE, HUD, LBNL, ACEEE, International Well Building Institute, and more). These relationships will be well suited to position PGE to work with our partners to secure additional funding from the Federal Infrastructure Bill related to funding around low-income Multifamily housing infrastructure needs and equity goals. **Customer Benefit:** Home Forward participated in early study design conversations with PGE and identified a number of overlapping challenges with how to evaluate the energy and IEQ needs of their buildings across their portfolio. Having the study results will inform their future planning for how to evaluate trade-offs when making capital investments to ensure occupant health and safety to a growing range of climate and public health threats, and considering the energy impacts and ways to minimize additional cost burdens. Moreover, project outcomes will be shared with general stakeholders who are seeking means to address energy burden in Multifamily renters, including our City and community partners engaged through the distribution system plan (DSP) and other	**Strategic Alignment:** This project is well-aligned with PGE's strategic commitment to Energy Justice and empowering our communities – commitments we made and have reinforced through the DSP. As part of the study, we also worked with PAE to evaluate the hourly carbon impacts associated with Load Flexibility offered, and how buildings might play a role in that. This will strategically help as we continue to plan for the upcoming DSP, IRP, and Clean Energy Plan under HB 2021.

venues. We expect these findings will be informative for our low-income housing partners who wish to pursue Portland Clean Energy Fund allocations for whole-building retrofits to aging affordable housing buildings.	

Value

PGE Participation:	**Value Derived**:
PGE played a key role to coordinate with Home Forward as prospective client, and will continue to work with the external project team to socialize the lessons learned about the project. PGE is a conduit for those groups to circulate their innovative work with a wider utility audience, and this dynamic is very helpful to continued work to answer new and emerging research questions that resulted from this initial effort. Many of the aspects relevant to this research are being talked about by stakeholders throughout the energy industry as we continue to see a shift to more societal decision making. Indoor air quality and the emerging threat of dangerous wildfire smoke across the Western US will continue to be a difficult challenge, and participating in this research has allowed PGE to show up as a critical partner enabling first movements in the right direction.	Final report is well put together, thoroughly researched, and will serve as a useful tool to circulate learnings and attract future funding from local, state, and federal sources. There is immediate value derived from the learnings in the report that PGE staff are able to translate into a variety of ongoing research across Customer product development channels, DSP community engagement proceedings, and local regulatory decision making processes related to next generation energy code updates for buildings.

Research & Development
Project Summary

Date: 06/21/2022

Project Name: EPRI Incubatenergy Labs

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: 2022, Renewal is on a yearly decision basis

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Jay Landstrom, Darren Murtaugh, David Worth, Larry Bekkedahl, Jake Wise, Andy Macklin **Project Team (external):** EPRI **Project Description:** Incubatenergy® Labs is built for startups to engage utilities in paid demonstration projects. A utilities summit and collaborative demonstrations program in one, the program links startup companies leading the advancement of electrification, decarbonization and grid modernization with utilities from around the world. Innovative companies are encouraged to submit products and projects from selected areas of interest in: • Customer and Community Engagement • The Digital Utility/AI • Integration of Distributed Energy Resources • Electric Mobility • Customer and Community Resilience • Workforce of the Future	**PGE Budget/Actual:** FY21: $50,000/$50,000 **Cost Share Total:** $50,000 **Cost Share Percent:** Approximately 10% Costs are shared between participating utilities: American Electric Power (AEP), Con Edison, Edison International, Enel, Nebraska Public Power District, New York Power Authority, Portland General Electric (PGE), Xcel Energy, Ameren, Tennessee Valley Authority (TVA), and Southern California Edison (SCE), Fortis and others
Benefit to PGE: PGE will have access to and engage with cutting edge companies that will shape the next generation electrical grid.	**Strategic Alignment:** Perform and Customer Satisfaction

Customer Benefit:	
Many of the new technologies in this effort are directed directly at the customer. As these technologies become more available PGE could offer them to customers to enhance their interaction with the grid.	

Summary

Synopsis of Project as Implemented:

PGE participated in the review and selection of companies that were chosen to develop demonstration projects with participating utilities. The finalists were:

- **COMMUNITY ENERGY LABS (PORTLAND, OR)** Grid-smart building controls that enable commercial building owners and facility managers to upgrade and autonomously operate clean, affordable, all-electric buildings without sacrificing occupant comfort, or disrupting power markets or the grid.
- **COPPER LABS (SAN FRANCISCO, CA)** Wireless energy monitor that delivers consumption and power quality data from electric, gas, and water meters so utilities can engage consumers with actionable insights for demand management, electrification, grid planning, and distribution network health monitoring.
- **DATCH (SAN FRANCISCO, CA)** Voice AI technology engineered specifically for the industrial workforce to interface with enterprise databases.
- **DCSIX TECHNOLOGIES (CORK, IRELAND)** An energy monitoring platform that reduces energy bills and encourages the pursuit of more sustainable energy use.
- **DESIGN INTERACTIVE (ORLANDO, FL)** Augmented Reality application that empowers experts to transfer knowledge, by making content easily authored by front-line employees. No software engineers are needed.
- **DYNAMHEX (BALTIMORE, MD)** Energy data API platform that pulls on a national GHG inventory to visualizes complex energy consumption and emissions data for individual, corporate, and government entities.
- **ENERBRAIN (TURIN, ITALY)** AI-powered software that optimizes HVAC energy

Decisions to be Made:

PGE is implementing a pilot project with Pano AI automated wildfire detection cameras in partnership with the City of Portland

Next Steps:

Participation for the 2022 program was approved.

consumption for sustainable, comfortable, and efficient buildings.

- **ENERYIELD (GOTHENBURG, SWEDEN)** Machine learning algorithms for intelligent energy analytics and control of electricity flow.
- **FUTURE GRID (MELBOURNE, AUSTRALIA)** SaaS "toolkit" to address the power quality challenges caused by renewable technology.
- **HEYCHARGE (MUNICH, GERMANY)** Device to enable electric car charging for apartments and garages.
- **INDOW (PORTLAND, OR)** Window inserts that press into existing window frames to bring energy efficiency without requiring window replacement.
- **LIVE-EO (BERLIN, GERMANY)** Satellite imagery and software to provide innovative infrastructure monitoring.
- **MICROGRID LABS (BOULDER, CO)** Comprehensive power management and control systems for industrials, utilities, and microgrids.
- **NOTEWORTHY AI (STANFORD, CT)** Real-time inspection and inventory for distribution assets.
- **PANO AI (SAN FRANCISCO, CA)** Powers actionable intelligence for fire professionals with ultra-high-definition, 360° Pano Cam networks, and AI-powered wildfire detection.
- **SHIFTED ENERGY (HONOLULU, HI)** Automated system that manages residential and commercial appliances to support load shaping across the electrical grid.
- **THERMO.AI (BINGHAMTON, NY)** AI-powered, smart controls for power plants to minimize emissions and maximize efficiency.
- **URBAN ELECTRIC POWER (PEARL RIVER, NY)** Zinc manganese dioxide battery technology for stationary storage.
- **WEXENERGY LLC (ROCHESTER, NY)** Interior-mounted window insulation panel that keeps the heat inside during cold weather and outside during warm weather.

Performance Against Objectives/Deliverables:

The Project delivered the final demonstration results in October 2021.

Research & Development
2020 Year End Summary Proposal for OIT Study

Date: 7/7/2022

Investigation on Transient and Steady State Behavior of Microgrids Before, During and After Islanding in Terms of Frequency and Voltage

Project Status:

☒ Complete

☐ Will Continue Next Year

☐ Discontinued (reason) _____

Project Sponsor: Darren Murtaugh **Sponsoring Department**: RC509 **Project Team (internal):** Manny Obi **Project Team (external):** Eklas Hossain (OIT) **Project Description:** In the proposed work, a detailed literature will be prepared to investigate the present condition of various types of microgrids. The factors to establish the microgrid parameters and well-defined boundaries will be extensively studied. The transient and steady state response of the system in terms of frequency and voltage for pre-islanding, during islanding and post-islanding conditions are to be observed. Moreover, the effect of under and over frequency or voltage on the microgrid and utility grid will be experimented. Several case studies with grid support, peak load shedding, peak shaving, load shifting, and voltage or frequency support will be observed.	**PGE Budget/Actual:** FY21: $2,340 **Cost Share Total:** (if applicable) **Cost Share Percent:** (if applicable) N/A
Benefit to PGE: Research into microgrid behavior before, during, and after islanding will support PGE's transition to cleaner energy. **Customer Benefit:** A better understanding of microgrid boundaries would support future PGE projects providing resiliency and reliability as a service to customers by reducing risk costs through outage mitigation.	**Strategic Alignment:** (Which PGE Corporate Imperative did this project address?) Decarbonize

Value

PGE Participation:	**Value Derived**:
Monthly meetings with OIT, provide technical guidance and PGE CYME models.	Microgrids with energy storage systems in addition to the reliability and resiliency benefits during islanded mode can also provide benefits while grid-connected such as bulk energy to be dispatched during peak demand, ancillary services (i.e. regulation, load following, spinning reserves, voltage support, and black start), and potential distribution equipment deferral. A final presentation and formal report from OIT of the project findings and recommendations for microgrid implementation.

Research & Development
Program / Project End Year Summary

Date: 6/30/22

R&D Program/Project Name: Developing Ergonomically Enhanced Tools for Manhole and Vault Cover Removal and Replacements

Project Status:

☐ Complete (To be completed in 2022)

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
Developing Ergonomically Enhanced Tools for Manhole and Vault Cover Removal and Replacements	Ben Lumsden	$ 0	$ 25,000	$ 25,000

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor: Forrest Carithers

Sponsoring Department: Health & Safety

Project Team (internal): Ben Lumsden, Rob Roloson

Project Team (external): John Shober (EPRI), Dr. Richard Marklin (Marquette University), Dr. Sean Gallagher (Auburn University)

Project Description: In this supplemental project, the EPRI research team will evaluate certain existing work practices and tools to remove or replace manhole and vault covers and will conduct field and lab tests with newly designed tool(s). Project objectives include the production of final tool designs with the intention of reducing the risks of musculoskeletal disorders (MSDs) to utility field workers. The new tools may be a modification to an existing tool or entirely new designs.

PGE Budget/Actual:

FY21: $25,000/$25,000

FY22: $25,000/

Cost Share Total: $50,000/$150,000

Cost Share Percent: The total cost of the project was shared over three member utilities and therefore the funding leverage is 3:1. For every dollar that PGE invests, it is being leveraged by $3 from other utilities.

Benefit to PGE: In this project, new or modified tools will be tested to reduce the risk of MSD injury to workers who are responsible for removing and replacing manhole and vault covers. Magnitude of manual force and body pressure are two key risk factors for MSD injuries. The new or modified tools must minimize manual force and physically jeopardizing body postures to reduce risk of MSD injury. Results from this project are expected to benefit PGE's efforts to reduce the incidence, severity, and cost of MSDs to our employees from manual movement of manhole and vault covers. These insights are anticipated to reduce injuries, enhance productivity, and indirectly enhance reliability through more efficient work product and fewer disruptions at job sites. Reduced total recordable injury rates (TRIR) will reduce insurance costs, worker compensation claim costs, lost time away from work, and potentially reduce re-training costs. **Customer Benefit:** Reducing the risk of MSD injury will reduce total recordable injury rates, thereby reducing costs associated with insurance, worker compensation, lost time away from work, etc. This project is anticipated to enhance productivity and indirectly enhance reliability through more efficient work products and fewer disruptions at job sites. This reduction in cost and increase in productivity is expected to reduce costs that can be passed along to our ratepayers.	**Strategic Alignment:** This project aligns with PGE's strategic goal of Operational Excellence by reducing overhead costs through injury reduction, enhancing productivity, and indirectly enhancing reliability through more efficient work products and fewer disruptions at job sites.

Value

PGE Participation: PGE's project team has participated in all project meetings, design reviews, and coordination calls. PGE project advisors will continue consultation with EPRI and other utility advisors with ongoing biomechanics/ergonomics testing at Auburn University, and after field test at Con Edison in August, 2022.	**Value Derived**: PGE has received engineering drawings of the prototype manhole and vault cover removal tool and training videos on how to use the prototype tool. The prototype tool will be field-tested at Con Edison in New York in August, 2022. Upon review with other utilities and the EPRI advisors, PGEs project team will review with our internal tool committee and line management.

Research & Development
Program / Project End Year Summary

Date:

R&D Program/Project Name:

Project Status:

☒ Complete

☐ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
Meter Collar R&D	PROGRAM MANAGER	$ -	$ 3,400	$ -

- Year to be Completed: 2021*
  *The original funding request was just for 2021. We may want to request additional R&D funds in 2022 in order to procure additional new devices from different manufacturers as they becomes available, and we would make a subsequent request to the R&D committee to that effect.

☐ Discontinued (reason) _____

Project Sponsor: Ian Beil &Manny Obi

Sponsoring Department: Grid Edge

Project Team (internal): Ian, Manny, Jonathan Wilson, Lyleen Dauz, Kristie Nixon, Scott Mara, many others

Project Team (external): none

Project Description:

There has been some push from third parties recently to get PGE to allow "meter collars" – devices that are installed between the meter and the meter base, in order to provide an electrical access point for PV, energy storage, or backup generators. Here are a few examples: ConnectDER, Generlink. These devices are not currently allowed per Chapter 7 of the ESR, and it is understood that there is resistance within PGE to change these policies.

We are contemplating an R&D project to install a few of these devices at PGE facilities in order to assess their performance. We'd like to use this project to assess the merits and drawbacks of these devices in general.

PGE Budget/Actual:

FY20: -

FY21: $20k / $3.4k

Cost Share Total: N/A

Cost Share Percent: 0%

Benefit to PGE:

- PGE can gather meter data from the DERs using meter collar
- PGE can directly control of the DERs through the meter collar
- Devices provide additional layer of protection against islanding of DERs, which is critical for the safety of PGE crews

Customer Benefit: Meter collars are a safe and reliable way of connecting residential small size generators or batteries to a utility meter. The collar is smart enough to know when grid power is restored and automatically disconnect the generator, thereby acting as an Automatic Transfer Switch (ATS). They clamp around and plug directly into the utility meter socket, with a snap on for the meter to be plugged into the collar. In other words, the meter collar is sandwiched between the meter and the meter socket.

Instead of running cables and drop cords all around the customer's house through the windows and/or doors, because the meter collar plugs into the meter socket at the service entrance, customers have one main plug for connecting the secondary power source, either a battery or a generator, at the meter collar. Using the existing main panel and house wiring, customers can independently switch on or off the respective breakers servicing their home loads or lighting.

Meter collars have also been shown to substantially reduce installation times for generator/battery connections.

Strategic Alignment:

PGE's January 2020 Electrical Service Requirements (ESR), section 3.4.6 explicitly prohibits the use of customer-owned meter socket adapters and meter collars.

This project seeks to provide guidance on three key questions:

- From a **technical perspective**, can meter collar devices be safely permitted for residential use within PGE's service territory?
- From a **program development perspective**, what is the best way to design and develop a program that is both safe and convenient? How have other utilities approached this challenge?
- **Who should be responsible for owning the installation and maintenance of these devices – the utility or the customer?** And what are the related impacts to labor relations (IBEW 48 or 125)

Value

PGE Participation:

- We've done some fact finding on meter collar devices and programs being deployed by other utilities. The attached report summarized our findings.

Value Derived:

The potential value of this product engagement will be revealed as the devices are tested and if we begin to deploy them as pilots in the field.

- We have developed the "Qualification Evaluation – Meter Mounted Transfer Switch," which will determine the technical testing requirement for these devices. - We've procured three devices – a Tesla "backup switch," a GenerLink transfer switch, and a ConnectDER collar. These devices are in the meter shop. The anticipated testing timeline for them is Q3 this year. - Finally, we've engaged product development on thinking through what a PGE program involving these devices might like look. Audrey and her team are starting to build this development work into their roadmap.	

Research & Development
Project End Year Summary

Date: 02/14/22

R&D Program/Project Name: Northwest End Use Load Research (EULR)

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: PGE's financial commitment ends this year (2022), however the project will be extended using the existing budget for 2+ years. Cumulative actual project expenses through Year-End 2021 are 44% of funding commitments, reflecting paused installations during COVID-19 case surges in 2020 and 2021, and recruitment challenges in the Commercial Energy Metering Study (CEMS). With the decrease is the Omicron cases throughout the region, instillations are expected to restart in March 2022 and the recruitment strategy for CEMS has been adjusted to increase participation. Project costs and activities are forecasted to be double those of 2020 and 2021.

☐ Discontinued (reason) _____

Project Sponsor: Andy Eiden

Sponsoring Department: Smart Cities & Grid Products (formerly Consumer Energy Solutions)

Project Team (internal):

- Andy Eiden, Steering Committee Member
- Ashleigh Keene, Working Group Member

Project Team (external):

- David Clement, NEEA, Project Manager
- Residential vendor, Evergreen Economics
- Commercial vendor, DNV
- Steering Committee, various participants
- Working Group, various participants

Project Description:

The End Use Load Research (EULR) Project is a collaborative effort of utilities and energy organizations to better understand behind-the-meter consumption patterns of residential and commercial buildings in the Northwest. Managed by the Northwest Energy Efficiency Association (NEEA), the primary goal of the project is to produce typical hourly load shapes for a range of end uses using circuit-level meter data. Project results will update industry-standard end use profiles developed in the 1980s

One-minute data is collected continuously over a five-year period and is accessible project funders. Aggregated data will eventually be made available for public use. Detailed end use data has several important uses for PGE, including informing our deep decarbonization planning, demand response planning, bottom-up forecasting, and rate design.

PGE Budget/Actual:

2018: $130,000
2019: $130,000
2020: $130,000
2021: $130,000
2022: $130,000
Total: $650,000

Cost Share Total:

The total 5-year budget for the project is $12.7 million, of which PGE is contributing $650k. The remaining budget will be covered by the other member utilities as well as regional stakeholders such as the Energy Trust and BPA, and the US Department of Energy.

Cost Share Percent:

PGE's share of the total 5-year project budget is 5%.

Benefit to PGE:

The data collected as part of this study will be a critical input as we take on a more distributed view of planning and resource deployment. The end use load data will inform the deployment, forecasting, and analysis of deep decarbonization measures on our grid. It will also improve our ability to conduct granular, bottom-up load forecasting to inform distribution resource planning efforts.

Customer Benefit:

Research from this project will help PGE better plan and develop programs that fit customer lifestyles and meet their desire for clean, reliable energy.

Strategic Alignment:

This research project is an example of PGE's commitment to investing in a reliable and clean energy future, and building and operating a smarter, more resilient grid. Underlying both strategic initiatives is a detailed, empirical understanding of how our customers use electricity so that we can develop accurate forecasts and effective demand response programming.

Collaborating with regional partners to improve shared data sources and increase our understanding of behind-the-meter consumption patterns is also evidence of PGE's drive to pursue excellence in our work.

Value

PGE Participation

While Covid-19 impacts put additional metering installations on hold after March 2020, the project moved forward with decisions and scoping for analytical deliverables from project implementers. Specifically, the working group recommended that the residential study not to attempt a data normalization process to align energy consumption patterns pre- and post-Covid-19 due to systemic shifts that are expected to hold (e.g., remote office workers).

Instead, the working group has recommended that the study move to:

1) Leverage participant surveys to provide context to notable changes in end use energy patterns to better understand how residential consumptions patters have changed during the pandemic and what changes might stay, and
2) Align whole home energy usage impacts with end use data to develop a disaggregation model.

Value Derived Performance Against Objectives/Deliverables:

Steering Committee member Andy Eiden was able to leverage the 1-minute residential data for some additional work with two national labs, NREL and PNNL, the latter of which resulted in a $60,000 award to PGE for contributing data to a machine learning approach to solar load disaggregation.

A primary goal for the PGE project team in 2022 is to work with Distribution System Planning, Load Research and IT to bring in and process the available meter data for internal uses, such as model training, forecast improvements, and demand response learnings, among others.

Research & Development
Program / Project End Year Summary

Date: 7/7/2022

R&D Program/Project Name: 161F – Next Gen Meter Vision and Criteria

Project Status:

☒ Complete

☐ Will Continue Next Year

☐ Discontinued (reason) _____

Project Sponsor: David Worth **Sponsoring Department**: RC712 DCIO Smart Grid **Project Team (internal):** Erik Cederberg, Kirk Page, Bob Simpson, Jay Landstrom, Jonathan Wilson **Project Team (external):** EPRI – Ed Beroset **Project Description:** Consortium of utilities looking to align on the vision for next gen metering solutions to inform strategy and vendor / market trajectory (more detail in proposal)	**PGE Budget/Actual:** FY20: $12,500/$25,000 FY21: $0 **Cost Share Total:** (if applicable) **Cost Share Percent:** (if applicable) Typically EPRI programs have an average of 40 times cost leverage.
Benefit to PGE: Informing the market is critical to achieve corporate objectives targeting direct customer and operational outcomes. Metering is a significant financial cost **Customer Benefit:** Earlier realization of vision by driving the market. Shared R&D work partnering with other utilities with a good planning structure helps manage costs.	**Strategic Alignment:** Metering is a key technical component in achieving critical use cases within PGE's long-term imperatives of decarbonize, electrify, and perform. Metering capabilities are a key constraint in offerings to customers and operations.

Value

PGE Participation: EPRI meetings and workshops	**Value Derived**: - Understanding of emerging technologies - Information on vendor strategies - Forcing function to advance PGE planning - Hearing perspective from industry SME's both as utility stakeholders and external advisors - Networking

Research & Development
Program / Project End Year Summary

Date: 2/10/2022

R&D Program/Project Name:
Investigating Ductile Iron Poles for T&D Infrastructure – DIST35

Project Status:

☒ Complete

☐ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
Investigating Ductile Iron Poles for T&D Infrastructure	**PROGRAM MANAGER – Jerry Donovan**	**$20,000**	**$20,000**	**$0.00**

- Year to be Completed: **2021**

☒ Discontinued (reason) **Project Objectives Achieved**

Project Sponsor: **Jerry Donovan**

Sponsoring Department: **Utility Asset Management / FITNES**

Project Team (internal): **Jerry Donovan**

Project Team (external):

OSU School of Civil & Construction Engineering

Jason H. Ideker, Ph.D. – Professor

O. Burkan Isgor, Ph.D.

Oregon State University

School of Civil & Construction Engineering

101 Kearney Hall, Corvallis, OR 97331-3212

PGE Budget/Actual:

FY20: **$20,000 / $20,000**

FY21: **$20,000 / $20,000**

Cost Share Total: **N/A**

Cost Share Percent: **N/A**

Project Description:

Evaluate the use of ductile iron as a viable support structure material in PGE's system, including as an alternative to wood for wildfire damage mitigation. PGE is soliciting the research capabilities of Oregon State University's School of Civil and Construction Engineering. This work will support a graduate research assistant and undergraduate research assistant for general investigations into the long-term performance of ductile iron poles. This will include a thorough literature review as well as accelerated testing of ductile iron pole sections conducted under three types of degradation scenarios: (1) Corrosive environment using OSU's Qfog system. (2) Placement and initial measurements in normal and sulfate rich soil environment in CCE's outdoor exposure site. During and after the accelerated aging, OSU will do electrochemical surface measurements (EIS) mechanical property determination, visual inspection and additional other non-destructive evaluation on outdoor

exposed samples. This will provide PGE with a repository of samples that can be measured periodically and will allow them continual updates, ahead of time, as to the long-term performance of ductile iron pipes. PGE has provided sections of ductile iron pipe and "comparison" pole material samples.	
Benefit to PGE: **Ductile iron poles have the potential to improve reliability and resiliency by eliminating woodpecker damage as one of the leading causes of premature wood pole failure. Additionally, the use of ductile iron poles addresses the growing concern around use of treated wood poles in environmentally sensitive areas. Provides an alternative to wood support structures in wildfire zones.** **Customer Benefit:** **A safe, reliable, and environmentally beneficial alternative to treated wood support structures. Ductile iron poles may also be a good alternative to wood poles for use in wildfire zones.**	**Strategic Alignment:** **Deliver operational excellence and competitive financial returns**

Value

PGE Participation:	Value Derived:
Assisted in development and refinement of project objectives, including comparison of ductile iron performance to galvanized steel coupons, placement of pole samples in outdoor environment to evaluate long-term performance of ductile iron poles in comparison to wood poles, and expansion of testing to include simulation of wildfire conditions to test resistance capabilities and determine limitations. PGE also coordinated acquisition and delivery of certain materials and components to be used in testing.	**Verified ductile iron pole resistance to corrosion under various environmental scenarios.** **Established outdoor placement of pole samples to evaluate long-term performance of ductile iron poles.** **Testing of ductile iron poles for resistance to fire damage.**

Research & Development
Program / Project End Year Summary

Date:

R&D Program/Project Name:

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
Pulsed Power DC Microgrid for Remote Area Highway Fast Charging Stations	PROGRAM MANAGER	$	$ 30k	$ 30k

- Year to be Completed: 2023

☐ Discontinued (reason) _____

Project Sponsor: Ian Beil & Manny Obi

Sponsoring Department:

Project Team (internal): Ian & Manny

Project Team (external): Yue Cao (OSU), Derek Jackson (OSU), Adam Morey (Daimler Truck North America)

Project Description:

As multiple DC fast charging stations are mapped along Highway I-5, utility infrastructures must meet these new load demands. Such DC fast charging stations can be viewed as pulsed power loads, as described by short-duration high-power draws from the grid. Instead of significant transmission and distribution infrastructure investment, a localized DC microgrid concept can be an attractive alternative. Onsite energy storage is an essential element to supply the pulsed loads while getting recharged from the grid at slower timescales. Batteries usually have high energy density but not high power density, whereas supercapacitors offer the reversed benefit to meet even faster transient peak loads. Such passive energy storage can support the DC microgrid in large, but an active power/energy control through DC/DC power converters between the energy storage and the DC bus is preferable for optimal energy storage sizing and better power quality, as well as system stability concerns. Additional onsite or nearby PV farms with DC/DC may offer additional benefits, although optional..

PGE Budget/Actual:

FY20: -

FY21: $30k/$30K

Cost Share Total: (if applicable)

Cost Share Percent:

Benefit to PGE:	**Strategic Alignment:**
The project supports PGE to meet the increasing DC fast charging demands as a result of the growing EV market. Transportation electrification is one primary driver for greenhouse gas reduction as well as electricity usage instead of fossil fuels. The project addresses PGE's infrastructure upgrade challenges by offering a much cheaper alternative of localized microgrids instead of constructing more transmission and distribution lines and facilities.	The internal team will conduct periodic updates with the external team regarding the progress, including presentations and reports. The team will demonstrate the effectiveness of the proposed solution by performing multiple simulation studies as well as necessary hardware-in-the-loop experiments. The team will disseminate the research outcome through peer-reviewed conference and/or journal publications.
Customer Benefit:	

Value

PGE Participation:	**Value Derived**:
PGE has held bi-monthly meetings with the project team. The project evolved during the 2021 timeframe with the following deliverables: - Literature review of relevant MD/HD charging infrastructure requirements - Development of models for EVSE, batteries, capacitor banks, and microgrid controller. - Submission of conference paper on bi-level optimization of a MD/HD EV fast charging site, which breaks down the optimization problem into two levels: system and converter level	Better understanding of MD/HD EV site designs, including sizing of chargers, deployment of battery energy storage, and potential microgrid applications. Ability to help guide customers as they attempt to design sites similar to Electric Island

Research & Development
Program / Project End Year Summary

Date:

R&D Program/Project Name:

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
Large-signal PV Inverter Enhanced Grid Model for Rural Area Voltage Stability Analysis and Control	PROGRAM MANAGER	$	$ 30k	$ 30k

- Year to be Completed: 2023

☐ Discontinued (reason) _____

Project Sponsor: Ian Beil & Jonathan Cicosz

Sponsoring Department: 509

Project Team (internal): Ian & Jon

Project Team (external): Yue Cao (OSU), Vinson Guov (OSU)

Project Description:

PGE rural-area customers are facing potential voltage stability issues due to the increased solar PV penetration and distanced distribution networks. This project proposes to study and prevent such PV caused localized system collapse, especially under N-1 or N-1-1 contingencies. We will focus on constructing a large-signal model describing the PV-tied power electronics inverter based distribution systems, with the coupling of transmission networks in mind. Using the model, we will analyze the voltage stability using an L-index approach. Further, we propose a holistic control solution to guarantee voltage stability, including but not limited to, inverter enabled PV curtailment and reactive power support, possible inverter-tied energy storage addon, in addition to traditional means such as on-load tap changer (OLTC) or capacitor bank (CB) regulation. We apply a mixed-integer optimization such that the discrete OLTC/CB voltage support can be maximized by the continuous operating spectrum of the active PV inverters. The developed model will also allow PGE to study the impact of PV penetrated distribution systems onto the transmission

PGE Budget/Actual:

FY20:

FY21: $30k/$30K

Cost Share Total: N/A

Cost Share Percent: -

systems (coupled T&D). Last, the effect of the single-phase PV inverter penetration causing an unbalanced three-phase system can be further investigated and yield a potential mitigation plan.	
Benefit to PGE: The project addresses the challenge of increased PV penetration, which is a renewable resource to help reduce greenhouse gas emissions and increase electricity usage especially in rural areas. The proposed solution will mitigate voltage instability issues so that the customers receive enhanced power quality. **Customer Benefit:** This project will provide a better understanding of the impacts to rural feeders due to high penetrations of solar PV resources. It will enhance existing PGE planning tools in order to model PV behavior during weak system voltage stability, aiding in the identification of potential trouble spots and providing insight into how the system can be reinforced to avoid such scenarios.	**Strategic Alignment:** The internal team will conduct periodic updates with the external team regarding the progress, including presentations and reports. The team will demonstrate the effectiveness of the proposed solution by performing multiple simulation studies as well as necessary hardware-in-the-loop experiments. The team will disseminate the research outcome through peer-reviewed conference and/or journal publications.

Value

PGE Participation:	**Value Derived**:
Working with OSU on this project provides a technical partner to analysis complex grid conditions and develop tools that will aid PGE planners to identify unacceptable voltage conditions due to solar PV prevalence on rural, lightly loaded lines.	This collaboration has so far produced: - An enhanced L-index tool that can be used to study weak system conditions (developed by Jon Cicosz with input from OSU) - Subsequent modeling efforts are focusing on grid-following and grid-forming PV inverters, in order to better understand how they behave during transient stability situations. These models will continue to be developed through 2022

Research & Development
Program / Project End Year Summary

Date:

R&D Program/Project Name:

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
OSU Synchrophasor Project	PROGRAM MANAGER	$	$ 30k	$ 30k

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor: Ian Beil

Sponsoring Department: 509

Project Team (internal): Ian

Project Team (external): Eduardo Cotilla-Sanchez (OSU)

Project Description:

Advance protection of the next generation 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.

PGE Budget/Actual:

FY20:

FY21: $30k/$30K

Cost Share Total: N/A

Cost Share Percent: -

Benefit to PGE:

More accurate models allow PGE transmission planners to better determine the needs of the future transmission system, optimizing capital investments and keeping rates affordable.

Customer Benefit:

Better understanding voltage and frequency dynamics on the system through the use of a synchrophasor measurement devices is a newer approach being used by other local utilities and especially BPA. PGE is interested to better understand how these PMUs can be leveraged to aid in system observation and

Strategic Alignment:

The internal team will conduct periodic updates with the external team regarding the progress, including presentations and reports. The team will demonstrate the effectiveness of the proposed solution via updated simulations that capture realistic system conditions. The team will disseminate the research outcome through peer-reviewed conference and/or journal publications.

control, and where they would best be placed. These investments will provide increased reliability to our customers in the long run.	

Value

PGE Participation:	**Value Derived**:
- PGE and OSU have engaged in meetings throughout the course of the project - This has been an iterative process, where OSU conducted initial analysis work, PGE provided feedback and later, transmission models, and OSU refined the analysis for PGE's specific system conditions	- OSU has investigated the concept of voltage control areas in detail and provided insights to PGE on how this analysis could extend to internal planning processes - This research has implications for both bulk power system analysis and microgrid applications - It also provides guidance for where synchrophasor would be most beneficial to the grid

Research & Development
Program / Project End Year Summary

Date: 2/18/2022

R&D Program/Project Name: Program 60: Electromagnetic Fields and Radio-Frequency Health Assessment and Safety

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
Program 60: EMF and RF Health Assessment and Safety	Rob Roloson	$ 101,371	$ 105,426	

- Year to be Completed: 2025

☐ Discontinued (reason) _____

Project Sponsor: Anthony Gomez

Sponsoring Department: Health & Safety

Project Team (internal): Rob Roloson/ Brian Williams

Project Team (external): Phung Tran / Mike Silva

Project Description:

The Program conducts and supports research addressing key environmental health and safety issues related to public and worker exposure to EMF environments associated with electric power system infrastructure. The program is the largest and most comprehensive EMF/RF research program in the United States. It provides a balanced research approach that addresses health & safety issues with regard to both the community and workers. In 2022 the focus will remain on epidemiologic research to help address issues such as childhood leukemia, neurodegenerative diseases, pregnancy outcomes, and EMF interference with implanted medical devices. EPRI's EMF research and expertise can augment and build in-house EMF issue management capabilities- gained from EPRI meetings, technical updates, webcasts and reports. In addition, EPRI has developed computer based training on various topics related to EMF that is available to all of PGE.

PGE Budget/Actual:

FY20: $101,371/$101,371

FY21: $105,426/ $105,426

Cost Share Total: N/A

Cost Share Percent: PGE's 1-year leverage for P60 is 26:1. For every dollar that PGE invests, it is being leveraged by $26 from other utilities.

Benefit to PGE: PGE will be able to provide proactive risk management strategies to address high priority issues concerning potential health effects related to EMF and RF exposures by contributing to the body of scientific knowledge, contributing to accurate health risk evaluations, and informing exposure guideline development. PGE will maintain expertise in the field through access to scientific experts and be able to share the expertise with other areas of the organization through the EPRI Knowledge Transfer Initiative. PGE will be able to provide scientific information to ratepayers that address issues raised by local constituencies with respect to new construction or upgrades of transmission lines or substations.

Customer Benefit:

Both EMF and RF have been classified by the International Agency for Research on Cancer as possible human carcinogens. As our infrastructure ages, the grid expands to address electric vehicles, renewable integration, and new technologies (T&D construction, smart meters); we need to understand the latest in EMF research. PGE's support of P60 demonstrates our leadership and proactive approach to addressing potential community and regulatory concerns. Without this participation, PGE would be unable to access experts and the benefits of EMF and RF research geared toward the electric utility industry.

Ultimately, the EPRI EMF/RF Program provides research, analyses, and expertise to better inform public dialogue and regulatory oversight on EMF and RF health and safety issues that is based on sound science.

Strategic Alignment:

Participation in EPRI's Programs fully meets the company strategies of: Delivering an exceptional customer experience (See Customer Benefits below):

1) Investing in a reliable and clean energy future by supporting plans to build infrastructure where we anticipate EMF/RF being issues and can work to proactively mitigate them.

2) Building a smarter, more resilient grid by developing and implementing design criteria to support EMF reduction in new construction.

3) Pursuing excellence in our work by having access to world class research, information, and tools needed to support external shareholder engagement.

Value

PGE Participation:

Participation in Program 60 has improved internal/external communication on EMF/RF issues and supported plans to build infrastructure where we anticipate EMF/RF being issues. PGE has hosted an EPRI Knowledge Transfer Initiative that has helped to develop RF training and informed worker safety. PGE has implemented an EMF/RF Working Group and Program document that helps

Value Derived:

PGE has hosted two EPRI Knowledge Transfer Initiatives that have helped to inform transmission and substation design to reduce EMF, brought knowledge to PGE regarding 5G and RF safety, and is continuing to provide training on various EMF and RF issues. PGE has implemented an EMF/RF Working Group

guide the EMF/RF customer concern process and management of EMF/RF Safety. Learnings from EPRI Program 60 participation and attending EPRI advisory council meetings have been shared across the company and to management in EMF/RF Working Group meetings.	and Program document that helps guide the EMF/RF customer concern process and management of EMF/RF safety. Learnings from EPRI Program 60 participation and attending EPRI advisory council meetings have been shared across the company and to management in EMF/RF Working Group meetings.

Research & Development
EPRI Program Summary

Date: 02/12/22

EPRI Program/Project Name: Program 62 Occupational Safety and Health, Project # 14

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2019	Cost 2020	Cost 2021
EPRI P62 Occupational Safety and Health	Messner	$ 44,168	$ 45,493	$39,585

These numbers are copied from the PGE R&D Expense Tracking Spreadsheet and the R&D Proposal for 2022 Funding

Please compare to below numbers copied from 2018 proposal

- Year to be Completed: 2025

☐ Discontinued (reason) _____

Project Sponsor: Alden Strealy

Sponsoring Department: **Environment Health & Safety**

Project Team (internal): Rob Roloson / Ben Lumsden

Project Team (external): Eric Bauman, EPRI Senior Technical Leader

Project Description: EPRI's Program 62 provides members with research relative to current and anticipated occupational health and safety (OH&S) issues. Deliverables derived from PGE's engagement are on-going and will be used to build, update and sustain our occupational health program. Deliverables relate directly to influence worker protective clothing (heat/cold stress) economic evaluation of ergonomic interventions, economic safety metrics/indicators and the development of an exposure database. Additional deliverables include monthly webcasts (recorded), a technical workshop and access to EPRI technical staff. By utilizing EPRI, PGE has an information resource that will allow for better short- and long-term safety planning and strategizing. The program is designed to address both current issues and anticipate those of tomorrow.

PGE Budget/Actual:

FY18: $50,450/$42,882
FY19: $51,963/$45,054
FY20: $53,522/$46,856
FY21: $44,669/$39,585

Cost Share Total: (if applicable)

Cost Share Percent:

The last 3-years the funding leverage has ranged from 33:1 to 35:1. For every dollar that PGE invests, it is being leveraged by $33-35 dollars from other utilities.

Benefit to PGE:	**Strategic Alignment:**
Program 62 Occupational Safety and Health deliverables for 2020: - Heat Stress Management Strategies for the 2020 Heat Season-webcast and white paper. - Human Performance Study for Assessing the Gaps, Reasons, and Results Between Work Planned and Work Performed. - Occupational Health and Safety Database Trends: 2019 data infographic - Occupational Health and Safety Annual Report, 2020: Occupational Health and Safety Trends Among Electric Power Industry Workers 1995-2018 - Implementing Fatigue Management Strategies in the Electric Utility Industry: Workshop Summary - EEI-EPRI Collaborative Industrial Hygiene Sampling Archive: Status Update 2020 - Fatigue Management Strategies in the Electric Utility Sector: Workshop Results and Research Opportunities - 2020 Ergonomics: delivered videos on awkward postures for overhead, underground, substation job tasks incl. ergonomic solutions for reducing risk factors for sprains and strains **Customer Benefit:** Participation in Program 62 will provide PGE with past, current and future research designed to address safety and health issues facing PGE. Implementing these research findings will lead to enhanced customer service and operational efficiency through the development of improved safety practices and procedures	Deliver exceptional customer experience Pursue excellence in our work Participation in EPRI's Program 62 fully meets the company strategies of: a) Delivering an exceptional customer experience (See (Customer Benefits below) b) Investing in a reliable and clean energy future by supporting plans to build infrastructure where we anticipate safety and health being issues. c) Building a smarter, more resilient grid by developing and implementing design criteria to support safety and health issue being part of new construction. d) Pursuing excellence in our work by having access to information and tools needed to support external shareholder engagement around safety and health issues.

Value

PGE Participation:	**Value Derived**:
PGE Participation 2020: - Participated in all webcasts and have involved SMEs across the company to be engaged in Ergonomics, Fatigue, Human Performance, and Driver Safety - Shared White Papers with SME's across the company.	- 2020 EPRI Technology Transfer Award won for use of the Heat Stress infographic and video. - Fatigue management information shared with work groups that will assist PGE in the development of a Fatigue Management Program.

- Incorporated learnings into program management and safety messages/alerts.	- Driver Safety learnings shared with Fleet Safety group and have assisted with safety investigations. - Occupational Health and Safety Database Trends and Annual Report has assisted the H&S department and data analyst discuss trends of Injury Data within the Electric Utility Industry.

Research & Development
Program / Project End Year Summary

Date: 12/30/2021

R&D Program/Project Name: EPRI P226 Boiler and Turbine Steam and Cycle Chemistry

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2019	Cost 2020	Cost 2021
EPRI P64/P226 Boiler and Turbine Steam Cycle Chemistry	Charles Linder	$ 33,727	$ 35,076	$ 30,000

- Year to be Completed: 2024

☐ Discontinued (reason) _____

Project Sponsor: Alex Banicki

Sponsoring Department: Maintenance, Monitoring, & Diagnostics Engineering

Project Team (internal): Alex Banicki, Charles Linder

Project Team (external): NA

Project Description:

Joined EPRI Program 64 (now Program 226) to allow Fleet Chemist and other stakeholders access to EPRI guidelines for optimal cycle chemistry control to provide long term asset protection, reduce overall operating and maintenance costs, increase steam turbine efficiency, minimize chemical cleanings, and increase operator knowledge of cycle chemistry. Inclusion in this program is essential in helping to shape the Thermal Fleet Chemist role and guide the development of PGE boiler and steam chemistry programs with the latest advances in industry knowledge. It will help PGE develop cycle chemistry and water treatment programs that are current, effective, and standardized across the Thermal Generation Fleet; which will help to ensure long term success with critically important aspects of thermal plant operations and asset protection.

PGE Budget/Actual:

FY19: $33,727/$33,727
FY20: $35,076/$35,076
FY21: $30,000/$30,000

Cost Share Total: NA

Cost Share Percent: NA

Benefit to PGE:

Access to this EPRI program provides us access to valuable operating experience, research, and other documentation as it relates to steam water

Strategic Alignment:

Perform – Delivering operational excellence

cycle chemistry. This is an area in the power generation industry that lends itself well to user experience and knowledge sharing from plant to plant. Access to the P226 catalog will provide access to resources and information enabling PGE to stay current on the latest cycle chemistry information, standards, and areas of concern across the power generation industry. **Customer Benefit:** Benefit to the customer will be realized through best use of capital and O&M resources. Involvement in this program allows us to leverage industry best practices for development and maintenance of PGE chemistry programs and will allow us to develop internal subject matter expertise at a faster rate.	

Value

PGE Participation: We have utilized our access to EPRI programs to update HRSG chemical treatment control, water and steam quality limits, investigate advances in online continuous chemistry analyzer technologies and how to utilize the data for asset protection. Membership has allowed PGE to participate in the EPRI Research Advisory Meetings in P226 and gain exposure to other emerging programs of significance such as Carbon Reduction and Energy Storage Technology Programs during 2021.	**Value Derived**: We have utilized the information accessible through EPRI to inform our thermal generation plants of the latest changes in water and steam quality guidelines, instrumentation, and operational and maintenance best practice recommendations for the Beaver and Carty Water Treatment Plants. We will continue to utilize the information available as ongoing development of the Chemistry Program Manager hired on in 2020.

Research & Development
EPRI Program Summary

Date: 06/30/2022

EPRI Program/Project Name: EPRI P161 Information and Communications Technology

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: Ongoing

☐ Discontinued (reason) _____

Project Sponsor: David Worth

Sponsoring Department: RC712 DCIO Smart Grid

Project Team (internal): David Worth, Joey Baranski, Kellie Cloud, Jess Borrevik, Dale Walker

Project Team (external): Rish Ghatikar, Ed Beroset, Patricia Brown, Sean Crimmins

Project Description:

This program addresses technical and economic challenges of identifying, evaluating, and implementing enabling Information and Communication Technologies (ICT) for grid modernization and digital transformation efforts. Enabling technologies can be applied to drive radical change in capabilities of a user or system.

The ICT program addresses these challenges by conducting research in the following functional research areas:

- **Interoperability:** The research accelerates the industry's migration toward interoperability by making technical contributions to standards development efforts, providing training to utilities, developing reference implementations, organizing interoperability tests of developing standards, and collaborating with utilities on the demonstrations of emerging standards.
- **Telecommunications:** The research provides leadership in communications standards development, provides tracking

PGE Budget/Actual:

FY21: $144,315

Cost Share Total: (if applicable)

Cost Share Percent: (if applicable)

Typically EPRI programs have an average of 40 times cost leverage.

and analysis of communications technologies, develops the tools and techniques to effectively plan and design communications networks, and conducts laboratory and field tests to evaluate the performance of evolving and emerging technologies. • **Data-Centricity:** This research leads effort to an enterprise-wide extensible data model, understanding that specific applications will come and go while the data model remains constant. Data, not applications, are at the core of the enterprise, and they are valuable and versatile assets. Ultimately, the goal of data-centrism is to enable data to deliver maximum business value, improve operational outcomes, and facilitate innovation through data-driven insight.	
Benefit to PGE: Research and Development cooperation between utilities in order to deliver grid modernization. Includes architectures, designs, and pilots that enable utilities to partner with vendors to deliver utility operations. Growing capability to provide reference architecture which can be leveraged to save solution planning hours. **Customer Benefit:** Helps maximize customer outcomes including cost management. Shared research efforts and collaboration ensure PGE is reviewing decisions and factors common across North American and international utilities that impact functionality, cost, reliability, and performance.	**Strategic Alignment:** This aligns to all three imperatives, Decarbonization through specific research into DER adoption and enablement, Electrification through the delivery of grid connected DERs like electric fleet and consumer vehicles and perform through shared information about costs and business cases for enablement at a good cost. The geospatial track provides valuable insight and awareness that impact the grid model used by major operational platforms at PGE.

Value

PGE Participation:	**Value Derived**:
EPRI meetings and workshops Cyber Security Project Set Webcasts	**Emerging ICT and Technology Transfer (161A)**

Interoperability webcasts Technology transfer webcasts	• Provides insights into emerging information and communication technologies and issues that could impact utility investments and enables technology transfer to personnel who can use and benefit from them. **DER Data and Connectivity (161D)** • Provides leading resources related to the evolving needs for DER data and connectivity, including tools and technologies, architectures, methodologies, insights, and leading practices to support distributed energy resources (DER) and demand response (DR) technologies integration and data services. A priority is reducing costs and improving efficiency of existing operations today while helping utilities prepare for a 2030 energy system. **Enterprise Architecture and Integration (161E)** • Puts tools and techniques into the hands of enterprise architecture practitioners and others driving towards the same objectives, with an eye to the unique needs and operating environments of utilities. Three primary areas of focus include 1) Organizational Alignment, 2) Application Portfolio Optimization, and 3) Enterprise Architecture (EA) Maturity. **Advanced Metering Systems (161F)** • Provides information and tools for the deployment of next-generation advanced metering systems while aiding utilities in optimizing existing system utilization and in discovering the full value of AMI-collected data; accelerates and guides the development of emerging standards and architectures to enhance interoperability, innovation, and marketplace competition; and identifies best practices for the support of system operations and monitoring of systems.

	Telecommunications (161G) • Provides insights, guidance, and tools to help utilities develop telecommunications strategies and apply emerging technologies and standards that play an increasingly critical role in the operation of the integrated grid. Areas of focus include: planning a scalable, multi-service network; evaluating new business models to make fiber deployment economically viable; addressing industry challenges with potential interference to licensed microwave links; stewarding the standards to enable interoperability and interchangeability; developing approaches to maximize the performance of wireless technologies; developing best-in-class telecom network management, visualization, and control systems while maintaining reliability, resilience, and cyber security; and many more related topics. **Geospatial Informatics (GIS) (161H)** • Provides leading practices for optimizing GIS system value. Address GIS data quality and data management challenges with a focus on the science and technology of acquiring, storing, cleaning, modeling, analyzing, producing, presenting, and disseminating geospatial datasets. Developing tools and insights that enable the next-generation GIS, including the support of immersive 3D environments. Assess geospatial technologies that enable utilities to expand their GIS capabilities for advanced analytics, network management, and process automation.

Research & Development
Program / Project End Year Summary

Date: 2/3/2022

R&D Program/Project Name: EPRI P-183 PDU Cyber Security

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
EPRI P-183 PDU Cyber Security	Toley Clague	$95,913	$ 84,615	$

- Year to be Completed: 2025

☐ Discontinued (reason) _____

Project Sponsor: Joey Baranski **Sponsoring Department**: 775 **Project Team (internal): Toley Clague** **Project Team (external): Ben Sooter** **Project Description:** Cyber and physical security have become critical priorities for electric utilities. The evolving electricity sector is increasingly dependent on information technology and telecommunication infrastructure to ensure the reliability and security of the electric grid. Specifically, measures to ensure cyber security must be designed and implemented to protect the electric grid from both cyber and physical attacks by terrorists and hackers, and to strengthen grid resilience against natural disasters and inadvertent threats such as equipment failures and user errors. The Cyber Security Program of the Electric Power Research Institute (EPRI) focuses on addressing the emerging threats to an interconnected electric sector through multidisciplinary, collaborative research on cyber security technologies, standards, and business processes	**PGE Budget/Actual:** FY20: $95,913 FY21: $84,615/ $84,615 **Cost Share Total:** (if applicable) **Cost Share Percent:**
Benefit to PGE:	**Strategic Alignment:**

EPRI's Cyber Security Program can provide the following benefits to members and the public: • A better awareness of industry and government collaborative efforts, where members can "plug in" to current activities; • Guidance on developing cyber security strategies and requirements for selecting effective technologies; • Guidance on security metrics; • Techniques for assessing and monitoring risk; • Practical approaches to mitigating the risk of operating legacy systems; • Early identification of security gaps through laboratory assessments of security technologies; and • Technologies which support the management of cyber incidents and increase the cyber security and resiliency of the grid. **Customer Benefit:** EPRI allows PGE to offset research costs associated with cyber security activities. PGE spends less than $100,000 to gain knowledge through EPRI labs for testing security tools within a utility. It has also provided research on security tools and techniques are best with operational technologies. Customers benefit from these activities through reducing cyber security related events. They also benefit from the research as PGE continues to focus on securing the grid to ensure that is reliable and resilient.	Perform

Value

PGE Participation:	**Value Derived**:
The P-183 project allows multiple organizations within PGE to work together. Currently we have representatives from numerous parts of Grid Architecture, Integration and System Operations, as well as Information Technology that are actively engaged in many of these projects. We are regularly engaged in meetings and are advisors on many of the projects that are associated	**OT Cybersecurity:** EPRI focuses on security challenges that affect multiple operations domains, such as designing security into products, creating security metrics for the electric sector, and developing technical solutions for meeting security compliance requirements.

with the projects under P-183. We attend technical meetings and advisory meetings that help shape the projects.	In 2021, EPRI: • Updated guidelines for implementing an Integrated Security Operations Center (ISOC) • Developed advanced monitoring and analytics platforms for recording and searching data for security events • Enhanced the cyber-attack scenario library for control centers and substations to include attack modeling and incident response playbooks • Developed ICS forensics analysis field guides for operational technology (OT) devices • Developed a Threat Management Guidebook for power delivery systems Cyber Security for Transmission and Distribution Operations and Systems: Technical solutions and guidelines to improve the security posture of transmission and distribution systems. In 2021, EPRI: • Created a secure IED Management guidebook, which leverages past research and cross-program collaboration to develop a comprehensive approach to the secure management of substation devices • Developed a methodology to assess how specific vendor solutions can be applied to demonstrate and maintain NERC CIP compliance. Cyber Security for DER and Grid-Edge Systems: Security requirements, solutions, and reference architectures for the deployment and integration of distributed generation and grid-grid technologies. In 2021, EPRI developed and published: • Distributed Energy Resources (DER) Cybersecurity Guidebook (3002021396) • Cybersecurity Requirements for Utility Owned Energy Storage Systems (3002021386) • Cybersecurity Requirements for Utility Electric Vehicle Charging Infrastructure (3002021392) • Cybersecurity for Grid Connected Devices: Risks, Opportunities, and Measure (3002021395)

	Cyber Security Metrics: A common set of metrics that quantify the effectiveness of cyber security operations. In 2021, EPRI developed and published: • Cyber Security Metrics Implementation Guidebook (3002021398) • OpenMetCalc 3.0 User Guide (3002021399) • OpenMetCalc 3.0 Workbook (3002021401) .

Research & Development
Program / Project End Year Summary

Date: 2/11/2022

R&D Program/Project Name: EPRI Program P216 & P217

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
EPRI Program P216 & P217	TJ Mulqueen	$ 107,093	$ 60,000	$ 61,174

- Year to be Completed: 2025

☐ Discontinued (reason) _____

Project Sponsor: TJ Mulqueen

Sponsoring Department: PSES

Project Team (internal): Ivan Auer

Project Team (external):

Project Description:

EPRI Program P216 & P217 provides resources to address all aspects of the life management of conventional and advanced gas turbines, and addresses aspects of combined cycle plant-wide integration. This program researches areas such as operations and maintenance of gas turbines, repair techniques, performance monitoring, and future trends and technology. Program P216 and P217 also collaborates and coordinates technical activities with the Steam Turbine program (P65) and Heat Recovery Steam Generator program (P88). PGE has 4 combined cycle power plants with newer gas turbines (Mitsubishi 501Gs, GE 7FA) to vintage units (GE 7B). Being part of the user group, knowledge base, and support service of EPRI is critical to our continued reliable and efficient operation.

PGE Budget/Actual:

FY20: $107,093/$107093

FY21: $60,000/$60,000 ($30K each)

FY22: $61,174/$TBD

Cost Share Total: (if applicable)

Cost Share Percent:

Benefit to PGE: Access to Program P216 and P217 provides access to research and data on programs, technology, and equipment that directly relates to our generating fleet. Access to this information will improve our programs and engineering design for related projects.

Strategic Alignment:

Perform – Delivering operational excellence

Customer Benefit: EPRI P216 and 217 has provided critical data for material properties of combustion turbine hot gas path parts. PGE has utilized EPRI's compressor maintenance and operation guidance documents for developing and refining our maintenance program. EPRI has supplied guidance documents on inspection and repair of all HGP components that we are utilizing as guiding documents for our own inspection and repair specification. EPRI has conducted third party review of combustion upgrades proposals from OEMs. They have provided combined cycle evaluation guidance. EPRI SME's have provided guidance on compressor stator vane rock limits and repair. Access to EPRI documentation and technology, such as PCRT, has driven improvements in our inspection and repair specifications.	

Value

PGE Participation: PGE SME is an active advisor and participant on all P216 and P217 meetings and conferences. Participating in these has allowed access to presentation on combustion turbine OEM upgrades, future technological developments, Third-party presentation on maintenance, cleaning and repair services offered for a range of components which allows for additional competitive bidding and service sourcing. PGE SMEs actively utilize the user group and communicate with EPRI SMEs and other industry SMEs to inquire about GT modification such as pinning, cleaning methods, and case cracking issue. We would still like to incorporate EPRIs PCR testing into our RD budget as this could add valuable long-term data to our parts history and is much faster and cheaper than X-Ray or UT inspection. My hope is to get support to do that this year with our parts at Beaver.	**Value Derived**: Our involvement has given PGE SMEs direct access to research to better inform recommendation and decision at Generating sites. Has given PGE source for a third-party review of OEM claims, thus better protecting PGE assets and finances.

Research & Development
Program / Project End Year Summary

Date: 2/8/2022

R&D Program/Project Name: P218 HRSG & BOP

Project Status:

☐ Complete

☒ Will Continue This Year

		Cost 2020	Cost 2021	Cost 2022
TITLE OF THE PROJECT	PROGRAM MANAGER	$ 80,536	$ 30,000	$ 30,587

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor:

Sponsoring Department: PSES

Project Team (internal): Brent Lee, Brad Hanna, TJ Mulqueen

Project Team (external):

Project Description:

Subscription to Program 218 provides best practice guidelines for HRSG and balance of plant (BOP) equipment operation, maintenance, and optimization for cyclic operation. This project will use the research provided by Program 218 to refine the core activities encompassing a Covered Piping Program (CPP), optimize HRSG inspection and repair using new technology, NDE guidelines, and techniques for improving access, and increasing HRSG reliability through better understanding of thermal cycling and transients.

PGE Budget/Actual:

FY20: $80,536/$80,536
FY21: $30,000/$30,000
FY22: $30,587/TBD

Cost Share Total: (if applicable)

Cost Share Percent:

Benefit to PGE: Access to Program 218 provides access to research and data on programs, technology, and equipment that directly relates to our generating fleet. Access to this information will improve our programs and engineering design for related projects.

Customer Benefit: Benefit to the customer has been and will be realized through best use of capital and O&M resources. Involvement in this program informs our inspections during planned outages and allows us to address industry concerns and potential issues during planned outages, which is economical

Strategic Alignment:

WIG 3 – Increase Operational Efficiency

when compared to possibly needing to repair with a forced outage. EPRI also advises on operational strategies, which improves expected life of equipment, plant availability, and flexibility to meet the changing demand associated with increased renewable energy.	

Value

• **PGE Participation:** Accessing EPRI historical documents • Review FAC inspection guidelines • Implement learnings into FAC inspection program • Review Covered Piping Program (CPP) reports • Implement learnings into CPP documentation • Gathered CO and SCR procurement guidelines • Attended Generation Advisory and Council meetings in Portland in 2018 and Indianapolis in 2019 • Utilized information around risk ranking for high energy piping and CPP for Carty, Port Westward, and Coyote Springs • Identified and evaluated attemperator issues utilizing information available via P88 • Utilized information regarding All Volatile Treatment (AVT) to update chemistry control methodology in HRSGs. We plan to complete the following in 2022: • Evaluate CO and SCR procurement guidelines/considerations for the possible SCR upgrade for Port Westward • Continue to evaluate improvements to Generation's FAC program and CPP based on historical and current information available to EPRI members • Continue to develop/refine risk ranking tool for high energy piping as it relates to the CPP (focus on Coyote Springs and eventually Beaver) • Evaluate HRSG boiler tube replacement options to support increased thermal stress due to plant cycling.	**Value Derived**: PGE has utilized technical data provided in the forms to apply to our programs, developed internal forms based on EPRI provided examples, and incorporated guidelines into our project and program work. Specifics include the risk ranking for our high energy piping (e.g., where should we focus our efforts), being able to identify and address dissimilar metal weld concerns before they become a significant event based on industry experience and evaluate HRSG boiler tube replacement options to allow for more robust operation due to increased plant cycling.

Research & Development
Project Summary

Date: 6/20/2022

Project Name: Cascadia Lifelines Project

Project Status:

☐ Complete

☒ Will Continue Next Year (OSU is continuing the research initiative beyond the original 5 year timeline)

☐ Discontinued (reason) _____

Project Sponsor: James Landstrom **Sponsoring Department**: R&D **Project Team (internal):** James Landstrom **Project Team (external):** Dan Cox, Mike Olsen, Armin Stuedlein **Project Description:** Cascadia Lifelines Program is a targeted research consortium aimed at improving Oregon's infrastructure resilience in a cost and value informed manner. Professor Dan Cox is the director of the program. Regular members at a cost of $50,000/year are ODOT, PGE, NWN, BPA, Port of Portland. Being at this level provides a seat on the Joint Management Committee. This is an important because the Joint Management Committee determines the research projects. This is a continuation of PGE's support over the last five years.	**PGE Budget/Actual:** FY21: $50,000 **Cost Share Total:** $150,000 **Cost Share Percent:** 20%
Benefit to PGE: Data derived from Cascadia Lifelines will be used to develop economic risk values that will directly inform the budgeting for T&D retrofits (near and long-term planning initiatives). This will in turn reduce the overall economic risk, make the grid more resilient and benefit the region. **Customer Benefit:** At the customer level, PGE will be able to prioritize projects that increase resiliency of our system which serves the critical loads like hospitals, fire stations and rescue centers.	**Strategic Alignment:** Perform/Operational Efficiency .

Summary

Synopsis of Project as Implemented:

PGE is continuing to collaborate with OSU and the Cascadia Lifelines project. Project deliverables, such as the structure fragility database tool, will support PGE's seismic modeling efforts into the future. Additionally new tools are being developed to help in planning for catastrophic events that help to increase our response.

Performance Against Objectives/Deliverables:

Detailed Project Reports were delivered, including cost-benefit analysis. Two of three critical objectives were addressed:

1. Determine what parts of the Grid/Infrastructure are most vulnerable during a severe seismic event
2. Determine what changes to components/operations can increase Grid resiliency

Decisions to be Made:

Next Steps:

Address the third major objective:

3. Determine how collaboration/cooperation between stakeholders can improve Grid resiliency.

Research & Development
EPRI Program Summary

Date: 04/14/2022

EPRI Program/Project Name: P94

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed:

☐ Discontinued (reason) _____

Project Sponsor: Darren Murtaugh **Sponsoring Department**: RC509 **Project Team (internal): Darren Murtaugh** **Project Team (external): Ben Kaun** **Project Description:** This program covers research related to energy storage and fueled distributed generation (DG) technologies. The scope covers energy storage connected to utility transmission system, distribution system, and customer premises. These technologies may provide a range of services and benefits to different stakeholders, including stacked services. It also covers fueled DG of less than 10 MW capacity, such as fuel cells or combined heat and power (CHP) connected to the utility distribution system or customer premise. The research covers and integrates multiple activities, including technology evaluation, economic and technical modeling to support grid planning and operations, and field demonstration, with a goal to support energy storage technology options and integration approaches which are safe, reliable, cost-effective, and environmentally responsible.	**PGE Budget/Actual:** FY19: $126,575/$126,575 FY20: $126,575/$126,575 FY21: $90,460/ $90,460 **Cost Share Total:** (if applicable) **Cost Share Percent:** (if applicable)
Benefit to PGE: Program development for energy storage offerings, energy storage as a grid resource to support a more decarbonized resource portfolio, energy storage as a T&D resource to support a more flexible and more reliable system including Microgrid support and expansion of Hosting Capacity **Customer Benefit:** Program development for energy storage offerings, energy storage as a grid resource to support a more decarbonized resource portfolio, energy storage as a T&D resource to support a more flexible and more	**Strategic Alignment:** (Which PGE Corporate Imperative did this project address?) Decarbonize

reliable system including Microgrid support and expansion of Hosting Capacity	

Value

PGE Participation:	**Value Derived**:
Webinars, twice-annual advisory meetings, and access to web portal	Reports on resiliency initiatives at other utilities, including examples of installations, cost/benefit and lessons learned. Examples of Non-wires Alternatives installations. Insights into technology development, as well as current fire safety practices and standards. Review of various use cases and operational trends for energy storage at other utilities. Access to DER-VET software tool for co-optimized benefits analysis.

Research & Development
Program / Project End Year Summary

Date: 7/7/2022

R&D Program/Project Name: Research and Testing of Alternatives to SF_6

Project Status:

☒ Complete

☐ Will Continue Next Year

☐ Discontinued (reason) _____

Project Sponsor: Brett Phillips **Sponsoring Department**: Engineering Services, Substation Design Engineering **Project Team (internal):** Rebecca Prich, Shane Freepons **Project Team (external):** Utility program participants include National Grid, New York Power Authority, Consolidated Edison, United Illuminating, PNM **Project Description:** This EPRI special research and testing program examines alternative gases that have been earmarked to directly replace sulfur hexafluoride (SF6), a potent greenhouse gas, in utility equipment applications. Extensive testing procedures developed by EPRI examine safety, reliability, and operating characteristics of four (4) identified alternative gases during normal operation and electrical fault scenarios.	**PGE Budget/Actual:** FY20: $60k/$60k FY21: $0 **Cost Share Total:** N/A **Cost Share Percent:** N/A
Benefit to PGE: The results of the research program will shape future equipment procurement strategy and minimize purchase of SF6 filled equipment in PGE transmission and distribution systems. The initiative strengthens PGE's position in SF6 management and reduction in anticipation of heightened federal or state regulations for greenhouse gases – like California Air Resources Board's recently adopted state-wide SF6 regulations. **Customer Benefit:** The project aligns with PGE's decarbonization strategy, including net zero emissions by 2040. Our customers and communities are passionate about	**Strategic Alignment:** **Decarbonize:** While highly effective in electric utility applications, SF6 is the most potent greenhouse gas and is estimated to remain in the atmosphere for 3,200 years when emitted due to its high molecular stability. SF6 is a synthesized gas, and 80% of global production is for use in the electric utility industry. Purchase of SF6 alternate equipment is critical for reducing global production of the gas, as well as reducing emissions associated with typical maintenance and aging of installed SF6 assets.

clean energy, and this research program supports the message of PGE's Full Clean Ahead campaign. In addition to decarbonization, this initiative supports cost efficient procurement decisions. Results of testing will provide third-party verification of alternative gas performance and will identify "best fit" equipment for future installations. This evaluation prior to large-scale investment will reduce purchasing risk.	

Value

PGE Participation:	**Value Derived**:
Participation in routine calls allows PGE engineering to be involved with research on a deep technical level. Feedback from program participants is directly used to shape the content of testing parameters.	EPRI provides detailed test plans, protocol and analysis of testing results through regular conference calls and PowerPoint presentations. Upon the completion of the program, a final report of findings will be published and provided to PGE. This report will assist PGE in developing a successful procurement strategy for future equipment purchases.

Research & Development
Program / Project End Year Summary

Date: 06/11/2022

R&D Program/Project Name: Sherwood Training Center Energy Storage Demo Project

Project Status:

☒ Complete

☐ Will Continue Next Year

			Cost 2020	Cost 2021	Cost 2022
Sherwood Training Center Energy Storage Demo Project	PROGRAM MANAGER	$	$ 10,000	$ 15, 594	$0.00

- Year to be Completed: 2021

☐ Discontinued (reason) _____

Project Sponsor: Darren Murtaugh

Sponsoring Department: Grid Edge Solutions

Project Team (internal): Manny Obi, Kevin Whitener

Project Team (external): N/A

Project Description:

This project will investigate how Residential energy storage can be used to back feed the system for intentional island support. The objective is to explore safety, testing and commissioning practices with PGE field operation linemen, wiremen, metering and communication techs. Funding will allow for a Tesla Powerwall or similar energy storage system which can be tied to the grid at our Sherwood training facility. Three different systems with ConnecteDER meters are being proposed for installation, namely: (a) Eaton Smart Breaker Panel (b) SPAN smart panel and a (c) Critical Load Panel

PGE Budget/Actual:

FY21: $15,594

Cost Share Total: (if applicable)

Cost Share Percent:

Benefit to PGE: PGE will learn how to roll out residential energy storage batteries as well as the controls and aggregation platforms like Virtual Peaker and Genonsys

Customer Benefit:

Customers will be better supported by PGE after PGE personnel and linemen are adequately trained following the completion of this project.

Strategic Alignment:

Reduce greenhouse gases by 80% by 2050

Value

PGE Participation:	Value Derived:
- Ordering of Battery systems - Installation of the Batteries at Salem Smart Power Center and Rose City - System integration with controls - Aggregation using Kitu Systems - Commissioning of installed Battery systems	- PGE now understands the technical challenges associated with installing, commissioning and operation of small scale residential battery systems. - PGE now has a Kitu system in place - These tests conducted as a result of this research has informed and continues to help us improve our program offerings for residential batteries.

Research & Development
Project Summary

Date: 07/08/22

Project Name: Smart PDX Air Sensors Partnership

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: **2023**

☐ Discontinued (reason) _____

Project Sponsor: Jake Wise **Sponsoring Department**: R&D **Project Team (internal):** Jake Wise **Project Team (external):** Christine Kendrick (Smart PDX, CoP), John Fink (PSU), Brianne Suldovsky (PSU), Molly Kramer (PSU), Dawn Nolan (PSU) **Project Description:** The City of Portland BPS/ Smart PDX has deployed air quality sensors in a variety of areas within the metro area and calibrated the data collected to the State of Oregon Department of Environmental Quality (DEQ) on SE Lafayette/ SE 58th. Their NIST-funded study is nearing completion and requires additional funding to continue the sensor install and maintenance, data collection, validation and analysis.	**PGE Budget/Actual:** FY20: $15000/ $10000 (per non-EPRI xls) FY21-23: **$1000** each year subsequent ($18000 in total) **Cost Share Total:** (if applicable) **Cost Share Percent:** (if applicable)
Benefit to PGE: Sensors are a potential part of a future Smart City offering that leverages PGE communications infrastructure, and this presents an opportunity to partner with a real expert (and potential customer) to understand technical aspects and market solutions. In partnership with Portland State University, Smart City PDX will provide objective evaluation for identification of locations of interest, research study criteria, methodology, communication strategies, data and findings to support beneficial electrification siting.	**Strategic Alignment:** Electrify/ Increase Structural Parity (e.g., grow load via beneficial electrification)

Data to be shared: seasonal and diurnals trends for sensor locations, distributions of hourly averages of pollutant concentrations

Customer Benefit:

PGE is interested in supporting this work because it will inform where to locate industrial electrification projects that will reduce diesel pollutants for the benefit of locationally disadvantaged communities.

Smart Cities are a conceptual vessel for improving the quality of life (QoL) of our customers. It is through this lens that Smart Cities intends to affect change. A better QoL is represented by public safety, reduced congestion, sense of community, climate action, and economic development in a manner that promotes broad-based access and inclusion and respects the security and privacy of the data. This project in particular provides a research benefit to all of our municipal customers and a potential health benefit to their citizens.

Summary

Synopsis of Project as Implemented:

- City accepted funding via ordinance (Dec 2019)

The $15k provided in support of the Smart PDX Air Sensors Partnership may be allocated across 2020-2021 as we recognize the City's focus has shifted to COVID relief efforts. Additionally, it is entirely within the scope of this project to allocate funds toward a guide that promotes awareness and provides education to community members who, as we learned in our survey work with PSU, asked for more information and guidance in this area. We are also excited to entertain ways in which to integrate our data with other public data sets to provide our communities better analysis tools.

Performance Against Objectives/Deliverables:

- Quarterly research brief that details online survey and technical field work complete "Smart Cities Report"

Smart Cities Report _ Final .pdf

Decisions to be Made:

- None at this time

Next Steps:

- Quarterly research briefs expected until data, report and presentation of study findings (Dec 2023)

• Qualtrics survey complete (approx. 420 respondents) ○ Team is currently focused on getting more non-white respondents (to mirror the racial/ethnic breakdown in the city and avoid getting a primarily white sample) Response rates have stalled with the Coronovirus crisis.	

Research & Development
Project Summary

Date: 6/22/2022

Project Name: Solar PV Monitoring Laboratory – U of O

Project Status:

☐ Complete

☒ Will Continue Next Year

- Year to be Completed: TBD, Ongoing support to gather solar radiation metrics

☐ Discontinued (reason) _____

Project Sponsor: Jay Landstrom **Sponsoring Department**: R&D **Project Team (internal):** Jay Landstrom **Project Team (external):** Dr. Frank Vignola, UofO **Project Description:** The University of Oregon collects data from a network of 30 Pacific NW monitoring stations. They submit this data to the National Renewable Energy Lab (NREL) and post this data on a Public website. The U of O maintains this network of solar PV monitoring stations.	**PGE Budget/Actual:** FY21: $12,000/$12,000 **Cost Share Total:** $160,000 **Cost Share Percent:** 6.25%
Benefit to PGE: Access to solar data that will help with analysis of future solar generation facilities **Customer Benefit:** Helps move PGE to a more renewable and carbon free generation mix. The solar lab is also the solar standard for developers to measure potential against as a benchmark.	**Strategic Alignment:** Decarbonize & Electrify

Summary

Synopsis of Project as Implemented: Data is accessed for solar facility studies **Performance Against Objectives/Deliverables:**	**Decisions to be Made**: None **Next Steps:**

Data consolidated from all measuring points in 2020. New high accuracy solar collectors were installed in 2021.	Provide access to solar data across PGE business units

Research & Development
Program / Project End Year Summary

Date: 1/28/2022

R&D Program/Project Name: EPRI Tree-Strike Testing

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
TITLE OF THE PROJECT	PROGRAM MANAGER	$ 0	$ 0	$ 71,740

- Year to be Completed: 2022

☐ Discontinued (reason) _____

Project Sponsor: Jacob Leeney

Sponsoring Department: **RC 311**

Project Team (internal): Standards

Project Team (external): EPRI

Project Description: This project aims to observe the distribution pole-top failure modes that occur during tree strikes. In a controlled environment, EPRI will conduct six full-scale tree strike simulations on distribution pole tops constructed to PGE standards and with PGE materials.

PGE Budget/Actual:

FY20: $0

FY21: Project moved to 2022

Cost Share Total: **N/A**

Cost Share Percent: **N/A**

Benefit to PGE: Understanding tree-strike failure modes will allow PGE to design the overhead system in a way that minimizes the loss of overhead assets from tree strikes. Mechanical coordination focuses design towards restoration, ensuring that tree-strike failures are contained to low-cost or easily replaceable hardware. This would significantly reduce the time/materials needed to repair a damaged system. Proper mechanical coordination will also reduce the risk of cascading pole failures, by ensuring the pole is not the weakest component of the system. **Customer Benefit:** Faster repairs and lower-cost tree-strike failures	**Strategic Alignment:** Customer Focus, Increased Reliability

Value

PGE Participation: First-hand observation of the tree-strike failure testing with a post-test analysis of all PGE hardware involved.	**Value Derived**: Improved framing standards that utilize better mechanical coordination to reduce impact from tree-strikes

Research & Development
EPRI Program Summary

Date: 06/13/2022

R & D Program/Project Name: Energy Management Circuit Breaker (EPRI Supplemental)

Project Status:

☐ Complete

☐ Will Continue Next Year

- Year to be Completed: **2022**

☒ Discontinued (reason) _____

Project Sponsor: Darren Murtaugh **Sponsoring Department**: Grid Edge **Project Team (internal):** Manny Obi **Project Team (external):** John Halliwell, (EPRI) – Senior Technical Executive , Doni Nastasi (EPRI), Project Technical Lead **Project Description:** The Energy Management Circuit Breaker (EMCB) field demonstration pilot is an experimental exercise conducted in collaboration with the Electric Power Research Institute (EPRI) and Eaton Corporation. There are two types of EMCB breaker to be deployed, the EMCB standard and the EMCB EV	**PGE Budget/Actual:** FY19: $115,000 Duration: 36 Month January 2020 – December 2022 **Cost Share Total:** (if applicable) **Cost Share Percent:** (if applicable)
Benefit to PGE: Test the EMCB use cases that are applicable to customers within PGE's service territory Customer Benefit: When the Eaton smart breakers become commercially available, PGE will be better prepared and positioned to offer a customer program that can use the EMCB in the implementation of Smart grid and advanced load controls.	**Strategic Alignment:** Reduce greenhouse gas emissions by more than 80% by 2050

Value

PGE Participation: EPRI meetings and workshops Aggregation and API integration demonstrations	**Value Derived**:

Knowledge sharing on use of EMCB and incorporation with Virtual Peaker Technology transfer webcasts	1) Hardware – EMCB standard breakers have been provided to PGE for installation at PGE facilities 2) Hardware – EMCB EV provided to PGE for installation at PGE facilities 3) The five identified use cases that EPRI identified and shall be tested within PGE service territory are as follows: • 1. Water heater on time schedule • 2. Solar installation, M&V* • 3. Management of transformer loading** • 4. Power quality (such as voltage data) • 5. Local load (such as refrigerator)

Research & Development
Program / Project End Year Summary

Date: 07FEB2022

R&D Program/Project Name: EPRI P193B Wind Generation

Project Status:

☐ Complete

☒ Will Continue Next Year

		Cost 2020	Cost 2021	Cost 2022
EPRI P193B Wind Generation Annual Research Program	Alex Triplett	$ 123,773	$ 34,000	$ 34,000

- Year to be Completed: 2025

☐ Discontinued (reason) _____

Project Sponsor: Alex Triplett

Sponsoring Department: RC283

Project Team (internal): Alex Triplett, Greg Bingham, Scott Phares, Jesus Carrera, Ian Brook

Project Team (external): Brandon Fitchett (EPRI), Raja Pulikollu (EPRI)

Project Description:

Participation in the EPRI Wind Program Annual Research Program.

PGE Budget/Actual:

FY21: $34,000/$34,000

FY22: $34,000

Cost Share Total: Leveraged funding is estimated to be 25 to 1 in 2022.

Cost Share Percent: NA

Benefit to PGE:

The objective this program is to reduce capital and O&M costs, increase capacity factors, and increase component reliability for wind turbine owners. Participation provides PGE the opportunity to stay informed of best practices for operating, monitoring, and maintaining a wind fleet.

Customer Benefit:

Wind plays a major role in PGE's vision for a clean energy future. It is important to take actions to make our wind fleet a reliable and cost-effective renewable generating resource for our customers.

Strategic Alignment:

This program is in alignment with PGE's corporate imperatives to Decarbonize and Perform.

Value

PGE Participation:	Value Derived:
- Generation Advisory Meetings, Feb 2021 - Generation Advisory Meetings, Sept 2021 - Wind Innovators Network (WIN) meetings with EPRI and other wind operators - Wind Component Reliability Database Webinars - Numerous 1-on-1 interactions with EPRI Wind staff to address opportunities specific to PGE	- Reviewed specific gearbox failure modes with industry experts to identify methods for early detection and mitigation. - Reviewed blade structural design and health monitoring research to understand blade failure modes and best practices for health monitoring. - Put in contact with other program members who have similar turbine types and issues to share knowledge and best practices. - Ongoing participation in wind component reliability database to better understand expected major component reliability over the life of a wind turbine. - Expert review of high temperature limitations of SWT-2.3-93 and -108 wind turbines. - Reviewed categorization of wind turbine blade damage and recommended actions (continue to run, regularly inspect, stop immediately, etc.) - Standardized reliability data for 2 major PGE failure modes, compared to industry failure rates, and developed failure projections. - EPRI reviewed historical operating data for leading indicators of: gearbox, generator, and pitch ram failures. - Discussed collaboration of sharing blade reliability data to improve industry knowledge. - Provided PGE with Python template and training to self-perform reliability analysis.