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MISSOURI PUBLIC SERVICE COMMISSION

FILE NO. ER-2021-0240

REBUTTAL TESTIMONY

OF

JASON A. WIBBENMEYER

ON

BEHALF OF

UNION ELECTRIC COMPANY

D/B/A AMEREN MISSOURI

St. Louis, Missouri
October 15, 2021

REBUTTAL TESTIMONY

OF

JASON A. WIBBENMEYER

FILE NO. ER-2021-0240

Q. Please state your name and business address.

A. My name is Jason A. Wibbenmeyer. My business address is One Ameren Plaza, 1901 Chouteau Ave., St. Louis, Missouri.

Q. By whom are you employed and what is your position?

A. I am employed by Ameren Services Company and my position is Technology Transfer Manager.

Q. Please describe your educational background and employment experience.

A. I hold a Bachelor of Science in Electrical Engineering from the Missouri University of Science and Technology, and a Master of Science in Electrical Engineering and a Master of Business Administration (MBA) from Wright State University in Dayton, Ohio. I served four years as an officer in the U.S. Air Force at the Air Force Research Laboratory where I managed research projects in aircraft controls and radio frequency components. I separated from active duty in the Air Force in 2003 at the rank of Captain. I joined Mission Research Corporation in 2003 and served as a Principal Investigator developing radiation hardened microelectronics. I joined Ameren in 2006 and have held the following positions: Career Engineer in project engineering, Career Engineer in distribution systems reliability engineering, Senior Training Supervisor, and my current

position of Technology Transfer Manager. I am a Missouri licensed Professional Engineer (P.E.) and I'm a certified Project Manager Professional (PMP).

Q. What are your responsibilities in your current position?

A. I am responsible for the management of a research and development portfolio of projects being undertaken in support of Ameren Corporation's utility subsidiaries, including Ameren Missouri. That portfolio includes work by the Electric Power Research Institute ("EPRI") and university research. I oversee the Research Advisory Committee, manage contracts related to research and development, coordinate new research efforts including research project requests, and maintain the research portfolio budget.

Q. To what testimony or issues are you responding?

A. I am responding to the portion of the Staff Cost of Service Report sponsored by Jason Kunst which deals with EPRI costs.

Q. What did Mr. Kunst allege in his portion of the Staff report?

A. He implied that Ameren Missouri did not have appropriate justification for its EPRI expenditures and recommended that Ameren Missouri be required to conduct detailed tracking of EPRI expenditures and benefits going forward.

Q. Would you start by explaining what EPRI is and why does Ameren Missouri participate in EPRI research?

A. EPRI's website describes its history as follows:

> In November 1965, the Great Northeastern Blackout left 30 million people in the United States without electricity, starkly demonstrating the nation's growing dependence on electricity and vulnerability to its loss. It marked a watershed for the U.S. electricity sector and triggered the creation of the Electric Power Research Institute (EPRI). Although power was largely restored within 12 hours, the blackout prompted public and political scrutiny that continued for

> years. Leaders in the U.S. Congress were troubled by the nation's dependence on a fragmented, critical industry for which there was no unified planning and research. Dr. Chauncey Starr answered the call from Congress to create an independent research and development organization to support the electricity sector and address its technical and operational challenges. At a formal hearing of the U.S. Senate Commerce Committee, he presented his vision for the Electric Power Research Institute in serving its mandate for objective, scientific research. Much has changed in the electricity industry with advances in such technologies as renewable energy, environmental controls, and the smart grid. EPRI meets traditional and emerging challenges with technological innovation, thought leadership and technical expertise. Our research portfolio addresses a range of issues that change with the times and the technology, even as the underlying expectations remain constant for electricity that is affordable, reliable, and environmentally responsible.

EPRI focuses on electric generation and delivery related research and development ("R&D"). It collaborates across the electric sector to conduct R&D designed to support safe, reliable, affordable, and environmentally responsible electricity. Ameren Missouri has participated in and gained knowledge from its collaboration with EPRI in many areas, including renewable energy generation, major component reliability, air quality, environmental controls and impacts, energy storage, water management, transmission operations, substations, electrification, customer technologies, distribution operations, communication, cyber security, and worker safety. EPRI is an important part of ensuring Ameren Missouri can fulfill its obligations to provide electricity for our customers.

Q. Would it be feasible for Ameren Missouri to conduct this research on its own?

A. It is not financially feasible for Ameren Missouri to conduct the same amount of research as performed by EPRI without incurring expenses which would be more than two times greater than Ameren Missouri's current research and development annual budget. There is also significant value in participating in an organization with multiple other electric utilities resulting in shared expertise, costs, and benefits as received from the R&D undertaken by EPRI.

Q. Mr. Kunst stated that he is concerned Ameren Missouri is spending money on R&D and does not have a method for determining if the research and development actually results in cost savings or other tangible benefits. What is your reaction to this concern?

A. First, I have to disagree with the underlying assumption in this statement. The idea that cost savings and tangible benefits can be tracked for all research efforts is a flawed concept. Many of the EPRI research projects that are funded result in knowledge goals where Ameren Missouri's advisors on the EPRI projects learn about new engineering approaches, field technologies, methods to improve reliability, new environmental requirements, and emerging technologies. This knowledge results in tangible benefits when applied to new generation and distribution system projects, however it is not feasible to retroactively track or calculate the tangible benefit gained from this research. Also, one must recognize that some projects with anticipated benefits may result in little or no retrospective tangible benefit, but that does not mean the expenditure and research should have been avoided.

Q. What other concern do you have with this recommendation?

A. It is my opinion that Mr. Kunst's summation of Ameren Missouri's response to Staff data requests on this topic doesn't fully capture the level of cost justification that was provided. Staff data request MPSC 0153 asked Ameren Missouri to explain various projects and benefits from those projects. Ameren Missouri's response contained 57 pages that explained, project by project, what each project was designed to accomplish and the expected research value. I have attached this data request responses as Schedule JAW-R1. The explanations provided more than justifies the expenditures Ameren Missouri has made to obtain EPRI research and assistance.

Q. How does Ameren Missouri determine which EPRI R&D projects to support?

A. Ameren Missouri utilizes a multi-faceted approach to determine benefits from R&D. The approach includes an annual expert panel and peer review as outlined in the Overview of Evaluation Methods for R&D Programs, A Directory of Evaluation Methods Relevant to Technology Development Programs, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, March 2007 as well as a quantitative and qualitative analysis called the Value Analysis Worksheet. Value Analysis Worksheets are completed by employees who serve as EPRI research advisors. An example of this worksheet is attached as Schedule JAW-R2.

The analysis is required for each EPRI research program and includes the computation of the monetary value of the project to Ameren Missouri based on three available methods including, direct value or the estimated cost if the deliverable were obtained through other means, or both. Other things considered by the Value Analysis includes benefits such as safety, environment, customer focus, and linkage to an Ameren Missouri strategy, initiative, or goal. The result of the Value Analysis is a net value calculation that can be used to justify a research program as well as for comparison purposes across multiple research initiatives. Ameren Missouri's response to Staff data request MPSC 0153.1 provided the Value Analysis results for multiple R&D projects and is attached as Schedule JAW-R3.

Q. What, specifically, is problematic about Staff's recommendation requesting additional documentation?

A. The recommendation presumes it is possible to quantify the potential benefits of R&D the same way one can identify costs. This presumption is not accurate.

Q. What types of R&D have benefits that cannot be accurately quantified in monetary terms by a cost benefit analysis?

A. Ameren Missouri funds EPRI research in the areas of cyber security, reliability, safety, and technologies with a technology readiness level (TRL) score of 9 or below. The benefits of these research programs cannot be accurately quantified in monetary terms. For example, what is the monetary benefit of research that prevents a future cyber-attack and what is the monetary benefit of performing research on carbon capture and storage technology that is not yet fielded? Attempts to quantify such benefits using a retrospective only approach avoids reliance on forecasted data and results in a high degree of uncertainty due to the inability to accurately determine a cut-off year in the analysis. What should the cut-off year be on carbon capture technology research? 1 year? 10 years? 30 years? Furthermore, cost benefit analyses include the benefits of only a subset of technologies developed within a project while taking into account total project cost which are weighed against the partial benefits. Some projects with anticipated benefits may result in little or no retrospective benefit. While others may result in little or no retrospective benefit after year one, but may have the potential for significant benefits and customer savings in later years. Cost benefit calculations cannot be accurately quantified in monetary terms for such projects.

Q. Given that fact, how can the Missouri Public Service Commission be assured that Ameren Missouri is prudently spending its R&D dollars?

A. This goes back to the multi-faceted approach I discussed earlier. The information provided to Staff and included in the schedules to my testimony is the appropriate

way to determine what R&D efforts Ameren Missouri should invest in. Given the nature of R&D efforts, additional documentation or quantification is neither necessary nor beneficial.

Q. Does this conclude your rebuttal testimony?

A. Yes, it does.

Ameren Missouri's
Response to MPSC Data Request - MPSC
ER-2021-0240
In the Matter of Union Electric Company d/b/a Ameren Missouri's Tariffs to Adjust Its Revenues for Electric Service

No.: MPSC 0153

1. During the period covering January 1, 2019 through September 30, 2021, please list and describe each research and development project that was started, completed or is currently in progress for which costs were charged to Ameren Missouri electric. 2. For each research and development (R&D) project listed in item 1 above, please provide a narrative timeline of events with regard to the status of each R&D project in terms of how the project was selected and what goals the R&D achieved or intends to achieve. Indicate if the R&D project was successful, unsuccessful or ongoing. 3. For each R&D project listed in item 1 above, provide a list and explanation of all ratepayer benefits that each project provided or intends to provide. 4. For each R&D project listed in item 1 above, please indicate if the R&D project is being handled internally by Ameren Missouri (or any of Ameren Missouri's affiliates). If it is conducted internally indicate the employees' names, job titles and employing entity that are responsible for each project. Also note if it is a Hub@1539 project. If it is being conducted by any party external to Ameren Missouri or its affiliates, please indicate each external party for which costs are being charged to Ameren Missouri electric for each R&D project on a separate basis. 5. During the period covering January 1, 2019 through September 30, 2021, by month, by FERC account, separately by labor and non-labor, expense and capital, and by vendor quantify all costs incurred for each separate R&D project. Lisa Ferguson (Lisa.ferguson@psc.mo.gov)

RESPONSE

Prepared By: Jason Wibbenmeyer
Title: Technology Transfer Manager
Date: April 28, 2021

2019 – 2021 R&D Programs

Project: EPRI Program 1 - Power Quality

Start Date: January 2021

End Date: TBD – Current Engagement, conducted by EPRI

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.

Research Value:

With this program, members have access to research results that can help improve operational cost-effectiveness and manage risk through enhanced PQ. Potential benefits include:

Improved cost-effectiveness and grid performance through the use of PQ data by near- and real-time assessment of equipment performance, detection of incipient equipment failure, and early identification of misoperation.

Through EPRI"s lab testing, new PQ-enabled, grid-connected devices can be assessed and improved to provide actionable PQ data.

Based on EPRI laboratory testing, an updated library of end-use and distributed energy resources (DER) models could be created that would allow assessment of the PQ impact of different and changing load configurations.

Benchmarking of system performance can be improved through development of updated benchmarking methods based on more robust PQ severity metrics and experience from recent and previous EPRI studies.

The development of methods such as innovative data visualization techniques, data validation techniques, and open-source data management and visualization platforms can help modern utilities get the maximum value from grid data streams.

PQ data can be integrated with other data sources to monitor the health of grid-connected equipment and, where possible, to detect incipient issues before failure or undue impact on grid performance. EPRI"s proven expertise can be leveraged in the development of methodologies for identifying key signature characteristics in PQ data and waveform recognition techniques to identify problems before they become catastrophes.

Highly cost-effective prevention of PQ compatibility issues may be facilitated through the development of key industry standards to increase compatibility between electric power and customer loads, principally through active support of the International Electrotechnical Commission (IEC), International Council on Large Electric Systems (CIGRE), and the Institute for Electrical and Electronics Engineers (IEEE) standards committees.

Dramatically increased value of PQ data and waveforms through automated analysis.

Utility PQ teams are supported by access to more than 1,000 EPRI-authored PQ technical documents and other resources via the MyPQ.epri.com website, and by expert advice on specific PQ- related problems from more than 60 EPRI PQ experts via the EPRI PQ Hotline. Lessons learned from support for the problems and questions raised are incorporated back into EPRI's PQ body of knowledge to be used to improve grid level power quality on a national basis.

The Power Quality research program offers fundamental insights on electrical grid power quality and compatibility to help improve the value of electricity service for society. Ultimately it may also contribute to public benefits including achieving environmental goals by reliably integrating

increasing levels of DER, contributing to enhanced customer satisfaction, and improving grid reliability overall.

Project: EPRI Program 77 - Continuous Emissions Monitoring
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
The purpose of EPRI's Continuous Emissions Monitoring (CEM) program (Program 77) is to assist industry in the development, evaluation, and implementation of CEM equipment and methods. For almost 30 years, Program 77 has collaborated with utilities, equipment manufacturers, stack testing contractors, and government agencies to help develop technologies and systems to meet stack monitoring requirements. As regulations become more stringent and pollutant levels reduced, concerns regarding instrument accuracies, calibration techniques, and reference methods become more important. The number of pollutants which require continuous monitoring also continues to increase.
CEMs for acid rain pollutants (NOx and SO2) have been operational since the early 1990s. However, experience with continuous mercury monitors (CMMs) is relatively fresh, and operation and maintenance (O&M) of these instruments has been labor-intensive in many cases. As a result, sorbent trap mercury measurement systems (developed with EPRI Program 77 support) have grown in popularity. Particulate matter (PM) monitors are now used more frequently, but the calibration process is currently cumbersome and detrimental to plant operations.
Hydrochloric acid (HCl) CEM monitors have yet to gain traction, with instrumentation and reference methods still in the early stages. Instruments and monitoring equipment continue to be important areas of EPRI research.
From a greenhouse gas perspective, the accuracy of CO2 measurements using CEM systems is gaining interest. There can be significant uncertainty in flue gas flow rate measurements on coal-fired stacks used to calculate CO2 mass flow, and EPRI is currently collaborating with the National Institute of Standards and Technology (NIST) to investigate best practices for minimizing these measurement uncertainties.
Pollutants which may require future continuous analyzer development for coal-fired units include condensable particulate matter, SO3, ammonia, selenium, and arsenic. Given the increase in gas-fired generation due to low natural gas prices, CEMs for combustion turbine (CT) systems (simple cycle and combined cycle) are an increasing priority in Program 77. Accurate monitoring of very low levels of NOx, CO, ammonia and volatile organic compounds (VOCs) from CT stacks can be a significant challenge.
Research Value
Program 77 helps members develop, evaluate, and successfully implement CEM equipment options. The program also investigates and develops best practices for system O&M and stack testing (auditing) methods.
Benefits can include:

• Access to EPRI's CEM Guidelines document, which is regularly updated. This comprehensive report has served as a CEM information repository and training/reference resource for more than 30 years;
• Participation in collaborative demonstration projects, which may save months of plant instrument technician and environmental engineer time needed to make newly procured monitoring technologies work;
• Preparation for anticipated lower-level mercury measurement requirements, as well as PM measurements (filterable and condensable) as surrogates for non-mercury metal hazardous air pollutants (HAPs);
• Optimization of de-NOx and sulfur trioxide (SO3) control operations via in situ continuous measurement systems for ammonia, NOx, SO3, and sulfuric acid;
• Increased understanding of stack flow measurement issues and accuracies on coal-fired stacks; and
• Participation in discussion and development of combustion turbine CEMs projects.

Project: EPRI Program 63 - Boiler Life and Availability Improvement
Start Date: Prior to 1 January 2019
End Date: December 2020, complete, successful, conducted by EPRI
Project Description
Fossil power generating plants worldwide are experiencing increased demand for operational flexibility and degradation age-related issues for major components. Safety and availability loss due to pressure-part failures are two key issues driving R&D on major fossil power plant components. Boiler tube failures (BTFs) continue to be the leading cause of lost availability in fossil-fired steam plants worldwide. High-energy steam and water piping systems issues must be managed reliably through the aging process for these assets to remain available for power production.
The Electric Power Research Institute's (EPRI's) Boiler Life and Availability Improvement Program (Program 63) collaborates domestically and internationally to develop technologies and guidance for safe management of boiler component life to increase reliability and reduce operation and maintenance (O&M) costs. Efforts focus on advanced inspection techniques for early and accurate identification of component damage, analytical tools to predict remaining life and risk of in-service failure, and decision-support tools to help balance risks and benefits under a variety of operating scenarios.
Research Value
Power generators need to balance the risks and costs of the largest, most costly equipment in the power plant and focus on using proven technologies to create solutions. By using the results of the R&D in this program, plant owners and operators can:
• Reduce the costs of lost availability due to boiler tube failures when program results are applied comprehensively.
• Increase the safety of high-energy and high-temperature piping systems; and
• Increase safety through control of flow-accelerated corrosion (FAC) in fossil plants.

Project: EPRI Program 65 - Steam Turbines - Generators and Auxiliary Systems

Start Date: Prior to 1 January 2019
End Date: December 2020, complete, successful, conducted by EPRI

Project Description

The power generation industry today requires cost-effective strategies for maintaining turbine-generator system reliability and availability. Plant operators need to focus not only on efficient maintenance outage planning and execution, but also on mitigating risks of unplanned outages. The EPRI Steam Turbines - Generators and Auxiliary Systems program (Program 65) supports continuous improvement in the safety and availability of steam turbines, generators, and auxiliary systems. R&D in this program supports all aspects of turbine-generator asset management through applied research in component life management, preventive maintenance, condition assessment, advanced monitoring, and control systems.

Technical meetings sponsored by this program help facilitate collaboration among all industry stakeholders to support proactive strategies and best-practices sharing to help solve industry reliability issues. The ongoing research and technology transfer activities help member organizations improve knowledge and effectiveness of their turbine-generator system engineers and utility personnel.

Research Value

Using an integrated approach that incorporates work from related EPRI programs and industry input from user groups, this program focuses on maintaining availability while reducing O&M costs, managing risk, improving plant staff technical knowledge, and producing information to support asset management strategies. Research results inform run/repair/ replace decisions, preventive maintenance processes, and provide detailed guidance for planning and performing critical turbine-generator overhauls and maintenance activities.

By participating in this program, utility plant staff may obtain information that they can use to:

• Reduce maintenance costs;
• Maintain high asset availability;
• Take proactive measures to lower operating risks;
• Extend component life; and
• Increase staff technical expertise and awareness of specific component reliability issues.

Involvement in the program can help:

• Educate participants about turbine-generator issues and solutions; and
• Provide opportunities to share information with industry experts, engineers, major turbine-generator original equipment manufacturers (OEMs), and vendor/service providers worldwide.

This program improves the reliability and availability of steam turbines and generators - key drivers of overall plant performance for all conventional asset types. Safety of the power plant environment also depends on effective management of component failure risk, which is an element of this program.

Project: EPRI Project: EPRI Program 193 - Renewable Generation

Start Date: Prior to 1 January 2019
End Date: December 2020, complete, successful, conducted by EPRI

Project Description

Driven by a combination of technology innovation, cost reduction, economic incentives and renewable portfolio standards to reduce greenhouse gas emissions, global deployment of solar photovoltaic, wind, and hydroelectric generation capacity has increased significantly in the last decade. This trend is expected to continue and possibly accelerate.
Over the long term, renewable energy assets will need to operate without mandates or subsidies to be cost effective. Research and development can improve the efficiency of various technologies in converting renewable energy resources to electricity. Technology innovations and improved operations and maintenance (O&M) practices can reduce costs associated with utility-scale renewable generation. Up-to-date information is critical to explore new and optimized strategies for deployment and O&M of renewable generation assets. Targeted research is necessary to help improve overall reliability and facilitate widespread deployment of these assets.
The Electric Power Research Institute's (EPRI's) Renewable Generation program (Program 193) provides a portfolio of research and development activities that:
• Assess the status, performance, and cost of renewable generating technologies including wind, solar, and hydropower;
• Perform strategic analyses to understand technology and commercial readiness, and economics and business models associated with emerging renewable generation plant designs;
• Support the needs of renewable generation plants across their full life cycles, from planning and design, through construction and commissioning, and O&M and asset management, to repowering and/or decommissioning;
• Advance technologies to improve operational intelligence for performance optimization and predictive maintenance through application of advanced sensors and data analytics techniques;
• Provide opportunities for members to engage in general-interest renewable generation activities including workshops, tours, and other events.

Research Value

The Renewable Generation program supports methods and technologies for the economic, reliable, and flexible operation of renewable energy generating assets in an environmentally sustainable manner, while advancing innovative renewable energy technologies. Each of the core renewable technologies researched in this program (solar photovoltaic, wind, and hydropower) has its own developmental status, readiness timeline, industry drivers, and economic and technology challenges. Program 193 conducts targeted research to improve the performance, availability, and cost-effectiveness of existing renewable technologies, and to develop new renewable technologies and applications. The program also adapts established asset management models to renewable assets. Additional targeted research may be conducted to understand current status of deployment trends for solar thermal, biomass and geothermal generation technologies. Through collaboration with key industry stakeholders and members, the program develops and demonstrates technologies to optimize operating efficiency, reduce overall costs, and improve reliability of large-scale renewable generation.

Project: EPRI Program 49 - Coal Combustion Product Management

Start Date: Prior to 1 January 2019
End Date: December 2020, complete, successful, conducted by EPRI

Project Description

The electric power industry faces a variety of challenges and opportunities regarding the management of coal combustion products (CCPs):

• Large volumes: The U.S. electric power industry currently produces more than 100 million tons of CCPs annually.

• Potential for environmental impact: CCP landfills and impoundments require engineering and environmental management to prevent groundwater contamination.

• Cost: Annual costs for disposal of CCPs and groundwater remediation are expected to increase sharply over the next five to ten years.

• Beneficial use: Only about one-half of CCPs generated annually are beneficially reused, and more than one billion tons of CCPs are stored in landfills and impoundments

To address these challenges, this program provides:

• Cost-effective, internationally-applicable CCP management and recycling practices that enhance environmental protection

• Scientific data, engineering knowledge, restoration methods, models, and other advanced tools and guidance associated with CCP storage, disposal, and reuse

• Educational workshops on technical topics hosted by the Groundwater Resource Center

• In-depth technical presentations and round-table discussion at the P49 summer meeting

• CPInfo leachate quality database

• In-situ remediation demonstration project (supplemental)

• Supplemental projects supporting alternative source demonstrations, groundwater modeling, monitoring at the groundwater-surface water interface, use of off-spec fly ash in blended cement and asphalt, spray dryer absorber material, and flue gas desulfurization (FGD) gypsum in agricultural applications

• Continuously updated summaries of existing and emerging CCP use technologies

• Workshops on key topics of interest, including CCP harvesting and beneficiation

Research Value

• Benefits the electric power industry and the public by providing cost-effective and environmentally protective solutions

• Helps minimize environmental impacts and develops state-of-the-science remediation technologies for enhanced corrective action when required

• Minimizes disposal costs while retaining or earning new revenue

• Reduces or eliminates long-term environmental liabilities associated with CCP management

Project: EPRI Program 54 - Fish Protection

Start Date: Prior to 1 January 2019

End Date: December 2020, complete successful, conducted by EPRI

Project Description

Ensuring adequate water supplies for operations while protecting aquatic life remains a challenge for power plant owners. This program helps owners and managers meet regulatory requirements and reduce costs for the electric power industry and rate payers by:

• Providing information, analytical tools, analyses, and expertise to help cost-effectively manage water resources while maintaining compliance with fish protection regulations

• Providing information and methods to support technology performance monitoring
• Evaluating fish protection technologies for cooling water intake structures (CWIS) and waterpower projects and procedures to assess impacts on aquatic communities

Planned Application Support

Great Lakes 316(b) Interest Group will discuss Federal and Great Lakes State plans for §316(b) implementation. Activities include knowledge-sharing on approaches for preparing I&E technology information; providing technical information on I&E mortality reduction technologies; disseminating updates and alerts on fish protection topics; and promoting consistency in peer review requirements.

Cooling Water Intake Operation, Maintenance and Optimization Interest Group provides information through webcasts, workshops, newsletters and technical briefs. Collaboration topics include sharing information on cooling water intake blockages, operational impacts, O&M best management practices and traveling screen optimization.

Fish Protection Compliance Support: Site-specific support of technically challenging and costly 316(b) optimization studies, including study plans, holding facility designs and fabrications, oversight of sampling, and data analysis and reporting.

Research Value

This program:
• Identifies ways to reduce compliance and social costs and enhance permitting processes
• Identifies cost-effective fish protection technologies that provide the greatest biological benefit
• Provides compliance managers and power plant operators with tools to manage water resources and protect aquatic communities in accordance with fish protection regulations
• Provides information on cost, economic, environmental, and electric system impacts of compliance and licensing / relicensing requirements

Project: EPRI Program 195 - Endangered and Protected Species

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

The electric power industry faces several challenges related to endangered and protected species:
• Throughout their life cycle, electric power projects and facilities directly and indirectly, through interactions with other facilities, other human activities, and natural events, affect species and their associated habitats.
• Expansion of international, federal, state, and local laws, regulations, and policies to protect and conserve species and ecosystems indicate that society highly values this protection.
• At the same time, the power industry must continue to provide cost-effective, safe, and reliable energy to meet increasing energy demand.
• Hence, the power industry faces two potentially conflicting societal values, and must responsibly address both amidst changing regulations and increasing societal expectations.

To address challenges at existing and planned facilities, this program:
• Identifies, prioritizes, and delivers scientifically rigorous research
• Develops forward-looking, in-depth studies of methodologies and ecological/spatial models related to species/ecosystems protection in the electric power industry

• Evaluates U.S. and international regulatory developments and economic implications
• Collaborates with members, regulators, and stakeholders to better inform species listing and delisting decisions
• Evaluates current and emerging options for species conservation to increase effectiveness of permitting, siting, planning, and conservation
• Identifies and evaluates current and emerging tools, methods, and technologies to improve species identification, habitat mapping/modeling, impact minimization, and deterrents
• Facilitates cooperation between regulators and stakeholders on conservation planning, critical habitat protection, and regulatory drivers
• Facilitates common sense programmatic and regional solutions for the benefit of species and habitat protection and the electric power industry
• Identifies of research gaps related to endangered protected species

Application Support

Power-in-Pollinators

• Supports, preserves, and protects pollinator habitats through collaboration on approaches for preparing impingement and entrainment technology information
• Provides a framework to identify and implement research related to endangered and protected pollinators especially as FWS lists or considers listing pollinators
• Enables member interaction and coordination with other industries, NGOs, and researchers
• Promotes collective action of power companies to preserve and protect pollinator habitats
• Endangered and Protection Species Application Support (Various Companies)
• Technology development using remote sensing (e.g., imagery, sound, eDNA)
• Species and species habitat detection and identification using machine learning and AI
• Evaluation of methods/technologies to develop effective best management practices (BMPs) and standards.

Research Value

This program:

• Reduces siting, permitting, operation and maintenance (O&M), and compliance costs
• Predicts O&M and compliance costs
• Informs corporate strategy and helps to reduce corporate liability
• Cost-effectively manages corporate, regulatory, and business interruption risk
• Enhances brand value
• Informs policy- and rulemaking
• Improves system resource and other planning
• Efficiently assesses potentially beneficial technologies
• Improves permitting processes
• Better engages with, and enables more informed decisions by customers, shareholders, regulatory agencies, the public, and other stakeholders

This program enables:

• Synthesis of biological and regulatory information
• Risk assessment of activities affecting endangered and protected species
• Effective modeling development and application
• Effective use of technology to identify and map endangered and protected species

• Development and testing of BMPs and technological solutions to reduce adverse interactions and minimize direct impacts
• Development and validation of conservation measures for utilities

Project: EPRI Program 203 - Air Quality and Multimedia Characterization, Assessment and Health
Start Date: Prior to 1 January 2019
End Date: December 2020, complete, successful, conducted by EPRI
Project Description
Protecting public health and the environment, the primary goal of environmental regulations, requires an ongoing dialogue among regulators, scientists, utilities, and other stakeholders about the following:
• Air pollutants mitigated inside power plants can impact other plant discharges.
• Pollutants emitted from the stack interact with other pollutants, and deposit in the environment in various ways.
• Pollutants that are inhaled and deposited can affect human and ecosystem health.
These complications pose the following challenges:
• The electric industry needs methods and tools to accurately characterize all emissions and discharges because emissions control technologies for achieving increasingly stringent air limits are complex, and can affect other media, such as water and solid waste discharges.
• Predicting what happens after air pollutants are emitted from power plants requires complex modeling and assessment techniques.
• Addressing scientific uncertainties as to how air pollutants in the environment, including criteria pollutants and air toxics, impact human and ecosystem health requires cutting-edge methods.
Research Value
The electric power industry needs an enhanced understanding of how emissions from power plants—in combination with emissions from other sources—affect air quality and ecosystem health. Included are the primary "criteria" pollutants as defined through the U.S. Clean Air Act and the trace pollutants referred to as air toxics. Domestic and international air quality standards continue to be key issues for power plant owners and operators. Through this program, EPRI informs and advances the science supporting policy development, regulatory decision making, and implementation planning through assessments of current and future impacts of air emissions on the environment.

Project: EPRI Program 51 - Transmission & Distribution: Environmental Issues
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
As electric transmission and distribution (T&D) infrastructure ages and expands, new rights-of-way (ROW) standards are developed, new products and services are delivered, transmission planning operations become more integrated, and distribution functions expand. These developments require utilities to manage and minimize human health risks, environmental

impacts, and species interaction with power delivery systems in order to maintain safe and reliable grid operation. Challenges in these areas include:
• Ensuring ROW vegetation management (VM) and transmission line siting are efficient, cost-effective, and compliant with new reliability standards and habitat enhancement.
• Protecting system components from spills, runoff, and cleanups.
• Developing environmentally-acceptable options for selecting and managing utility poles and dielectric fluids, designing facilities, and remediating contamination.
• Ensuring ROW construction and maintenance does not adversely impact sensitive species, their habitats, or cultural and natural resources.
This program helps utilities manage the environmental aspects of T&D by delivering:
• Balanced, cost-effective solutions for addressing the economic and environmental challenges of siting, developing, managing, and upgrading T&D assets and ROWs
• Data, tools, and information that deepen understanding of the environmental consequences of company actions, including operations and maintenance
• Information, tools, and methods for preventing, characterizing, and remediating soil and water contamination at T&D facilities, and for designing and retrofitting T&D facilities
• Data and products that support information needs for scientifically sound regulations and cleanup standards for chemicals associated with T&D and ROW facilities and operations
Planned Application Support
• Observational and manipulative studies to document the effects of VM techniques on pollinators
• Assessing IVM performance of partner utilities through field and procedural audits with recommendations for improvement
• Implementing avian collision avoidance technology using light to mark power lines
• Exploring the efficacy of bat houses in mitigating VM alongside consideration of construction and maintenance activities on bats
• Integrated hazing systems for substations, switching stations, power plants, and construction centers
• Customized unmanned aerial system (sUAS) solutions for utility environmental issues
• Exploring use of naturally occurring seedbanks to achieve vegetative cover during restoration

Research Value

This program delivers innovative tools, practical guidance, and state-of-the-art information that help utilities reduce T&D and ROW costs, protect natural and cultural resources, enhance regulatory compliance, improve service reliability, and address strategic goals. The program:
• Reduces costs for ROW maintenance, used oil and other environmental management, utility pole and other asset management, mineral oil spill and other risk management, spill prevention, control, and countermeasure compliance, and VM.
• Addresses ecological and human health issues/risks along T&D ROWs, via IVM, by preventing bird strikes and electrocutions, and by remediating soil and water contamination at T&D facilities.
• Enhances regulatory compliance by providing scientific data and information to improve communication with stakeholders and inform development of regulations and cleanup standards for chemicals associated with T&D and ROW facilities and operations.

• Improves power system reliability by expediting transmission line siting, enhancing T&D ROW equipment choices, and decreasing the potential for transmission outages via proactive environmental management.
• Achieves corporate goals by helping reduce financial risk and balance the economic and environmental challenges of siting, developing, managing, and upgrading T&D infrastructure and ROWs.

Project: EPRI Program 62 - Occupational Health and Safety
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Workplace injuries affect employee health, quality of life, productivity, and job satisfaction, while increasing the cost of doing business. In addition to the high cost of serious injuries, EPRI's Occupational Health and Safety Database (OHSD) shows the number of industry workplace fatalities has recently increased, while all injuries have declined over 20 years. Additionally, EPRI and industry databases show that strains and sprains remain 40% of occupational injuries in the electric power industry. Typical risks result from poor ergonomic design in equipment, human factors such as distraction or physiological fatigue, and long-term or repetitive physical and chemical exposures.
The research in this program focuses on strategies, tools and insights to reduce injuries, illnesses, and productivity losses. The work focuses on specific exposures to various hazards, including heat stress, utility worker decisions, fleet motor vehicle-related incidents and injuries, and exposure of third-shift (night shift) workers to bioactive blue light. As the generation, transmission, and distribution systems evolve, new occupational ergonomic risks need to be characterized, and potential new interventions (e.g., wearables and monitors) need to be developed to reduce workplace injury.
Application Support:
• Six working groups of funding companies' advisors to provide immediate insights and guidance to activities in: Human Performance; Predictive Analytics; Driving Safety / Motor Vehicle Accidents; Heat Stress; Ergonomics; and Occupational Exposure Database.
• Heat Stress Demonstration Projects
• Ergonomic Handbooks to apply task relevant interventions.
Research Value
This program can provide the following benefits:
• Provides the basis for informed health and safety practices for current and anticipated future electric utility infrastructure
• Identifies data gaps, evaluates potential data requirements, and addresses critical issues related to the assessment of risks and the design of intervention strategies in the power generation and delivery sector
• Provides the scientific research needed for informed decisions on strategies for injury prevention, safety program targets, exposure controls, regulatory compliance, and intervention and training methods

• Provides insight into future health and safety deliberations and an integrated approach to health, exposure, and surveillance data for occupational planning in the electricity sector
• Contributes to reduced lost productivity and medical costs from occupational injuries, and improved workforce morale and retention, if effectively integrated within utility safety management systems
• Helps utilities build safer and healthier work environments and potentially reduce injuries
• Informs industry, regulators, and society with high quality, credible scientific information

Project: EPRI Program 198 - Strategic Sustainability Science
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Expectations of utilities regarding sustainability commitments and performance are rising as utility customers, investors, employees, and other industry stakeholders become more engaged in the sustainable electricity dialogue. As corporate strategies advance beyond regulatory compliance to a more comprehensive focus on driving value through economic, environmental, and social responsibility, electric power companies need ways to embed sustainable practices into day-to-day operations and strategic long-range planning.
To address these expectations, this program identifies and develops the tools, models, and analyses that utilities need to integrate a sustainability mindset throughout their organizations. As we explore how a commitment to sustainability throughout electricity production, distribution, and utilization supports a sustainable economy, the program serves as a resource nexus to bring sustainability thought leaders together and propel progressive scientific research and analysis.
Application Support
• Electric Power Sustainability Maturity Model facilitated workshops
• In-person meetings to advance technical work and share leading practices
• Easy-to use deliverables allow for direct use of research findings by sustainability managers and their colleagues
Research Value
This program provides the following benefits:
• Serves as a focal point for the present and future of sustainability-related research for the electric utility industry
• May help utilities operate more efficiently, better mitigate risk, and meet growing customer and other stakeholder expectations
• Enables utilities to enhance strategic planning, risk management, financial analysis, and communications processes by engaging colleagues in these areas directly and developing tools to help root sustainability into these functions
• Enhances the two-way dialogue on sustainability issues and solutions between various internal and external stakeholders, which drives timely, proactive engagement and improved understanding
• Enables better informed utility decision making on a broad range of strategic decisions, by incorporating sustainability dimensions

• Enables utilities to increase the maturity of their sustainability approach, thus demonstrating their sustainability leadership

Project: EPRI Program 34 - Transmission Asset Management Analytics
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Transmission companies face issues—among them, aging infrastructure, stringent operating requirements, financial constraints, and retiring expertise—that make maintaining and managing assets challenging. In response, many electric utilities are considering or already have moved toward more analytically based decision processes to improve maintenance and reliability and to minimize equipment life-cycle costs and risks. However, the data, analytical tools, and models required for power delivery equipment risk assessment and management are not well established. Diligent actions for maximizing performance and minimizing equipment life-cycle costs should be based upon risks associated with actual equipment condition and historical performance, but such information is sparse.
To achieve these objectives, four key steps are needed:
1. Understanding existing performance
2. Understanding required performance
3. Projecting future performance
4. Understanding how to bridge gaps
Decision support analytics and methodologies require new knowledge, tools, and methodologies to accomplish these steps and help with the best allocation of operations and maintenance (O&M) and capital resources for transmission assets.
Research Value
The core values are:
• A sound technical basis for decision-making
• Improved reliability of electric service
• Controlled life-cycle costs and risks that contribute to keeping electric rates affordable
• Help in assessing and managing risks
The research can enhance asset management decision-making processes and improve their results by providing data, tools, and methodologies that can be used by T&S asset and maintenance managers for better decision support.

Project: EPRI Program 35 - Overhead Transmission
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Among other challenges that they face, transmission companies must strive to improve safety and reliability as well as reduce operations and maintenance (O&M) costs. They are also seeking ways to reduce capital expenditures for new and refurbished equipment and to increase transmission capacity without making large capital investments.

This program is designed to address the research needs of transmission asset owners and operators. Key drivers
of this are:
• Reduced operation and maintenance costs
• Improved reliability and resiliency
• Extending asset life
• Improved safety
The program offers a portfolio of tools and information focused on components (such as conductors, insulators, compression connectors, and composite structures) and system issues (such as lightning and grounding, live working, transmission capacity, inspection and assessment, and high-voltage direct current [HVDC] lines).
The program delivers immediate benefits—such as field guide apps and a blend of short-term tools (software, reference guides, and field guides)—together with longer-term research, such as component aging tests and the development of failure and degradation models for line components.

Research Value

The research results provided by the program addresses asset-specific performance and industry issues. The collection of projects intends to provide members with knowledge that can help with the following:
• Management of aging transmission line assets
• Approaches to selecting, applying, inspecting, and assessing components
• Inspection and assessment tools and techniques
• Lightning performance and grounding reliability
• Efficiency of transmission line design, including resiliency
• Live working techniques, tools, and procedures
• Methods to increase the capacity of existing overhead lines

Project: EPRI Program 37 – Substations

Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Transmission companies face challenging issues, such as improving safety and reliability while simultaneously reducing operations and maintenance (O&M) costs. These challenges are compounded by pressure to reduce expenditures for new and refurbished equipment.
The EPRI Substations research program is designed to address the research needs of substation asset owners and operators. The program includes projects focused on assets (such as transformers, circuit breakers, protection and control, gas-insulated substations, ground grid, arresters, capacitively coupled voltage transformers [CCVTs], batteries and chargers, and high-voltage direct-current [HVDC] substations) as well as projects focused on industry issues (such as evaluation of online monitoring technologies, sulfur hexafluoride [SF6] replacements, SF6 leak sealing, alternative fluids, and the performance of external insulation in contaminated environments). The program delivers a blend of short-term tools—software, reference guides,

field guides, technology assessment results, and so on—and longer-term research, such as new materials, component aging tests, and the development and evaluation of monitoring techniques.

Research Value

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 resinimpregnated 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 with maintenance guidelines
• Reduce maintenance times and costs via condition-based maintenance
• Assess SF6 replacements
• Improve SF6 management
• Implement predictive maintenance practices for reduced 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

Project: EPRI Program 39 - Transmission Operations

Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Today's electric power system is being operated to transfer large amounts of energy over greater distances, with greater variability, than was considered when built. Widespread decarbonization by renewable resources whose availability is variable and uncertain, inverter-based and at times located in the distribution system or within customer facilities, has created new operating challenges for visibility, decision making and rapid control action. As a result, new monitoring and control processes, analysis methods, and decision support tools are required to operate tomorrow's grid reliably and efficiently.

EPRI's Transmission Operations research program is addressing these needs through the following:

• Operator situational awareness through improved alarm management, EMS visualization, and human factors innovations
• Methodologies and tools to optimize the use of reactive power resources to maintain appropriate voltage control and increase operation security margin
• Extreme event operations and system restoration methods and tools to increase resiliency to high-impact, low-frequency events and restore the system efficiently after outages

• Outage coordination, and operational planning risk assessment to schedule facility outages and operations plans under increasingly uncertain operating conditions and to ensure operating criteria such as reactive requirements are met
• Real-time monitoring, control, and data analysis methods that use synchrophasor measurements to assess complex operating conditions and contingencies, and provide mitigations
• Wholesale market operations and market management software for evolving technologies and reliability needs

Research Value

The mission of EPRI's Transmission Operations research program is to address the needs of system operators required to maintain efficient, effective and sustainable grid operations through the energy transition. This is accomplished through development of next-generation situational awareness, software, analysis, and control capabilities required to effectively operate the transmission grid of the present and future. Once identified, the EPRI Transmission Operations team works with members to structure and conduct specific projects. Finally, this value is transferred to members through collaborative advisory and task force interactions, workshops and webcasts, and specific applications and demonstrations of the developed methods and tools.

Project: EPRI Program 40 - Transmission Planning

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Traditional power system planning methods and tools are increasingly challenged in today's power system environment. 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 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 dynamic behavior from synchronous generation. The challenge of meeting reliability requirements with the changing landscape and increasing levels of uncertainty may necessitate adjusting and augmenting transmission planning criteria and methods and may require new tools and models for transmission planners.

Transmission planners need models of emerging technologies that are validated periodically for planning studies.

Transmission planners are also increasingly tasked with considering deeper and varied contingencies requiring screening of many more potential contingencies and prioritizing the contingencies for more detailed analysis.

They also need to plan the system to withstand "atypical" circumstances such as the impacts of geomagnetic disturbances, electromagnetic pulses, and various physical security attacks on system reliability. Some of these more advanced contingency analyses also require consideration of breaker-node representation and closer coordination and explicit integration of protection system models in planning models. Also, analysis of deeper contingencies may require new approaches and methods for analysis which are not used at present. Increased application of power electronic-interfaced transmission assets such as HVDC and some power flow control technologies may require transmission planners to consider analysis that is not typically

performed in day-to-day planning. This may require the resource performance characterizations and associated models, new analysis methods, and new planning processes.
Resource and transmission planners are also increasingly challenged as environmental and economic drivers force the retirement of more conventional generation, as supply resources become more variable and uncertain, and as distributed and demand-side resources become more prevalent. Additionally, demand response and extreme temperatures in traditionally shoulder load periods are increasing the uncertainty in load levels at specific points in time. Therefore, moving forward, planners may require risk-based approaches to build power flow cases as well as analyze them using risk-based indices that can provide more insights on system reliability and efficacy of proposed system reinforcements.
Lastly, the optimal performance of protection system is critical to the safe, reliable and stable operation of modern power systems. As the power system changes with changing supply mix and new transmission infrastructure increasing the complexity of the system, protection system requirements also become more complex. Moving forward, planners and protection engineers will need 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 guidelines to explicitly model protection systems in planning studies.

Research Value

The mission of EPRI's Transmission Planning research program is to support the development and validation of planning study models, planning processes and frameworks, protection system analysis from transmission planning perspective, and reliability assessment analytics that will be required to build a reliable and economic transmission grid that integrates an evolving generation mix to supply an increasingly complex load that can also act as a system resource. This is accomplished through a collaborative process in which EPRI works with utility

Project: EPRI Program 173 - Bulk Power System Integration of Variable Generation

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Installed capacity of renewable energy has increased significantly over the last decade due to policy decisions such as state-mandated renewable energy standards and federal air and water standards, along with improved economic viability for these resources. Much of the existing and estimated development of renewables comprises variable, and sometimes distributed, generation resources such as wind generation and solar photovoltaics (PV), which when integrated with the grid, create new challenges for maintaining reliable system operation. Future projections are that a more significant build-out of these variable and distributed renewable resources is likely at both the transmission and distribution levels.
With these developments, bulk power system planners and operators require new tools and resources to provide a reliable, sustainable, and cost-effective supply of electricity to consumers. Tools to aid in meeting these objectives include (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, and (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.
EPRI"s
Bulk Power System Integration of Variable Generation (VG) research program addresses these needs and directly supports EPRI"s Research Imperatives #2 "Integration of Dynamic Customer Resources and Behavior" and #3 "Integrated Power System and Environmental Modeling Framework", as well as many aspects of EPRI"s Integrated Grid and Integrated Energy Network initiatives.

Research Value

The Bulk Power System Variable Generation Integration research program provides variable generation integration analytics; development of planning and protection methods, tools, and models; and development of operator methods and tools to reliably and economically integrate wind and solar PV generation, as well as other distributed resources such as battery energy storage. This is accomplished through a collaborative process wherein EPRI works with its utility and independent system operator (ISO) members and other stakeholders to identify existing research gaps and associated project needs that would provide value to society and to EPRI members. Once identified, the EPRI Bulk Variable Generation Integration team of technical and project management experts works with members and the world's foremost experts in related research areas to structure and conduct specific projects that delivers value in the near-term, mid-term, and long-term. Finally, this value is transferred to members through collaborative advisory and task force interactions, workshops and webcasts, and specific applications and demonstrations of the developed methods and tools.

Project: EPRI Program 174 - Integration of Distributed Energy Resources

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Increased amounts of distributed energy resources (DER) in the electric grid brings technical and economic challenges for the electric industry. Managing and screening interconnection requests, specifying grid support functions and settings and applying control options are new business and require new learning for most utilities. Effective integration of DER needs to be considered in all aspects of distribution planning, operation, protection coordination, voltage regulation, power quality and safety. Hosting DER also brings new economic challenges and tradeoffs for providing reliable service with increasing deployment levels. Business risks and opportunities need to be evaluated.

This research addresses all aspects of DER integration, with emphasis on transfer from R&D to field use. Project sets address advances in feeder integration tools, hosting capacity analysis, performance and use of smart inverters (and other controllers), application of interconnection standards, learning with DER data analytics, monitoring and control via DERMS and microgrids. New interconnection standards such as IEEE 1547 are addressed. DER business strategy and cost-benefit analysis are key elements of the program such as research to optimize PV operation with storage and controllable loads. Tools such as DRIVE (Distribution Resource Integration and

Value Estimator), PVAT (PV Adoption Tool), reference DERMS and smart inverter simulators are produced through the research of this program.
Identifying utility practical applications and providing effective technical transfer of learnings are key. Training, workshops, webinars, discussion forums are frequent. The program includes interest and user's groups, laboratory and field evaluations and demonstrations of DER management and communications. A primary objective of the work in the field is to expand utility hands-on knowledge for managing distributed energy resources.

Research Value

The knowledge acquired through this research program will support members to:
• Manage interconnection queues and identify effective screening methods
• Track, document, and address grid issues caused by rising DER levels
• Access and apply new analysis tools and methods for assessment at various levels and types of DER
• Determine requirements and take advantage of evolving standards for DER interconnection
• Train staff on integration technology (smart inverters, grid edge devices, control systems etc.)
• Develop strategies for managing and integrating customer-sited DER
• Assess both technical and economic aspects of DER integration with existing distribution assets
• Explore new methods and tools for DER integration and use in distribution
• Use data analytics for assessment and insight into DER operation cost and benefit
• Prepare existing and future distribution grids for more effective integration

Project: EPRI Program 180 - Distribution Systems

Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

The Distribution Systems research program aims to address the challenges facing distribution asset owners and operators. This program is focused on distribution assets, their life-cycle, and industry issues.
Research addressing the 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.

Research Value

This research program supports grid modernization and focuses on distribution system assets, their specification, operations, maintenance, and disposal. The results from this program should help asset owners:
• 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

Project: EPRI Program 200 - Distribution Operations and Planning
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
The distribution system is changing at an ever-rapid pace. Much more so than any other areas in the power system. Much of this has been driven by recent regulation such as the California Distribution Resource Plans (DRPs) and New York's Reforming the Energy Vision (REV). Other reasons are driven by changes in customer behaviors (low load growth), customer adoption of distributed energy resources (DER), prosumers, as well as recent technological advancements newly available to distribution planners and operators. Tools and methods for planning and operating the distribution system were not designed to meet this changing landscape.
Distribution systems have been designed for one purpose: reliably serve all customers in a safe and cost-effective manner. However, in this new era additional objectives must be considered as well including integrating DER cost-effectively, utilizing DER as non-wires solutions, increasing resiliency, improving operational efficiency, and actively using distribution systems to provide bulk system services. Grid modernization efforts are underway throughout the industry to achieve these goals.
Tools and technologies, such as distribution management systems, automation systems, protection systems, and planning tools must adapt to facilitate the needs of this new modern distribution system. New technologies and their integration will be critical to allow distribution planners and operators to meet these goals and realize the concept of an "Integrated Grid" where traditional assets work in concert with new technologies and resources to yield a more efficient, reliable, and customer-centric sustainable grid. This creates certain challenges as some of these needs are current and immediate. As such, a more focused effort in the form of a dedicated EPRI program that is focused on assisting utilities in their grid modernization efforts is required.
EPRI's Distribution Operations and Planning Program (P200) is designed specifically to provide members with research and application knowledge to support planning and management of today's grid as well as tomorrow's.
The Program provides research results that assist utilities in their transition to tomorrow's distribution system using a balanced, no-regrets approach to grid modernization. Advanced tools for planners, operators, and analysis experts are central to these efforts. This program will serve as the hub for all activities related to distribution modernization, focusing on:
• Developing and implementing new planning processes and tools that target grid modernization, balancing reliability, cost and risks
• Developing and implementing new, advanced operation and control schemes that maximize use of existing and new technologies
• Improving visibility (situational awareness) through new methods and technologies for cost-effective metering
• Developing adaptive and scalable protection solutions for active distribution systems

• Developing new and innovative distribution automation schemes that improve reliability
• Advancing workforce skill development through new training activities and tools
• Sharing new learnings from industry-wide grid modernization efforts.
• Transmission system operator/distribution system operator (TSO/DSO) interaction
Members of the Program gain access to a portfolio of projects that cover the range of distribution issues, as well as the opportunity to collaborate with other members and EPRI technical experts to share ideas and solutions, improve knowledge transfer, and ultimately improve safety, reliability, and operational performance.

Research Value

The mission of EPRI's Distribution Operations and Planning research program is to assist utilities in their grid modernization efforts, helping them optimize the use of existing assets while simultaneously maximizing benefits of new technologies and resources to yield a more efficient, reliable, and customer-centric sustainable grid. The research within this program is intended to equip distribution planners and operators with the means necessary to overcome the challenges of today while attaining the desired modern grid of the future. 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 and resources.

With the knowledge acquired through this research program, members will gain access to information that can help them accomplish the following:

1. Plan and operate a changing, integrated distribution system;
2. Enable planners to take advantage of new analysis methods within their existing planning tools (e.g., hosting capacity methodology, advanced distribution automation and control, etc.)
3. Support the implementation of advanced distribution observability and control for reliability improvement, voltage control, and the dynamic grid management;
4. Assess and vet the costs and benefits of smart grid applications and advanced technologies; and
5. Leverage industry-leading practices in the management and operation of modern distribution systems.

Project: EPRI Program 206 - Wind

Start Date: January 2021

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

The wind energy industry is maturing due to innovations in technology, improving economics, and cost reductions driving increased deployments projected to reach 1 TW globally by the mid-2020s. The market is also expanding in some locales due to portfolio standards, corporate and public demand, and now-waning incentives. As costs continue to fall, wind power is becoming one of the lowest cost forms of energy on a plant output basis. The rapid deployment has led to some future unknowns and research opportunities, however, with the vast majority of wind power capacity less than 10 years old. The quantity of deployment, falling costs, changing power systems, and lack of data around aging assets is driving research needs related to:

• Siting, plant configuration and operational strategies for achieving longer term assets and greater production compared to industry averages
• Quantification, monitoring and improvement of wind turbine performance
• More reliable, efficient energy production from reduced operations and maintenance costs combined with production improvement efforts
• Flexible operations and new plant designs to support grid services and integration strategies
• Asset management life-cycle issues related to equipment health, turbine repowering decisions, and eventual end-of-life environmental topics

Research Value

In EPRI's Wind Generation program (206), research is conducted to benefit EPRI members and the public through innovation and collaboration for advancement of safe, economic, reliable, and flexible wind energy. In the face of increasing renewable generation deployment, the program provides current information on key renewable generation technologies, including technical performance and system costs. The work undertaken in this program enables cost-effective, reliable integration of renewables into the power generation mix while tackling the unique issues around renewables O&M and asset management.

Project: EPRI Program 207 - Solar

Start Date: January 2021

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

The renewable energy industry is changing rapidly due to innovations in technology and manufacturing; new plant designs that facilitate the provision of grid services and flexible operations; cost reductions driven by an expanding market; and improving economics supported by incentives and portfolio standards.

Solar generation deployments continue to grow annually, with projections for global capacity doubling over the next decade. More than 60% of this capacity is ground-mounted, large-scale (1 MW+) photovoltaic (PV) plants. This segment of the PV market is the primary research focus of EPRI's Solar Generation program (P207). More than 600 gigawatts of solar plants are installed globally, with more than 90% operating fewer than 10 years. Lessons learned from the genesis fleet of large-scale plants have helped increase the affordability of solar electricity through reductions in capital expenses (e.g., scale economies and increasing efficiency along the supply chain), operating expenses (e.g., continuous improvement processes throughout the life cycle) and technology innovations (e.g., progress along manufacturing learning curves and increasing lifetime energy output).

Furthermore, existing PV deployments serve as informational feedback loops to drive future learning and provide a deepening understanding of existing technologies and processes, with the possibility of breakthrough innovations. Greater understanding of plant performance is needed to better predict and optimize lifetime costs against lifetime energy production. Accurate and predictive knowledge of technology performance and reliability will reduce project risk.

A comprehensive understanding of the PV life cycle is needed to develop best practices for all aspects: design, commissioning, operations, maintenance and end-of-life. Collaboration with industry participants is key to understanding a solar plant's life cycle — from design through

decommissioning — and enabling informed plant owners' decision-making about balancing lifetime costs against lifetime energy production. Data-driven analysis is anticipated to hasten best practice creation.

Research Value

The Solar Generation program supports methods and technologies for the affordable, reliable, and flexible operation of renewable energy generating assets in an environmentally sustainable manner, while advancing innovative renewable energy technologies. The program also adapts established fossil generation asset management models to solar assets and collaboratively develops and demonstrates technologies to optimize costs and operating efficiency and improve reliability of large-scale renewable generation.

The work undertaken in this program enables power producers to most effectively integrate renewables into their generation fleet and tackle the unique issues associated with renewable O&M and asset management.

Project: EPRI Program 209 - Cyber Security for Generation Assets

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

The power industry is expected to have a mature cyber security strategy that will prevent and detect attacks, and recover through swift, competent operational technology (OT) cyber program implementation. While at the same time, generation owners face market pressures that are forcing plant flexibility and reduced cost. To meet changing market conditions vendors and owners are adopting advanced digital technologies for controls, automation and monitoring. In addition, the cyber security regulatory environment is changing, affecting more plants and systems.

The research in Program 209 will focus on fossil generation assets, renewable generation assets and generation interdependencies. Numerous factors are taken into consideration when developing a generation OT cyber security program. Program 209 will address the specific considerations associated with existing and new fossil assets, new and existing renewable assets, and other critical infrastructure sector interfaces (i.e., transportation systems, municipal water, natural gas, fuel pipelines, etc.)

Research deliverables, technical meetings, developmental workshops and research teams sponsored by this program help facilitate collaboration among industry stakeholders including utilities, asset owners and operators, vendors, suppliers, academia, standards bodies and governments to help address these challenges. The technology transfer activities within this program (i.e., field pilots and demonstrations for members) are used to improve the application of the technologies, methodologies and guidance to improve knowledge and effectiveness of their generation OT cyber security programs.

Research Value

By accomplishing the ultimate goals of this program, the members should expect to:

• Improve overall generation OT cyber security posture and maturity

• Become less susceptible to a changing threat landscape

• Become less sensitive to a changing regulatory environment by utilization of best practices beyond regulatory minimums
• Be better prepared to protect, detect, and respond and recover from cyber threats

Project: EPRI Program 219 - Steam Turbines and Auxiliary Systems
Start Date: January 2021
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
EPRI's Steam Turbines and Auxiliary Systems program (Program 219) supports continuous improvement in the safety and availability of steam turbines and auxiliary systems. Research and development in this program support all aspects of steam turbine asset management through applied research in component life management, preventive maintenance, condition assessment, advanced monitoring, and control strategies.
The power generation industry today requires strategies for maintaining turbine-generator system reliability and availability. Plant operators need to focus not only on efficient maintenance outage planning and execution, but also on mitigating risks of unplanned outages.
Technical meetings sponsored by this program facilitate collaboration among industry stakeholders to develop proactive strategies to help mitigate and resolve industry reliability issues. The ongoing research and technology transfer activities help member organizations improve the knowledge and effectiveness of their steam turbine system engineers and utility personnel.
Research Value
This program improves the safety, reliability, and availability of steam turbines - key systems for overall plant performance in conventional, combined-cycle, and nuclear generating asset types. Safety is a key element of this program due to its importance in a power plant environment. This program addresses safety by providing resources that improve management of component failure risk through development of asset integrity management processes and equipment-specific risk guidance.
Equipment reliability and affordability are achieved by applying an integrated approach that incorporates research from related EPRI programs and input from industry experts.

Project: EPRI Program 220 - Generators and Auxiliary Systems
Start Date: January 2021
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
EPRI's Generators and Auxiliary Systems program (Program 220) supports continuous improvement in the safety and availability of generators and auxiliary systems. Research and development (R&D) in this program support all aspects of generator asset management through applied research in component life management, preventive maintenance, condition assessment, and advanced monitoring.
The power generation industry today requires strategies for maintaining turbine-generator system reliability and availability. Plant operators need to focus not only on efficient maintenance outage planning and execution, but also on mitigating risks of unplanned outages.

Technical meetings sponsored by this program facilitate collaboration among industry stakeholders to develop proactive strategies to help mitigate and resolve industry reliability issues. The ongoing research and technology transfer activities help member organizations improve the knowledge and effectiveness of their generator system engineers and utility personnel.

Research Value

This program improves the safety, reliability, and availability of generators - key systems for overall plant performance in conventional, combined-cycle, nuclear, and hydro generating asset types.

Safety is a key element of this program due to its importance in a power plant environment. This program addresses safety by providing resources that improve management of component failure risk through development of asset integrity management processes and equipment-specific risk guidance.

Equipment reliability and affordability is achieved by applying an integrated approach that incorporates research from related EPRI programs and input from industry experts.

Project: EPRI Program 222 - Advanced Generation & Carbon Capture and Storage

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Program 222 focuses on power generation and carbon capture and storage (CCS) using fossil- and other carbon based fuels. Fossil fuels continue to provide nearly 80% of the world's energy, and major studies show that the world will continue to rely on fossil fuels to meet its energy demand for many decades to come. CCS is the only option for fossil fuels to remain a viable energy source in a carbon-constrained future. Without CCS, the world's CO2 emissions reduction goals and energy supply growth are unlikely to be simultaneously achieved. Equally important, CCS is central to minimizing the cost of deep decarbonization.

The program's research and development in fossil and biomass power generation is focused on gasification, integrated CO2 capture and novel fossil power cycles (e.g., supercritical CO2). The objective is to identify and

accelerate the development of new approaches for generating power from fossil fuels while providing flexible, lower carbon, synchronous power generation. Specifically, the program aims to:

• Advance development of novel, high-efficiency power generation cycles that ultimately reduce CO2

• Evaluate concepts that improve the flexibility or performance of retrofits to existing fossil plants

• Foster fossil-based power generation technologies that can operate in a highly flexible manner

• Review other carbon-based power generation systems, including biomass

Research and development in CCS address the cost, availability, performance and technical challenges of CCS. Specifically, the program aims to:

• Advance development of pre-, oxy-, and post-combustion CO2 capture technologies with lower energy and cost penalties for both coal- and natural gas-fired power plants.

• Conduct R&D needed to demonstrate the permanence, safety and environmental acceptability of long term CO2 storage and enhanced oil recovery options for power plants.
• Monitor developments for CO2 utilization and direct air capture.
The research covers and integrates multiple activities, including techno-economic assessments, comparisons of cost and performance data, novel process evaluations, feasibility studies, exhaustive reviews on cutting-edge technologies, and field demonstrations.

Research Value

The goal of the program's research is to provide the industry and society with fossil power plants that can meet the market needs of improved flexibility and higher efficiency, and provide low carbon power generation.

Project: EPRI Program 223 - Heat Rate and Flexibility: Generation Fleet Optimization

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Generation fleets are being challenged to deliver the capability for increased flexibility and efficiency while maintaining reliability, affordability, safety and clean electricity production. The increasing competition from a variety of power producers and the use of variable energy resources are primary drivers for these needs.

Program P223, Heat Rate and Flexibility: Generation Fleet Optimization, covers research related to thermal power plants to cost effectively increase flexibility and efficiency of those plants. The program aims to develop solutions that can be applied to solve a variety of flexibility and efficiency needs to deliver an optimized generation fleet. The optimal solution for any fleet is dependent on a complex interplay of the existing generation fleet assets, the market drivers, and the direction of regulatory policy where the fleets operate.

Rising operating costs, increased competition from other non-thermal power generating sources, and regulatory pressures have increased the need to improve heat rate and flexibility. Heat rate improvements have a direct relationship to tonnage releases of all air emissions, including CO2. Flexibility has a direct relationship on the ability to integrate additional variable energy resources. The integration of heat rate and flexibility assessment capabilities to evaluate physical and operational changes of operating plants and new plant designs is critical for optimizing operating, maintenance and investment strategies.

The focus of EPRI's Heat Rate and Flexibility: Generation Fleet Optimization program is to improve operating plant heat rate and flexibility, independent of the fuel fired. The program helps advance technologies that may benefit all power generating companies, including those now starting performance and flexibility improvement programs as well as those with mature programs.

The efforts behind improving heat rate and flexibility require a broad understanding of power plant design, operation, maintenance, ambient conditions, thermal-hydraulics, combustion, plant processes, measurement techniques, controls, materials and fuel types. To be successful, a holistic view must be taken to ensure the results of any action are both cost effective and have known and acceptable effects on other plant equipment.

Research Value

The Heat Rate and Flexibility: Generation Fleet Optimization program focuses on a holistic approach to optimize power plant flexibility and efficiency without creating adverse effects on power plant equipment and operation downstream or leading to sub-optimization of the overall generating fleet.

Project: EPRI Program 214 - Boiler Life and Availability Improvement
Start Date: January 2021
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
The Boiler Life and Availability Improvement program (Program 214) uses international collaboration to develop technology and guidance on safe management of boiler component life to increase reliability and reduce operation and maintenance (O&M) costs. Efforts focus on advanced inspection techniques for early and accurate identification of component damage; analytical tools to predict remaining life and risk of in-service failure; and decision-support tools to help balance risk and benefit under a variety of operating scenarios. These efforts will be investigated with an increased emphasis on development of tools for fitness-for-service and flaw evaluation.
Fossil-fueled generation stations around the world are experiencing increased demand for operational flexibility due in large part to increased penetration of renewable energy and changing market conditions. These units may experience damage differently depending on whether they are new, highly efficient, high pressure and temperature units or older operating units that have experienced a high number of operating hours. Damage may occur in many different locations and by varying damage mechanisms depending on design and materials used during the construction of the unit.
Safety and availability loss due to pressure part failures are two key issues driving R&D on major fossil power plant components. Boiler tube failures (BTFs) continue to be the leading cause of lost availability, with equipment availability losses due to BTFs averaging approximately 3% in fossil-fired steam plants worldwide. Damage in thick section components from flexible operation continues to increase, including bore hole cracking in components that experience high thermal stresses, such as superheater outlet headers and economizer inlet headers.
Locating and sizing of damage in various components continues to be a challenge. Non-destructive examination (NDE) development will continue to be required to locate and size damage in affected areas. Program 214 will investigate techniques that can scan larger areas with greater speed and resolution.
Remaining life assessment of major boiler components is also an important industry driver. This includes development of industry fitness-for-service approaches and guidance on specific boiler components. Understanding options available to the generation asset owner if a defect is identified in a component provides valuable insights needed to inform run-repair-replace decisions.
Research Value

Power generators need to balance the risks and costs of operating power plants and focus on using proven technologies to create solutions. By using the results of the R&D in this program, plant owners and operators can:
• Reduce risk of in-service failures to high temperature and pressure components
• Significantly reduce the impact of lost availability due to boiler tube failures
• Make fitness-for-service decisions to determine if components can remain in service or if repair or replacement activities are required
• Safely extend time between outages and inspections though use of advanced inspection and analysis techniques

Project: EPRI Program 215 - Power Plant Piping
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
The Electric Power Research Institute's (EPRI's) Power Plant Piping program uses international collaboration to develop technology and guidance on safe management of piping systems to increase safe and reliable operation and reduce operation and maintenance (O&M) costs. Efforts focus on advanced inspection techniques for early and accurate identification of piping damage; analytical tools to predict remaining life and risk of in-service failure; and decision-support tools to help balance risk and benefit under a variety of operating scenarios. These efforts will be investigated with an increased emphasis on development of tools for fitness-for-service and flaw evaluation.
Research Value
EPRI brings more than three decades of research in typical piping failures to the industry including longitudinal seam welded piping failures and circumferential weld failures. Tools for addressing FAC are well established and simplified walk downs are available to assist utilities in understanding inspection locations. Standard inspection protocols for most damage mechanisms have been developed and are available to build on and improve for new issues and materials.

Project: EPRI Program 226 - Boiler and Turbine Steam and Cycle Chemistry
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Program 226, Boiler and Turbine Steam and Cycle Chemistry, conducts targeted research on key corrosion and deposition damage mechanisms by providing practical solutions to mitigate risks. The program develops guidelines, technology solutions, demonstrations, and training materials to help plant operators and utilities manage water-steam cycle chemistry to reduce unplanned outages and O&M costs and address the impact of flexible operation on cycle chemistry. The program also offers guidance on proper selection, application, and optimization of unit cycle chemistry.
Research Value

The industry is challenged to find the optimal balance between managing risks of chemically influenced failures and asset preservation with O&M cost reduction and sustained production. By using the results of the R&D in this program, utilities can:
• Improve overall unit availability and flexibility by preventing unmitigated damaging corrosive conditions that result from improper response to cycle chemistry excursions
• Reduce steam turbine availability losses by properly managing steam chemistry to avoid salt deposition, offline corrosion, and metallic oxide deposition
• Reduce chemically influenced boiler and HRSG tube failures and the need to conduct chemical cleaning
• Improve plant safety by reducing incidences of FAC damage and failures
• Reduce chemistry-related O&M costs
• Improve methods of major equipment offline preservation and storage
• Reduce incidences of chemistry-related corrosion damage associated with low-load and cyclic operation
• Optimize cycle chemistry programs and operating specifications for units scheduled for retirement
• Reduce boiler chemical cleaning frequency and associated costs of waste management

Project: EPRI Program 235 - Air Quality Assessments and Multimedia Characterization
Start Date: January 2021
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Program 235 conducts detailed assessments of air quality resulting from power plant and other emissions and air quality standards by applying analytical techniques such as air quality models, ambient measurements, data analysis, and risk assessment methodologies. These assessments and applications help inform the development and implementation of air quality standards and provide context to the role of power plant emissions on air quality and risk. The program collects and generates data on fleet-wide emissions and releases and plant-wide multimedia release assessments that have the potential to impact the environment. This includes producing and updating pollutant measurement databases and developing emission factors that can be used in facility air permits and in the Toxics Release Inventory (TRI) reporting software.
Research Value
This program also focuses on clarifying the chemistry and partitioning of pollutants in power plant process streams, a focus that began more than 30 years ago. This long-term outlook helps EPRI better anticipate issues, inform evolving regulations, and develop practical solutions to reducing power plant releases and subsequent environmental impacts. The research performed under this program enhances understanding of pollutant chemistry, provides methods and tools to accurately characterize the chemicals, and facilitates development of more effective pollution control strategies. Improved sampling and analytical methods can provide more accurate results to better inform decisions on control technologies and to assist in communicating risk to regulators and the public. The research provides credible emissions data to help power companies respond to permitting and regulatory requirements. The program develops emissions estimates that are used by other programs for risk assessment research. Measurement data

produced by the program (and other sources) is compiled into the Power Plant Toxics Measurements Database, the most comprehensive database available on HAPs emissions. The program assists power companies with Toxics Release Inventory (TRI) reporting by providing annually updated reporting software, helping to minimize the cost of environmental compliance.

Project: EPRI Program 239 - Aquatic Resource Protection
Start Date: January 2021
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Program 239 provides research that:
• Conducts technically sound I&E sampling programs
• Evaluates fish protection technology technical feasibility and biological efficacy
• Analyzes costs and benefits of intake and discharge technologies
• Researches the environmental impacts of thermal discharges
• Creates cost-efficient strategies to minimize impacts and enable flexible operations
• Evaluates and identifies gaps in understanding of:
    o Emerging technologies and techniques of quantitative thermal mapping
    o Fish responses to thermal discharges
Research Value
The results of this program help:
• Provide up-to-date information on fish protection technology performance, operations, and maintenance methods for performing U.S. Environmental Protection Agency (EPA) required optimization studies, I&E sampling methods, DNA monitoring techniques, fish and shellfish life history, T&E species issues, thermal impacts to fish, and environmental resource economic analyses
• Enable cost-effective determination of best technology available for I&E control and provide resources to determine balanced indigenous populations potentially impacted by thermal effluent
• Enable more flexible and resilient power plant operation by maximizing plant dispatch availability and reducing impacts of variable thermal loads on aquatic organisms
• Provide compliance managers and power plant operators with tools to manage water resources and protect aquatic communities

Project: EPRI Program 241 - Coal Combustion Products Management
Start Date: January 2021
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Coal Combustion Products (CCPs) are man-made, inorganic, solid particulate materials associated with coal-fired generation. The compositions, sizes, and shapes of CCPs give these materials unique properties. Because CCPs are secondary materials, understanding the characteristics of CCPs as generation operations change, and associated CCP handling technology, is important for operation of generating facilities.
About 60% of CCPs produced in the U.S. are recycled into products like concrete and wallboard, while about 40% are disposed in landfills and impoundments. Because use of CCPs benefits

utilities, rate payers, and CCP users, new technologies to use CCPs in different products are being developed, and independent research by Program 241 is needed to understand the capabilities and limits of these technologies as well as the safety and value of the associated end products. For CCPs that cannot be used, research is needed on safe, effective methods of disposal due to unique properties of CCPs compared to other wastes.
The focus areas of this research will be on development of information, data and technologies for:
• Characterization of CCP materials
• Handing of CCP materials
• Beneficial use of CCP materials
• Disposal of CCP materials
• Harvesting of disposed CCP materials

Research Value

Research in Program 241 informs utility planning and decision making about safe and economical management of CCPs, including handling, beneficial use and disposal. Utilities apply disposal research to designing and operating of cost-effective landfills that will remain environmentally protective over the long term. Users of CCPs apply the research on beneficial use tools and technologies when manufacturing products like concrete. Consumers of products made with CCPs, including farmers and builders, also indirectly benefit from published research on CCP use. Policy makers may also be informed by Program 241 research when considering technical aspects of rules and laws regarding management and use of CCPs.

Project: EPRI Program 242 - Coal Combustion Products, Land and Groundwater Management

Start Date: January 2021
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

EPRI's Program 242 is focused on the release, fate and transport, and remediation of inorganic constituents that drive environmental risk, such as arsenic, chromium and selenium, and that have the potential to drive corrective action, even if the environmental risk is low, such as boron and lithium.
The focus areas of research in this area are on the development of information, data, techniques and tools for:
• Characterization of coal combustion product (CCP) sources
• Evaluation of groundwater transport
• Assessment of risk as a function of toxicity and exposure
• Remediation of groundwater and land resources
• Monitoring groundwater and performing data analysis

Research Value

Program 242 research:
• Provides methods and data for understand groundwater transport and risk
• Supports power companies that are designing remediation systems tailored to the unique suite of constituents that can be released from CCP sites

• In collaboration with Program 241 (Coal Combustion Products Management), provides research on CCP management and associated environmental characterization to inform science-based regulatory actions.

Project: EPRI Program 233 - Continuous Emissions Monitoring and Measurements
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Depending on the type of fuel, stack CEM systems can include monitors for a wide range of emissions that have traditionally included NOx, SO2, CO2, CO, Hg and particulate matter (PM). More recently, emissions of ammonia (NH3), hydrochloric acid (HCl), sulfur trioxide (SO3), sulfuric acid (H2SO4) and formaldehyde (H2CO) have been included in select instances, and/or regions. As a result, Program 233 is closely involved in the technologies and procedures related to these measurements. For example:
• Given the increase in gas-fired generation due to low natural gas prices, evaluation and demonstration of advanced CEM technologies (e.g., laser-based monitors) for combustion turbine (CT) systems (simple cycle and combined cycle) are an increasing priority in Program 233. Accurate monitoring of very low levels of NOx, CO, ammonia and volatile organic compounds (VOCs) from CT stacks can be a significant challenge, with the need to secure U.S. Environmental Protection Agency (EPA) approval for potentially different methods to conduct daily calibration routines for in situ line-of-sight average measurement applications.
• From a greenhouse gas perspective, the accuracy of CO2 measurements using continuous emissions monitoring systems (CEMS) is a key issue. There can be significant uncertainty in flue gas flow rate measurements on fossil-fuel power plant stacks used to calculate CO2 mass flow. EPRI is currently collaborating with the National Institute of Standards and Technology (NIST) to investigate best practices for minimizing these measurement uncertainties.
• Evaluations of new and existing manual stack test methods for quarterly or annual compliance tests are conducted in situations where a technology may be unproven or where emission limits have been significantly reduced to levels approaching, or below, previous minimum detection limits for a given method.
• Particulate matter monitors are now used more frequently, but the current calibration process is cumbersome and can be detrimental to plant operations. New calibration approaches are under development with EPRI assistance.
Research Value
Program 233 helps participants develop, evaluate, and successfully implement CEM equipment options. The program also investigates and develops best practices for system O&M and stack testing (auditing) methods.
Benefits from program participation include:
• Access to EPRI's CEM Guidelines document, which is updated on a regular basis. This comprehensive report has served as a CEM information repository and training/reference resource for more than 30 years.

• Opportunities to participate in collaborative demonstration projects, which may save months of plant instrument technician and environmental engineer time needed to assess applicability, installation requirements, and O&M associated with new monitoring technologies.
• Preparation for anticipated lower level mercury measurement requirements, as well as PM measurements (filterable and condensable) as surrogates for non-mercury metal hazardous air pollutants (HAPs).
• Optimization of NOx and sulfur trioxide (SO3) mitigation system process control via in situ continuous measurement systems for ammonia, NOx, SO3 and/or sulfuric acid.
• Increased understanding of stack flow measurement issues and measurement best practices on coal fired stacks.
Program 233 research benefits the power industry and public at large by enabling reliable and accurate continuous monitoring of a broad range of emissions and pollutants.

Project: EPRI Program 201 – Energy, Environmental, and Climate Policy Analysis
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
The electric power sector faces a wide range of external forces and uncertainties that present challenges for operational decision making and investment strategies. Domestic and international drivers of these uncertainties include:
• Changing energy, climate, and environmental policies and overlapping state and regional regulations (e.g., carbon reduction policies such as proposed clean energy standards, mandates on electrification and energy efficiency, and renewable policies)
• Energy market dynamics and uncertainty in energy prices
• Technological changes in the supply and consumption of energy
• Rapidly expanding use of intermittent generation
• Competing drivers of grid-delivered load growth (e.g., energy efficiency, distributed generation, and electrification)
• Climate impacts including extreme events challenging the reliability and resiliency of generation
Research Value
Through the various project sets, this program provides the following benefits:
• High quality analyses of the impact of new and proposed energy and environmental policies and regulations (e.g., proposed clean energy standards, mandates on electrification and energy efficiency, and renewable policies)
• Helps inform company strategies and develop less risk business strategies
• Helps utilities reduce policy and compliance costs, in the form of reduced capital and operating costs
• Provides utilities and policymakers with crucial information for economically and environmentally sound policy and investment decisions

Project: EPRI Program 18 - Electric Transportation
Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Electricity is the only widely available and domestically produced form of energy for transportation that addresses the simultaneous needs for fuel diversity, energy security, reduced greenhouse gas emissions, and improved air quality. The transition of transportation energy from petroleum to electricity represents a paradigm shift for electric utilities to the role of fuel provider for vehicles. It also represents a significant opportunity for electric utilities.

To help advance the use of electricity as a transportation fuel, the EPRI Electric Transportation program conducts research and development on electric vehicle and infrastructure technologies, analyzes the economic and environmental impacts of electric transportation, and supports industry and utility programs to build public awareness of as well as foundational work supporting electric transportation in the public interest.

The early market for electric vehicles (EVs) has been characterized by modest but steadily increasing sales, high vehicle reliability and customer satisfaction, and a rapid evolution of both vehicle and charging technologies. Compared to the first mass-produced EVs, new vehicle models can charge at faster rates and travel with greater range per charge. A variety of EV models ranging from sedans to bucket trucks are seeing increased usage in fleet applications. Mass-market, 200+ mile range EVs are being launched. In addition, public charging infrastructure to support EVs is expanding, with the installation of thousands of public and workplace charging stations. A fast-charging network is also beginning to emerge, using direct current (DC) electricity at levels of 50 kW to 120 kW to charge EVs in as little as 20 minutes. In addition, automotive manufacturers have developed the first production charging systems that enable EVs to potentially interact with the grid. By the end of April 2018, total U.S. EV sales exceeded 812,000 vehicles and more than 40 EV models were available from 15 automobile manufacturers, including five of the six largest U.S. automotive manufacturers. Nearly 100 EV models are scheduled to be available by the end of 2023.

Nearly all major automakers are reaching out to the utility industry to help develop and standardize EV charging infrastructure and to help educate their mutual customer. The customer, meanwhile, is also looking to the utility for guidance as an impartial trusted energy advisor. Residential, commercial, and industrial customers—fleet managers, employers, retail stores, developers, local governments, and others—are seeking guidance on the design, location, and installation of charging infrastructure. Utilities need to understand the system impacts and customer requirements associated with plug-in vehicles, and prepare their grid to support the rollout and adoption of EVs. This program helps utilities address these challenges.

Business customers are also looking to utilities for help in quantifying the value of incorporating EVs into their vehicle fleets in both on-road and non-road operations to offset high fuel costs, improve operating efficiencies, meet environmental requirements, and enhance customer satisfaction. This program equips utilities to conduct such evaluations. Mass-market, 200+ mile range EVs are being launched. In addition, public charging infrastructure to support EVs is expanding, with the installation of thousands of public and workplace charging stations. A fast-charging network is also beginning to emerge, using direct current (DC) electricity at levels of 50 kW to 120 kW to charge EVs in as little as 20 minutes. In addition, automotive manufacturers have developed the first production charging systems that enable EVs to potentially interact with

the grid. By the end of April 2018, total U.S. EV sales exceeded 812,000 vehicles and more than 30 EV models were available from 15 automobile manufacturers, including five of the six largest U.S. automotive manufacturers. Nearly 100 EV models are scheduled to be available by the end of 2023.
Lastly, EPRI provides impartial information to the public on electric transportation technologies, research projects, and results. EPRI provides impartial information to the public on electric transportation technologies, research

Research Value

For more than a decade, the EPRI Electric Transportation program has played a leading role in the advancement of EV technologies that are at the forefront of automotive industry development efforts. EPRI also serves as a focal point of collaboration between the automotive and utility industries for the development of infrastructure standards, vehicle demonstration programs, and advanced infrastructure technologies. EPRI"s commercial and industrial electric transportation efforts have demonstrated the cost-effective use of electric vehicles in numerous commercial and industrial applications, and serve as the technical foundation for successful, customer-focused utility commercial and industrial electric transportation market expansion programs.

Project: EPRI Program 94 - Energy Storage and Distributed Generation

Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

This program covers research related to energy storage, fueled distributed generation (DG), and microgrid technologies. The scope covers energy storage connected to utility transmission system, distribution system, and customer premises. 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 premises. These technologies may provide a range of benefits to the power system, including enhanced power quality, reliability, avoided costs to grid infrastructure, operational efficiency, and greater integration of variable, renewable resources. Depending on location and usage, these benefits may be “stacked” and shared across multiple stakeholders, which can create opportunities, as well as challenges, to realize the full potential of these technologies.
The research covers and integrates multiple activities, including technology evaluation, economic and technical modeling to support grid planning and operations, and field demonstration. The current program mission is to facilitate development of energy storage technology options and integration strategies which are safe, reliable, cost-effective, and environmentally responsible.

Research Value

Energy storage and distributed generation, effectively utilized, may result in higher power system reliability, increased utilization of renewable energy, and the avoidance of future cost increases to electricity consumers. The outputs of this research are expected to support these following outcomes for members and society:

• Understanding the fast-evolving state of energy storage and DG technology development, relative to expectations and requirements for power system applications to utilities and end customers.
• Development of tools, methods, and guidelines for utilities and industry participants to improve communication, lower project soft costs, and promote safety and reliability of energy storage deployments:
• Economic and technical evaluation methods and tools to support understanding of best location, sizing, and usage of energy storage, DG, and microgrid technologies

Project: EPRI Program 182 - Understanding Electric Utility Customers
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Customers are growing more sophisticated, with increasing expectations of value, speed, and reliability based on service interactions across multiple business sectors, including home entertainment, business computing and communications, and connected devices enabled by the Internet of Things. These expectations carry over to the electricity sector. At the same time, customers have an increasing array of options related to electricity supply and use, coming from third parties in addition to their utility.
Technology advances give customers more choice and control over when and how they use electricity—from smart appliances and thermostats, to plug-in electric vehicles, and options for local generation including rooftop solar photovoltaics and batter storage technology. The choices customers make already have recognizable impacts on the electricity system, particularly on energy consumption and load shapes, and these impacts are expected to continue to grow.
Utilities are finding that traditional methods for forecasting customer electricity needs are inadequate in an environment with increasing customer choice and expectations. It has become imperative that new ways to forecast and plan for customer needs be developed to incorporate customer preferences and choices for emerging technologies and associated services.
Customer choice and control can also enhance the value of electricity service to the individual customer as well as to society. Because utilities have established relationships with their customers, they can be effective change agents and offer customers choices for both existing and new products and services that align with customer, utility, and societal objectives. Utilities have opportunities to meet customer expectations while dynamically integrating customers and their technology choices into the power and grid delivery systems.
New and diverse strategies are needed to integrate these increasingly sophisticated customers going forward. Electric utility companies can learn from the methods competitive industries use to better understand and meet their customers' needs and expectations. Many different businesses have developed detailed knowledge of their customers' preferences and behaviors over decades of information gathering and analysis. This knowledge of customer interests and values is applied to create products and services that meet customers' diverse demands and interests. Additional analytics are used to then develop appropriate offers targeted to the most likely interested customers. Similarly, utilities need strategies for creating and offering compelling choices for electricity service to their customers.

EPRI's Understanding Electric Utility Customers research program is focused on providing utilities with insights and tools to better understand, and to call their customers to action, to offer choices aligned with customer preferences as well as utility and societal objectives of providing reliable, affordable, and environmentally responsible power.

Research Value

This research provides insights and tools that can be used to develop customer programs with a greater likelihood of successful implementation and customer acceptance, and that ultimately contribute to greater benefit to customers, utilities, and society. The costs of implementing ineffective programs can be avoided by participating in and using this research. The research also can help utilities factor in customer participation and associated load impacts into consumption forecasts and load shapes used in utility planning and operations. The program's collaborative approach provides opportunities to interact with diverse member organizations that have pioneered research methodologies, taken the risk to implement pilot programs, and have mature customer programs in place. Collaboratively-developed tools often are more cost-effective and designed based on larger and/or more diverse data sets, resulting in more robust tools that yield higher value results than those developed by a single entity. Furthermore, such tools can be expanded with each new wave of research and the underlying foundations can be shared. Delving into existing programs and pilots provides a rich set of secondary research results that often can be used to estimate impacts on utility systems in place of costlier primary research. With resources and results available, members can increase program effectiveness and customer satisfaction by offering energy programs and services that customers prefer, and by targeting those customers who prefer them, can implement them more cost effectively while meeting corporate, regulatory, and societal goals.

This program supports one of EPRI's Research Imperatives to "Enable Integration of Customer Resources" by providing critical information related to customer preferences for and adoption of new technology and service offerings. It is also a critical component of EPRI's vision for an Integrated Energy Network that strives to provide affordable, efficient, and clean energy solutions to meet customers' needs.

Project: EPRI Program 199 - Electrification for Customer Productivity

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Business enterprises are constantly striving to increase productivity and enhance their competitiveness in the global marketplace. In many cases, electrification—i.e., the application of novel, energy-efficient electric technologies as alternatives to fossil-fueled or non-energized processes—can boost utility productivity and enhance the quality of service to the enterprise and the customers it serves. Electricity offers inherent advantages of controllability, precision, versatility, efficiency, and environmental benefits compared to fossil-fueled alternatives in many applications. A lack of familiarity and experience with emerging technologies, however, impedes many enterprises, particularly small- to medium-sized businesses and civil institutions, from pursuing electrification measures that can improve the productivity and efficiency of operations. Such enterprises would benefit from information and support from their electric utility. However,

electric utilities themselves face obstacles to serving as effective partners in this regard. Identifying and measuring the prime opportunities for electrification in a given service territory can be difficult. Utilities must also reconcile electrification strategies with mandated energy efficiency goals that are usually narrowly defined in terms of kilowatt-hour reductions. Moreover, the lack of an analytical framework for quantifying the net benefits of electrification strategies—from the customer, utility and societal perspectives—hinders the development of utility-business partnerships to facilitate beneficial electrification. This research program aims to address these gaps by developing and refining analytical tools and a knowledge base of technologies, applications, and markets and facilitating stakeholder networks to help utilities evaluate and pursue electrification opportunities.

Research Value

With the knowledge acquired through this research program, members will have access to expertise and information that can help them in the following ways:

• Acquisition of strategic frameworks to evaluate electrification opportunities in their service territories, and tactical tools to pursue program implementations with business customers.

• Exposure to the latest electric technologies and their market applications.

• Connection to a network of stakeholders—including other utility members, technology vendors, industry associations, end-use customers, government agencies, national laboratories, and other organizations— to advance electrification standards and metrics. Through these avenues, members may position themselves for multiple benefits:

• Could improve productivity and competitiveness of end-use customers through advancements in overall energy efficiency, reduced costs, and improved throughput.

• Could reduce on-site emissions at end-use customers' facilities, which assists compliance with environmental regulations and fosters worker health and safety.

• Could reduce net emissions to benefit society-at-large.

Project: EPRI Program 161 - Information and Communication Technology

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Utilities are deploying monitoring, communications, computing, and information technologies to enable grid modernization applications such as wide area monitoring and control, asset management, distribution automation, integration of distributed energy resources (DER), and demand response. Companies face significant challenges when deploying these technologies, including:

• Selecting the technologies that best meet current and future business needs, while minimizing the risk of early obsolescence and vendor lock-in;

• Creating an overall architecture that integrates the many intelligent devices, communications networks, and enterprise systems to leverage resources and provide information to all users;

• Managing the tremendous amount of data that is generated;

• Managing a growing network of intelligent devices that have different capabilities and use different protocols and data formats in a way that optimizes performance; and

• Creating pervasive, resilient communications networks that can enable multiple applications.

The Information and Communications Technologies (ICT) Program addresses these challenges by conducting research in the following areas:
• Interoperability - The program accelerates the industry's migration towards interoperability by making technical contributions to standards development efforts, providing training to utilities, developing reference implementations and organizing interoperability tests of developing standards, and collaborating with utilities on the demonstrations of emerging standards.
• Telecommunications - The program provides leadership in communications standards development, provides tracking 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.
• Enterprise and Grid Architecture - The program creates artifacts that help to improve the state of the art in enterprise architecture and develops guides to help utilities with standards-based systems integration.
• Advanced Metering - The program leads an industry effort to develop open, interoperable, and advanced metering systems; it develops best practice guides for the operations and maintenance of Advanced Metering Infrastructure (AMI) systems; and it investigates approaches for maximizing the value of AMI systems.
• Connectivity and Integration of Intelligent Field Equipment, Edge Devices, Mobile Workforce and Consumer Internet of Things (IoT) Devices with Utility Systems -- The program is developing requirements and informing standards-making efforts for integrating and managing grid-edge devices with utility systems.
• Data Management - The program is documenting industry best practices for how data is acquired, validated, stored, protected, and processed --- and how accessibility, reliability, and timeliness is ensured. The program also is advancing the Common Information Model (CIM) standard.

Research Value

The ICT program provides information and tools that are designed to provide members with immediate value while conducting longer-term R&D to help guide the industry towards a highly-connected and interoperable future.
In the near-term:
• IT departments may reduce the time and cost of integration and management from guides that provide best practices for enterprise architecture, systems integration, and substation and AMI data management.
• Telecommunications departments may reduce cost and the risk of early obsolescence of equipment by applying best practices for network operation, maintenance, and management, and tools for effectively planning and designing multi-technology communication networks.
• Metering departments that are planning on implementing advanced metering systems may receive value when developing their procurement from the industry AMI database and resource center. They may also reduce cost and risk by using the Wi-SUN reference meter tool.
Companies that have already deployed AMI systems may reduce operation and maintenance costs by applying the information from the program's suite of best practice guides.
In the long-term, members may benefit from R&D and industry leadership to advance interoperability standards for advanced metering systems, distributed energy resources, demand

response and enterprise system integration. This may reduce capital and integration costs and reduce the risk of vendor lock-in.

Project: EPRI Program 183 - Cyber Security
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
Cyber and physical security have become critical priorities for electric utilities, which are 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 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.
Research Value
The rapid pace of change in the electric sector creates a challenging environment for asset owners and operators to monitor the cyber security activities of industry groups, develop an understanding of how new technologies affect security, and maintain the right internal resources for assessing those technologies. EPRI employs a team of experts with comprehensive backgrounds in cyber security who address these challenges by providing insight and analyses of various security tools, architectures, guidelines, and results of testing to program participants.
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;
• Techniques for assessing and monitoring risk;
• Tools and metrics to better assess security posture and return on investment;
• 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.

Project: EPRI Program 236 – Air Quality and Health
Start Date: January 2021
End Date: TBD – Current Engagement, conducted by EPRI
Project Description
EPRI's Air Quality and Health program addresses key scientific uncertainties regarding the health effects of air pollutants. The objective of the research is to inform industry stakeholders, regulators and the public—in the United States (U.S.) as well as internationally—to ensure the development of protective public health policies and standards based upon the latest scientific data and analyses.

Protecting public health and the environment is the primary goal of environmental regulation. In the U.S. the Clean Air Act's National Ambient Air Quality Standards (NAAQS) set limits for ambient concentrations of six criteria pollutants (carbon monoxide [CO], lead, nitrogen dioxide [NO2], particulate matter [PM], ozone [O3] and sulfur dioxide [SO2]) considered harmful to public health. The focus of EPRI's Air Quality and Health program is to perform research that informs this review process for regulatory actions and monitors the health impacts of air pollution at the local, international and national levels.

The program's health effects information, developed from epidemiology, toxicology and exposure assessment studies, as well as applied risk assessment analyses, addresses key scientific uncertainties related to health effects of PM, ozone, NO2 and SO2. The focus of current research is on closing research gaps related to several key issues, including investigation of the long-term effects of air pollution; the shape of the concentration response functions for criteria pollutants, including the existence of a minimum threshold concentration below which health effects do not occur; and the methods employed for calculating benefits of air pollution regulations or other scenarios, such as electrification. In addition, the program's forward thinking, proactive, and strategic nature ensures that the research also includes evaluation of emerging issues that may be important in the evaluation of health information in the future. Such issues could include the use of pollutant sensor data for epidemiological studies, new statistical methods for evaluating health impacts, such as causation modeling, and novel experimental approaches for use in the air pollution health setting.

Research in the Air Quality and Health program is relevant to coal and natural gas generation as well as a broader set of new generation technologies, and includes research not only specifically aimed at understanding the health effects of power plant emissions, but also to evaluate the health impacts of a variety of other air pollution sources and put power plant emissions into context.

Research Value

EPRI research provides a holistic perspective on the overall air pollution mixture and how health risks due to power plant emissions compare with risks from emissions from other sources. EPRI is also continuing important work on the health effects of PM components, as this research has the potential to catalyze a paradigm shift in informing how PM is regulated. The current mass-based approach regulates total PM concentration; however, PM is composed of hundreds, if not thousands, of individual components, and there is a growing scientific consensus that not all components are equally toxic. This research addresses key scientific uncertainties to determine which components of air pollution are associated with negative health impacts (and which are not) and generates information to support health risk estimates of air pollution components. The value of the research is in its ability to more accurately identify the specific causative agents, and thus the sources of those agents, affecting human health and the environment.

Project: EPRI Program 41 - Nuclear Power

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Effective materials aging management supports the safe and reliable functionality of a nuclear plant throughout its lifetime. Stress corrosion cracking and other degradation mechanisms in reactor coolant system components have resulted in forced and extended outages, increased inspection requirements, and component repairs and replacements. A better understanding of crack initiation and propagation processes and environmental corrosion in reactor coolant system components can inform the development of reliable predictive models and cost-effective mitigation technologies.

Research Value

• Strategic roadmaps outlining research gaps associated with key issues—such as PWR reactor internals aging management and reactor pressure vessel integrity through extended operation—and the collaborative actions needed to address these gaps
• Detailed inspection and evaluation guidelines for susceptible areas of the reactor coolant system in pressurized water reactors
• Technical bases to inform decisions regarding the extended operation of PWRs
• Mitigation, repair, and replacement methodologies for aging degradation mechanisms
• Technical analyses and technological options for evaluating and managing in-service degradation
• Guidance and tools for fatigue-specific materials management in existing plants and design guidance for new plants to address environmentally assisted fatigue

Project: EPRI Low Carbon Resource Initiative

Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

The energy system is transforming rapidly in many parts of the world, driven by economic growth, changes in the relative costs of regional fuel supplies, growing deployment of wind and solar generation, advances in distributed resources and energy storage technologies, digitalization of supply, delivery and use, and increasing societal demands for energy that is clean and sustainable. Looking forward, economy-wide decarbonization is emerging as a key focus for nations, regions, cities, corporations and individuals. Economy-wide decarbonization, however, requires substantial technology advances, a refocusing of energy investment and a dramatic acceleration of the current pace of change.

Most countries and companies believe that they understand the fundamental technologies needed to achieve near-term carbon emission reductions. Energy efficiency, cleaner electricity, efficient electrification (e.g., switching from gasoline to electric passenger vehicles) are projected to play large roles for much of the economy, providing substantial emission reductions at affordable costs.1 Biomethane, advanced end-use technologies and efficiency provide near-term reduction opportunities for gas users. While large technology and implementation challenges remain, the basic technology direction seems clear.

However, two fundamental research questions remain where deeper reductions are required:

• How to decarbonize the hard/expensive-to-electrify end-uses that are projected to comprise as much as 40% of energy use after extensive electrification efforts?

• How to provide the reliable, resilient, safe, affordable very-low or net-zero emission electricity that powers the low-carbon economy?

The Electric Power Research Institute (EPRI) and the Gas Technology Institute (GTI) have created the Low Carbon Resource Initiative (LCRI) to help fill this gap by accelerating the development and demonstration of low-carbon energy technologies for large-scale deployment to 2030 and beyond to reduce long-term environmental consequences, benefitting society as a whole. This five-year initiative will provide a centralized, collaborative platform to identify and accelerate development of promising technologies from around the world, to demonstrate and assess the performance of selected key technologies and processes and identify possible improvements, and to inform key stakeholders and the public about technology pathways and options.

Research Value

Fundamental advances in a variety of low-carbon technologies and low-carbon chemical energy carriers (e.g., bioenergy, hydrogen, biomethane) can help create viable pathways to economy-wide decarbonization, providing a variety of specific benefits to the public and to businesses:

• Energy carriers to help decarbonize hard-to-electrify end-uses (e.g., heavy-duty transportation, industrial processes, building heating in colder weather)

• A low-carbon option to balance electricity supply-and-demand across time and location (e.g., seasonal storage of renewable energy to enable greater renewable deployment)

• A clean fuel for both utility-scale and distributed power generation

• A valuable co-product or new demand (e.g., hydrogen production via electrolysis) for low-carbon electricity generation

• New energy pathways that complement both electricity and natural gas to help increase the economic efficiency and resiliency of the energy system as it becomes more integrated.

Project: EPRI Toxics Release Inventory for Power Plants User's Group

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

To cost-effectively comply with Toxics Release Inventory (TRI) reporting requirements, power producers need tools to accurately estimate releases from fossil-fired plants and streamline the reporting process. Determining reporting responsibilities and developing credible estimates of release quantities present considerable technical challenges—and can consume significant personnel resources.

Power plants that burn coal or oil, or that burn natural gas at the same facility as a coal or oil-fired plant, must report annual emissions to the U.S. Environmental Protection Agency (EPA). TRI reporting requirements cover 595 individual chemicals and 34 chemical categories. A TRI report must be filed if estimated annual mass releases to land, air, and water from an individual facility exceed specified threshold values for one or more of the chemicals or categories. EPA frequently changes reporting requirements and also changes the forms and electronic data transfer procedures for reporting chemical releases.

EPRI has developed a software tool, TRI for Power Plants, to assist power plant owners in TRI reporting. The software is kept up to date with EPA requirements, incorporates results of EPRI

research and provides a vehicle for developing and applying new information on power plant toxics manufacturing, release, and distribution to land, air, and water.

Research Value

TRI for Power Plants software is a tool by which EPRI's new and evolving research into power plant emissions, including EPRI's updated emission factors, may be applied to TRI reporting and other emissions estimation tasks. The tool is revised to reflect current research, such as recently updated EPRI emission factors.

Project: EPRI Coal Ash Toxicity

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Coal ash is and will continue to be a newsworthy topic as utility groundwater monitoring data are published per the CCR Rule on public-facing websites, corrective action plans are developed, and power companies make decisions concerning remediation and whether to close facilities, especially ash ponds, in place or to close by removal. The word "toxic" is sometimes used as a modifier to "coal ash" in non-technical publications. While coal ash does contain elements that have defined toxicity values, the impact of those elements on human health and the environment is complex and belies simplistic classification. Research on toxicity and exposure will help build a more comprehensive understanding.

Risk to human health requires exposure as well as toxicity. This project will provide research on the potential toxicity and risk of coal ash to human health, and issue communication briefs to effectively inform stakeholders on toxicity and risk concepts as they relate to coal ash and coal ash management in landfills and impoundments.

Research Value

This research potentially can help inform utilities and the public on the potential toxicity and risks associated with coal ash. It will provide technical information as well as communication briefs to clearly and objectively assess and explain risk, toxicity, and exposure concepts.

Project: EPRI Environmental Data Management and Reporting

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Utility environmental managers face an ever-expanding number of monitoring and compliance requirements. Management of these requirements is challenging due to the large quantities of data produced and the diverse objectives for which monitoring data are collected. Types of data that require management may include groundwater quality, surface water quality, soil composition, and waste characteristics. This project is intended to assist participants in meeting new monitoring requirements, managing data, and developing compliance strategies consistent with newly evolving regulations such as the CCR Rule published in 2015.

In 2018, the capability to use MANAGES software for statistical analysis required under Resource Conservation and Recovery Act ("RCRA") monitoring programs, including the CCR Rule, was enhanced. Version 4.0 also includes functionality to export effluent discharge data to

create electronic Daily Monitoring Reports required by state agencies for monthly National Pollutant Discharge Elimination System ("NPDES") wastewater discharge reporting. EPRI plans to respond to user comments to add new data management and reporting features to the MANAGES software.
MANAGES software may benefit the public by providing better surface and groundwater data assessment, which may result in improved environmental performance of existing and new facilities. Regulatory agencies may benefit through more accurate electronic data submission of effluent discharge (NPDES) data from permitted facilities.

Research Value

The following deliverables are intended under this project:
• Annual workshop—Participants may provide input to workshop content.
• Webcast training as needed.
• MANAGES software upgrades to enhance the program, as prioritized by participants in this application.
• Online and phone user support.
• MANAGES customization (may require additional funding, depending on the level of customization).
The non-proprietary results of this work will be incorporated into EPRI R&D program 49 Coal Combustion Products –Environmental Issues, and made available to the public, for purchase or otherwise.

Project: EPRI Battery Energy Storage Fire Prevention and Mitigation

Start Date: May 2020
End Date: February 2021, complete, successful, conducted by EPRI

Project Description

As lithium ion battery storage costs decline and renewable energy deployments increase, the importance of energy storage to the electric power enterprise continues to grow. The rapid evolution of this technology has imposed intense pressure on developers to deploy quickly and reduce costs, leaving codes and standards to play catchup. The combination of limited experience, immature codes and standards, and inadequate scientific data has produced significant uncertainty in defining leading practices, particularly in the handling of battery fire hazards. Future deployment of battery systems is likely to be hindered by the absence of clear guidelines for effective mitigation of fire risk.
Objective data on battery storage fire behavior and mitigation approaches may require resource-intensive testing – potentially destruction – of costly equipment. Broad collaboration can help to maximize the value of this research, avoid duplicative work, and bolster new designs and procedures.
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.

New learnings from this project should include, but are not limited to, answers to the following questions:
• What threats may lead to fire safety hazards?
• How may fire safety threats be avoided or mitigated?
• How may barriers and suppression systems reduce the propagation of thermal runaway conditions?
• What other mitigations may be employed to reduce consequences of large-scale fire?
• How might mitigation and response efforts impact the efficacy from a systems perspective?
• What gaps are present in available data and analysis to support informed safety codes, standards, and responses to fire hazard?

Research Value

This project is expected to provide necessary information to support owners, operators, and developers of energy storage to proactively design, build, operate, and maintain these systems in such a way as to minimize the risk of fire. The investigations will identify, assess, and address battery storage fire safety issues to aid in avoidance of safety incidents and loss of property. This effort is expected to address a major challenge to the widespread deployment of energy storage, which may increase system reliability, increase penetration of renewable energy, and may ultimately reduce the potential for future rate increases.
Funder benefits may include improved understanding of risks with energy storage assets to support development of internal safety guidelines, project design specifications, and education of various stakeholders who may interact with these systems.

Project: EPRI Alarm Management and HMI

Start Date: March 2019
End Date: December 2019, complete, successful, conducted by EPRI

Project Description

To learn about current Transmission Control Center (TCC) alarm management and Human Machine Interface (HMI) practices, recent EPRI research has included workshops, surveys, TCC visits and case studies. Based on this background research, a set of observations and a list of opportunities to improve the current alarm management practices and operator HMIs in TCCs have been identified.
This project seeks to explore some of those improvement opportunities identified in the EPRI base research and case studies and apply them to the real-time alarm management and HMI systems of Ameren's TCC. Specific objectives include baselining and segregation of alarm types, the development of an alarm management philosophy, baselining Ameren's TCC HMI display design and development of a HMI philosophy and Style Guide as described in the Tasks section below.

Research Value

The new learning from this supplemental project is expected to include:
•Identification of specific areas of improvement for the alarm management system for Ameren through alarm system baselining, alarm segregation and HMI baselining.

•Better documentation and processes for management of alarms and HMI; and upgraded methods and ideas for how alarm and power system data is displayed and presented to TCC operators.
•Improved TCC operator and operations staff efficiency and improved operator situational awareness, resulting in improved power system reliability.
•Auditable, industry standard documentation and processes for managing alarms and HMI in Ameren's TCC.
•Understanding of the alarm management system performance and HMI design for future improvement needs.
In addition to developing its own body of knowledge on TCC alarm management and HMI practices, EPRI expects the results and implementation of this research to bring more reliable system operation to other members and untimely to end users of electricity.

Project: EPRI Efficient Electrification: State & Utility Assessment for Missouri
Start Date: May 2019
End Date: November 2020, complete, successful, conducted by EPRI
Project Description
The Electric Power Research Institute (EPRI) has underway an Efficient Electrification research initiative to help the electric power sector and related stakeholders identify cost-effective and resilient strategies to produce and use clean energy. This 2-year scope lays out research to address what cost-effective strategies members can implement to realize a greater potential for efficient electrification in their operating state(s).
The research conducted as part of this project will be completed in four tasks over the course of 24 months. The first three tasks: Energy System Assessment, Environmental Assessment, and High-level Transmission Assessment have a geographic scope at the state level and will take 6 to 18 months to complete. The fourth task, Electrification Potential and Implementation Plan, is a utility, service territory-level assessment for relevant participants which starts six months into the project. Additional details for each task are described below.
Research Value
Economic and environmental factors will increasingly reward and drive the application of electric technologies to boost energy efficiency and grid flexibility, increase productivity, and improve product quality while supporting emissions reduction, water savings and safety. Keys to understanding the impact of efficient electrification include analyzing how a state's energy system could evolve over time under various policies; a comprehensive customer and societal assessment of electrification technologies; and developing and gaining stakeholders' acceptance. The results of this project, covering electrification options, energy system analysis, and environmental benefits analysis, supports future efforts by EPRI in its research portfolio across various programs in the areas of Energy Utilization and Energy and Environmental Analysis groups.

Project: EPRI Energy Storage Analysis Finding, Designing, and Operating Projects
Start Date: August 2018
End Date: December 2020, complete, successful, conducted by EPRI

Project Description

This supplemental research project is designed to seek effective and efficient methods to perform the necessary economic dispatch optimization of storage and other distributed energy resources (DER), as well as the required time-series analyses to assess the full integration impacts to the grid.

Wherever possible, EPRI intends to leverage previously developed and validated methods to address this goal. EPRI's Integrated Grid Benefit-Cost Framework is intended to be used as a foundational methodology for conducting economic analyses.

This proposed integrated simulation approach may enable locational value and hosting capacity analyses to be integrated with evaluation of the energy storage economics and the customer level economics to fully capture the entirety of a system's value from both financial and societal perspectives.

Research Value

The goals of this supplemental research project are to advance distribution capacity planning and locational net benefit methods to consider energy storage as one element of a DER portfolio. This includes the following high-level objectives:

• Demonstrate energy storage screening approaches to identify, define, and quantify the value of services that energy storage systems can provide in specific locations and applications

• Demonstrate application of energy storage hosting and accommodation analysis to ensure that different deployment scenarios do not cause violations to power quality and reliability criteria

• Demonstrate analysis of energy storage system requirements (including sizing, location, control modes) to adequately address distribution needs within any identified operational constraints

• Demonstrate how advanced power flow modeling tools can be used to quantify DER accommodation capacity at specific locations on a utility distribution system

• Demonstrate how advanced optimization and simulation tools can be used to evaluate energy storage research questions related to sizing, locating, and usage of advanced energy storage services

• Demonstrate how integrating these tools in a single approach can provide integrated decision support for optimal storage sizing and location portfolio

The end result of this approach is expected to be higher resolution into the modeling and analysis of sizing, placement, and operating characteristics of energy storage systems, which may result in more efficient planning and operation of the electric power system, with the ultimate goal of greater grid reliability and flexibility and potential reductions in cost.

Project: EPRI Energy Sustainability Benchmarking for Electric Utilities

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Companies across many industries are increasingly working to understand how their sustainability performance compares to peers. There are a growing number of third-party reporting "standards" which companies can follow and an equal number of private consultants offering benchmarking services. Under all of these approaches, specific metrics are used to communicate with stakeholders, predict future performance, and compare to peers. It is

important under any benchmarking effort to use metrics that properly compare information that was collected using similar methods.
The plethora of metrics in use in the electric power industry has created a heavy burden of reporting. This burden translates into business and customer cost, and may create an unintended hurdle in being sustainable.
The project utilizes an online benchmarking platform. The benchmarking platform will contain a set of sustainability metrics identified as most relevant to the industry by EPRI in collaboration with EPRI's Energy Sustainability Interest Group. The database allows users to benchmark their sustainability performance data against other companies who also participate in this project. This benchmarking platform intends to provide a foundation for businesses success by understanding how companies compare to peers and managing overall performance. Such understanding can assist companies in being more sustainable, which may benefit the public, ecosystems, and companies.
The database has the capability to run annual comparisons, trend analysis, metric-by-metric summaries, filter results to compare to companies with similar characteristics, and many other analyses, all in one platform.

Research Value

EPRI intends to publish a report utilizing collaborative input from project funders. The report, if published, will be freely available to the public and will not disclose data identifying project funders.
• EPRI will consider instituting a formalized data sign-off process, informed by learnings from year four of the sign-off pilot.
• It is possible that additional "Method of Data Preparation" categories will be added to better understand the quality of data associated with each benchmarking submission, allowing users to more carefully assess if appropriate comparisons are being made between companies.
• Version 6.0 of the On-line database will be released and utilized.

Project: EPRI Energy Sustainability Interest Group

Start Date: December 2018
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

Growing attention to corporate transparency, disclosure, and opportunities to improve sustainability performance are driving investment and research. Financial markets are increasingly using environmental and social measures as factors in valuing a company. International efforts such as the Global Reporting Initiative (GRI), Dow Jones Sustainability Indexes, and CDP (formerly Carbon Disclosure Project) have encouraged transparency on sustainability-based issues.
Electric power companies face unique challenges and tradeoffs. They are expected to manage financial, environmental and social performance, while providing safe, clean, reliable and affordable power. However, power companies may not be fully realizing the opportunity to optimize company decisions, inform public and stakeholder priorities, and inform future sustainability initiatives. Electric power companies can achieve enduring growth, superior long-

term financial performance, and improved risk management by thoughtfully addressing sustainability issues.

Research Value

The Energy Sustainability Interest Group was launched in 2008 and consistently has over 40 members with combined assets of over $1 trillion. The group collaborates regularly through regular webcasts, in-person workshops, and participation in working groups that provide guidance on technical projects. In addition to offering venues for collaboration, the webcasts and workshops have hosted guest speakers from environmental groups, other industries, federal and state agencies, among many others.

The interest group's continuing purpose is to create business value while driving innovation and collaboration. The group will continue advancing several technical projects, including the development of a Maturity Model that identifies categories of sustainability that companies can apply to self-assess sustainability maturity level, relevant research to identify industry and stakeholder sustainability priority issues, research on metrics most relevant for the industry, and work to better understand the frequency, trends, and value of sustainability reporting for the electric power industry.

Project: EPRI Generation Advanced NDE Development

Start Date: Prior to 1 January 2019

End Date: TBD – Current Engagement, conducted by EPRI

Project Description

EPRI's Generation Advanced NDE Development program uses international collaboration to develop technology on, and gather research for, safe management of power plant component life to promote high reliability and reduce Operations and Maintenance (O&M) costs for components that are not being addressed (or for NDE technologies that are not being addressed) by the component-based programs within EPRI. Efforts focus on advanced NDE techniques for early and accurate identification of component damage; analytical tools to help identify remaining life and risk of in-service failure; and decision-support tools to help balance risk and benefit under a variety of operating scenarios.

This program develops and identifies new technology, tools, and application support to maximize safety and reliability of power plant components and to determine optimal timing for repair or replacement. This program also seeks to help develop reliable and cost-effective NDE techniques to reduce O&M costs and improve life management options. NDE developments in other industries will also be evaluated for application to fossil plants.

Research Value

Maximizing safety and reliability of power plant components and determining optimal timing for repair or replacement require accurate and timely detection of service-generated damage. New technologies for NDE can lead to faster examination of power plant components at a lower cost, resulting in shorter outages and thus maximizing benefits to the public. This supplemental program furthers the technology, tools, and application support regarding NDE development via R&D, applications, workshops, and training for the benefit of the public.

Project: EPRI Groundwater Resource Center

Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

The EPRI Groundwater Resource Center (GWRC) is a cross-program and cross-sector initiative established to coordinate, leverage, and disseminate information and research on the broad range of groundwater issues faced by the utility industry. It serves as a focal point for collective industry knowledge, and provide tools for the characterization, management, and remediation of groundwater resources. The GWRC offers a central location for linking all EPRI groundwater-related research in an easily accessible format, and facilitates productive interaction with external organizations actively involved in groundwater technical issues, such as the United States Geological Survey, university consortia, trade groups, and industry partners. It is also a platform to launch collaborative research addressing groundwater issues and needs that are common across several programs.

Research Value

Results from this project provide new environmental and engineering information and technologies for monitoring, investigating, and remediating groundwater across multiple programs and sectors at EPRI. The public benefits by the reduced environmental risk associated with groundwater releases, and improved management of groundwater resources.

Project: EPRI Industrial Center for Excellence

Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

EPRI's Industrial Center of Excellence (the "ICoE") was established to encourage specific energy and technology related developments. Using EPRI, utility, and industry subject matter expertise, the ICoE supports knowledge transfer; applications; and seeks to identify opportunities for demonstrations and commercialization of advanced efficient electric technologies and utilization methods. The ICoE supports funders and their customers through laboratory and field testing, site assessments for energy efficiency and electrification opportunities, training, education and outreach.

Advanced efficient electric technologies and environmental controls for industrial applications bring about a unique opportunity for electric service providers to improve the overall energy utilization of customer processes and reduce overall production costs. Rejuvenated industry emphasis on energy efficiency and CO2 emissions reduction, coupled with substantial improvement in reliability and efficiency of power electronic component technology, suggests that the timing has been appropriate for EPRI to form a collaborative ICoE.

Research Value

New learning from this project aims to include improved understanding of the needs of industry, as well as insights on new technologies and processes available to meet these needs. All new learning from this research is expected to be published and made available to the public and may provide public benefits through increased energy utilization opportunities.

Project: EPRI Pole RF Sensors for Distribution Poles

Start Date: Prior to 1 January 2019
End Date: December 2019, complete, successful, conducted by EPRI

Project Description

The demonstration utilized the existing EPRI RF downed pole sensor to record measurements that could be used for the purposes of determining the health of a distribution pole. The data captured from the EPRI RF downed pole sensors includes measurements of the pole inclination and 3 axis accelerations. The downed pole sensors were modified to retrieve raw acceleration data from either measured vibrations or during weather events. Data from other sources such as a weather station were collected for analysis along with the pole sensor data. For the demonstration, the EPRI RF sensors attached on to the pole using a lag bolt, a pole band, or magnets. The sensors were placed on wooden poles in one location at an Ameren location. During the demonstration planning several factors were considered in choosing how to construct the test setup.

Using the sensor data, pole information and weather data it is hoped that a pole assessment sensor can be developed. The data analysis will be done offline using data from all data sources during the demonstration project. For this technology demonstration, the data from the sensors and base station (weather data) will be transmitted back to and stored on the EPRI servers in Charlotte, NC. The data will be available for visualization and analysis by both EPRI and Ameren staff via a web portal and email alarms can be generated.

Research Value

The outcome of this demonstration seeks to provide an understanding of how to optimize and develop a bespoke RF sensor and detection algorithms specifically for the pole health monitoring application. The development of a method for the inspection of wood poles using an RF sensor could provide several benefits to utilities and the general public. They include:

• Reduction in O&M dollars spent for pole inspection
• A method to monitor wood poles on a more frequent basis than rounds inspections currently allow
• Ability to detect a downed pole during a major event with the ability to perform rapid damage assessment over a wide area to allow for faster service restoration.

Project: EPRI MMVT - Modeling and Model Validation Tools User Group

Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

In March 2014, the U.S. Federal Regulator Commission (FERC) approved standards developed by the North American Electric Reliability Corporation (NERC) that require all generating facilities in North America to perform model validation. In May 2014, FERC approved the future application of two NERC standards for modeling and model validation for the steady-state and dynamic computer simulation models of the entire power system. Inherent in this latter requirement is the need to perform model validation for all other major active power system components such as for example static var compensators (SVCs). Also, transmission planning standard TPL-001-4 was revised by NERC, and approved by FERC in November 2014, requires

that transmission authorities and system operators model the dynamic behavior of loads in their planning studies.
For many years, EPRI has been performing R&D related to all these aspects of modeling, model development and model validation. Most notably, after several years of R&D, EPRI developed in 2009 the Power Plant Parameter Derivation (PPPD) software tool. PPPD provides a semi-automated platform for deriving and validating power plant models using either staged field test data or recorded on-line disturbance data. This tool has been supported since 2010 by an active user group that included more than twenty power authorities including utilities, independent system operators, and independent power producers. Many of these user group members have successfully applied the tool and methodology to collectively validate the models of over one hundred generating units. The approach when applied using disturbance monitoring, can help achieve model validation in a fraction of the time and expense of other traditional methods. Furthermore since 2016, the PPPD tool incorporates the latest generic models for Static Var Systems (i.e. SVC and STATCOM) and renewable energy systems (i.e. type 3 and 4 wind turbine and PV inverters) that can be validated.
In addition, EPRI has developed the Load Model Data Processing and Parameter Derivation (LMDPPD) Tool and the Load Composition Data Tool (LCDT). LMDPPD can be utilized to derive composite load model structure parameters based on measured response of distribution feeders to voltage disturbances. LCDT pulls information from various public sources and data provided on load demographics by a utility to create composite load model records for use in planning studies. For all these tools, the output text file from the tool can be read into the two major commercial software platforms for power system simulations used in North America (i.e. GE PSLFTM and Siemens PTI PSS®E).

Research Value

The new learnings are as follows:
1. Learning to use tools and techniques for model validation of generation and transmission equipment which supports system reliability
2. Support for using such tools and learning in general about the process of modeling and model validation from EPRI and other peers / members of the user group
3. Learning to use tools for determining load composition for developing composite dynamic load models for transmission planning
4. Learning how to accomplish both power system component level (i.e. validating the models for power plants, renewable energy resource models, SVCs, STATCOMs, etc.) and system wide model validation through the application of EPRI develop software technologies.
5. Through the application of these methods and technologies for model validation, learning how the methods and software tools can be improved and made more efficient and effective.
6. Learning how to perform model validation of renewable energy power plant (wind and PV) through the use of disturbance monitoring.
7. Learning how to better model loads in system studies by developing aggregate, composite load models with dynamics represented.

Project: EPRI E1 Electromagnetic Pulse Hardening of Substations: Design and Implementation Support

Start Date: April 2019
End Date: October 2020, complete, successful, conducted by EPRI

Project Description

Numerous studies by the U.S. government and others have examined the potential impact of high-altitude electromagnetic pulse (HEMP) on the electric grid. Despite many years of research, there are still outstanding questions regarding the effects of a HEMP attack on the bulk power system.

In April 2016, EPRI initiated a large-scale research project to: 1) investigate the potential impacts of HEMP on the bulk power system; and 2) develop/identify cost-effective mitigation options that can be deployed in existing and future substations. Through this research, the potential impacts of HEMP (E1) have been assessed and a number of mitigation options have been identified and/or tested; including some that may yield promising solutions.

Because of the risk of unintended consequences with implementing E1 mitigation in a substation environment, additional testing and analysis is required before actionable information (performance requirements and installation details) can be widely provided to EMP project members. Field evaluation of these mitigation technologies/approaches is of paramount importance.

Evaluating equipment deployed in the field provides a unique opportunity for new learning, such as:

• Identifying potential unintended consequences and associated engineering solutions.
• Identifying/developing maintenance processes and procedures.
• Providing realistic cost data to inform future decision making.

Research Value

This project can potentially provide the following benefits:

• Increase understanding of how to mitigate potential HEMP impacts on transmission components.
• Increase understanding of the system impact in the case of an HEMP event
• Develop knowledge that may be utilized to improve

Project: EPRI Incubatenergy

Start Date: May 2019
End Date: TBD – Current Engagement, conducted by EPRI

Project Description

This project covers the innovation challenge platform and process by which EPRI links member innovation teams with the innovation startup ecosystem (including but not limited to Incubatenergy participating entities), as well as organizing specific proof of concept assessments and the sharing of individual demonstration results and engagement best practices. This project facilitates the identification of challenge areas, engagement with the startups delivering solutions in those areas, and assessment of their technologies. Specific demonstration projects that are beyond laboratory and proof of concept assessments will be organized and funded separate from this project. Results from demonstration projects that are organized as a result of coordination in this project will also be tracked so that relevant results can be shared with all members.

Research Value

The project provides an innovation challenge platform to connect participating utilities with innovators from around the world that are focused on developing solutions in targeted, high-value innovation areas for next generation integrated grid, efficiency, energy management and electrification technologies. By leveraging an open innovation approach, utilities get the benefit of engaging peer innovation teams, leveraging peer resources and sharing in the best practices and demonstration results achieved. Startups gain the benefit of engaging multiple utilities through the same process and having assessment and demonstration results shared across multiple utilities. This open and collaborative process to innovation sourcing lowers the cost of participation, the time to deployment for new innovations, and industry risk in deploying these innovations.

Project: Hexalayer Graphene Cells
Start Date: June 2019
End Date: TBD – Current Engagement, conducted by Hexalayer, LLC.
Project Description
This project facilitates the identification of challenge areas and engagement with the startup, Hexalayer, LLC as part of a follow-on project under the Ameren Accelerator. This project delivers solutions in the area of increasing battery storage density and the testing of battery cells incorporating graphene nanotechnology aimed at increasing the energy density of lithium-ion batteries.
Research Value
This project leverages nanotechnology developed by Hexalayer, LLC and works to move the technology from proof of concept to the testing of battery cells utilizing Hexalayer's graphene-based battery technology. Hexalayer's technology works to increase the energy density of lithium-ion batteries. Increased energy storage is viewed as an important aspect of increasing the electrification of vehicles and decreasing carbon dioxide emissions.

Project: Missouri University of Science & Technology Power Program
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by the Missouri University of Science and Technology
Project Description
The MO S&T Power Program completes basic research on problems facing the electric power industry including robotics, battery technology, load monitoring, electric vehicle impacts on load, solid state transformers, power electronic converters, extreme fast charging, and fly ash-based concrete.

Project: Missouri University of Science & Technology Microgrid Consortium
Start Date: Prior to 1 January 2019
End Date: December 2020, complete, successful, conducted by the Missouri University of Science and Technology
Project Description

The MO S&T Microgrid Consortium Center conducts research, performs technology evaluation, provides the academic and industrial community with enhanced education capability and facilitates information exchange and technology transfer related to the design, construction and operation of "Microgrids".

Project: University of Missouri -Columbia Student Training in Engineering Problem Solving (STEPS)
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by the University of Missouri – Columbia
Project Description
The UM-Columbia Student Training in Engineering Problem Solving (STEPS) completes basic research on problems facing the electric power industry including load monitoring, nuclear safety, electric vehicle adoption, impacts of ridesharing, transmission bus design, and other industry related topics.

Project: University of Missouri - Columbia Power Electronics Research Center (PERC)
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by the University of Missouri – Columbia
Project Description
The UM-Columbia Power Electronics Research Center (PERC) completes basic research on problems facing the electric power industry including high power electronic devices and new dielectrics for energy storage that utilizes nanotechnology.

Project: NEETRAC Membership (Nat'l Electric Energy Testing Research & Apps Center)
Start Date: Prior to 1 January 2019
End Date: TBD – Current Engagement, conducted by Georgia Tech
Project Description
NEETRAC is a self-supporting, membership based center within the School of Electrical and Computer Engineering at Georgia Tech. NEETRAC's goal is to help the electric utility industry solve the everyday problems associated with the complex task of transmitting and distributing electric energy reliably and efficiently. NEETRAC staff and facilities combine with the significant technological resources of Georgia Tech to provide a wide array of analytical, engineering, research and testing services on both collaborative and proprietary projects.

See attached for R&D cost information.

R&D Program/Project Budget Worksheet

	Enter data/information in yellow cells.	Blue cells are calculated values. Do not modify.
1) Title:	Substation Equipment Asset Management Analytics Tools (P34.001 & P34.002)	
2) Brief Description:	To assist in the development of Asset Models to be utilized with ABB Ellipse APM software	
3) Advisor:		
4) Approving Director:		

5) Value created based on reduced cost, reduced revenue requirements, increased sales, etc.:

5a) Deliverables:	5b) Value
Reduce capital and maintenance cost through analytical based asset management	$ 500,000
Improve service availability and reduce outage time through condition based monitoring of substation equipment.	$ -
	$ -
	$ -
	$ -
	$ -
	$ -

6) Value created based on cost to do work in-house, hire a contractor, or purchase alternative product:

6a) Deliverables:	6b) Hours required to do in-house or by contractor	6c) Cost per hour	6d) Value Calculated as Alternative Cost
Substation Maintenance Engineer to develop program to manage asset	1500		$ 300,000
			$ -
			$ -
			$ -
			$ -
			$ -
6e) Total equivalent benefit from Program			**$ 800,000**

7) Intangible or qualitative benefits:

Project results may help reduce capital costs and maintenance through the application of analytics-based approaches for substation asset management. Results may also help improve service availability and reduce unplanned outages and improving customer satisfaction.

8) Link to capital project (can this work be tied to one or more capital projects?):

8a) Captial Project Name, Description, or WO #	8b) Capital Project Budget Owner or Project Manager	8c) Will the captial project begin or end next year?
		☐ Yes ☐ No

9) Is this project part of a risk mitigation strategy in the BRM System? If so, which risk? If not, should it be?

9a) In BRM? If so, give BRM No.		9b) If not in BRM System, should it be?	

10) Annual cost of Program	$ 53,635
11) Net Value	**$ 746,365**

12) O&M Accounting Information

12a) Is this project for electric or gas?	☑ Electric ☐ Gas	20b) Which business divisions benefit from this project?	☐ AIC Trans. (ZT) ☐ AIC Distr. (BD ZA) ☐ AIC Gas (ZA) ☑ UEC Trans. (20) ☑ UEC Distr. (20) ☐ UEC Gen/Env (5A) ☐ UEC Nuclear (65) ☐ UEC Gas (89) ☐ ATX Transmission Company (TX)

Instructions for R&D Budget Worksheet

Use this worksheet to request R&D projects, programs, or other services. This form should be used whether payment is made by cash or using credits provided by the research organization (e.g. Self-Directed Funds). This worksheet is provided to assist Requestors in analyzing the value of programs or projects to Ameren. It is intended to be a useful tool in communicating the need for each project to Corporate Planning, the approving Director, and to senior management as they establish appropriate investment levels for R&D. Below are step-by-step instructions for completing and submitting this form.

IMPORTANT NOTE: Yellow cells indicate unprotected cells where information or data can be entered. Blue cells are protected cells with calculated values and should not be changed.

1) Fill in the title.
2) Fill in a brief description.
3) Indicate who will be the Ameren Advisor for the project/program. This is the Ameren employee who will provide technical direction to the research organization.
4) Indicate who will be the Approving Director. This is normally an operating company employee, not R&D.

Determine how you will be calculating the value of the project/program. You can estimate value created based on:

- the direct value of the deliverables to Ameren, **or**
- the estimated cost if the deliverable were obtained through other means,
- a combination of both.

Fill in the deliverables in the appropriate sections. If you are valuing deliverables based on reduced cost and/or reduced revenue requirement, enter those deliverables in Section 5. If you are valuing the deliverable based on cost to do the work in-house or through a contractor, enter those deliverables in Section 6.

5a) Fill in a description of each deliverable that you are valuing based on reduced cost and/or reduced revenue requirements.
5b) Enter the estimated value of each corresponding deliverable.
6a) Fill in a description of each deliverable that you are valuing based on the cost to do the work in-house or through a contractor.
6b) Estimate the hours required to do the work for each deliverable
6c) Estimate the cost per hour for each deliverable. Typical values to use for labor rates are $105/hr in-house and $220/hr for contractors. If you know the actual labor rate, you should use the actual rate.
6d) The spreadsheet will calculate the value for each deliverable in Section 6.
6e) The spreadsheet will total up the value of all deliverables in both Section 5 and Section 6.

For EPRI Programs, a list of deliverables is provided each year during the Portfolio Rollout. This can be found on EPRI.com, or your Manager of EPRI Technology Transfer (METT) can help you obtain the list.

7) If there are additional benefits of the project besides monetary value (e.g. safety, environment, government reporting, customer perception) they should be listed under "Intangible or qualitative benefits".
8) If the project can be tied to a capital project, list any linkage to company capital projects in the space indicated.
8a) Fill in Capital Project name, Description, or WO # if known.
8b) Fill in the owner of the captial project budget (this is often, but not always a driector) or the project manager's name.
8c) Fill in whether or not the capital project will begin next year (Note: this helps schedule invoicing timing if applicable).
9) Indicate whether the project is part of a risk mitigation strategy in the Business Risk Management System? If so, provide BRM Number. If not, consider whether it should be, and if so, notify Enterprise Risk Management.
10) Enter the annual cost of program participation.
11) The spreadsheet will calculate the value of the program over the commitment period. Note that this calculation excludes travel and labor expenses.
12) Provide O&M accounting information. Check all boxes that apply. If you are funding the project with capital funds then skip number 12.
13) Indicate whether or not the project will require data to be sent to EPRI. Important note: Confidential data must be labeled "Confidential" prior to being sent to EPRI. EPRI does not treat data as confidential unless it is labeled "Confidential". Data sent to EPRI is treated as public data unless it is marked "Confidential". Note: projects requiring protected or restricted data to be sent to EPRI will require Data Governance and Ameren Corporate Counsel approval prior to project approval or start of project.

After completeing the worksheet, the Advisor should forward it to the Approving Director for review and approval.
The Approving Director can approve electronically, attach to an e-mail and send to jwibbenmeyer@ameren.com with text saying "Approved".
Approval of this form does not mean that the program or project will necessarily be purchased. Actual Implementation is subject to availability of funds and prioritization of need.

Ameren Missouri's
Response to MPSC Data Request - MPSC
ER-2021-0240
In the Matter of Union Electric Company d/b/a Ameren Missouri's Tariffs to Adjust Its Revenues for Electric Service

No.: MPSC 0153.1

Please refer to the response to Staff Data Request No. 153. Please provide a cost benefit quantification for each of the projects included in the response. If no cost benefit analysis was performed, please explain why no cost benefit analysis exists and how Ameren Missouri determines that the benefits of the projects outweigh the costs. Requested by Jason Kunst (Jason.Kunst@psc.mo.gov)

RESPONSE

Prepared By: Jason Wibbenmeyer
Title: Technology Transfer Manager
Date: 06/07/2021

Ameren's Value Analysis calculation results in a net value dollar amount that can be used to justify a research program as well as for comparison purposes across multiple research initiatives. The net value amounts calculated for each of the research program are listed below.

Project: EPRI Program 1 - Power Quality, Net Value = $334,092
Project: EPRI Program 195 - Endangered and Protected Species, Net Value = $488,440
Project: EPRI Program 51 - Transmission & Distribution: Environmental Issues, Net Value = $1,847,414
Project: EPRI Program 62 - Occupational Health and Safety, Net Value = $205,482
Project: EPRI Program 198 - Strategic Sustainability Science, Net Value = $71,794
Project: EPRI Program 34 - Transmission Asset Management Analytics, Net Value = $746,365
Project: EPRI Program 35 - Overhead Transmission, Net Value = $363,559
Project: EPRI Program 37 – Substations, Net Value = $20,020,000
Project: EPRI Program 40 - Transmission Planning, Net Value = $137,970
Project: EPRI Program 173 - Bulk Power System Integration of Variable Generation, Net Value = $15,829
Project: EPRI Program 174 - Integration of Distributed Energy Resources, Net Value = $456,239
Project: EPRI Program 180 - Distribution Systems, Net Value = $604,041
Project: EPRI Program 200 - Distribution Operations and Planning, Net Value = $386,305

Project: EPRI Program 207 – Solar, Net Value = $67,272
Projects: EPRI Program 219 - Steam Turbines and Auxiliary Systems & **EPRI Program 220 - Generators and Auxiliary Systems**, Net Value = $805,044
Project: EPRI Program 222 - Advanced Generation & Carbon Capture and Storage, Net Value = $323,000
Project: EPRI Program 223 - Heat Rate and Flexibility: Generation Fleet Optimization, Net Value = $1,937,272
Project: EPRI Program 214 - Boiler Life and Availability Improvement, Net Value = $2,948,000
Project: EPRI Program 215 - Power Plant Piping, Net Value = $1,400,000
Project: EPRI Program 226 - Boiler and Turbine Steam and Cycle Chemistry, Net Value = $751,047
Project: EPRI Program 239 - Aquatic Resource Protection, Net Value = $882,272
Project: EPRI Program 241 - Coal Combustion Products Management, Net Value = $367,272
Project: EPRI Program 242 - Coal Combustion Products, Land and Groundwater Management, Net Value = $337,272
Project: EPRI Program 233 - Continuous Emissions Monitoring and Measurements, Net Value = $792,418
Project: EPRI Program 201 – Energy, Environmental, and Climate Policy Analysis, Net Value = $231,986
Project: EPRI Program 18 - Electric Transportation, Net Value = $133,783
Project: EPRI Program 94 - Energy Storage and Distributed Generation, Net Value = 149,813
Project: EPRI Program 182 - Understanding Electric Utility Customers, Net Value = $603,600
Project: EPRI Program 199 - Electrification for Customer Productivity, Net Value = $251,085
Project: EPRI Groundwater Resource Center, Net Value = $380,000
Project: EPRI Industrial Center for Excellence, Net Value = $94,000
Project: EPRI Coal Ash Toxicity, Net Value = $445,000
Project: EPRI Energy Sustainability Benchmarking for Electric Utilities, Net Value = $50,000
Project: EPRI Program 63 - Boiler Life and Availability Improvement, Net Value = $2,948,000

Due to the difficulty in estimating future benefits, Net Value calculations are not available on the projects listed below. The following projects were selected to be funded by Ameren Missouri due to anticipated qualitative benefits such as safety, environment, customer focus, security, reliability, and linkage to a company strategy, initiative, or goal. Ameren Missouri engineers follow and serve as advisors to the research performed under these projects.

Project: EPRI Program 161 - Information and Communication Technology
Project: EPRI Program 183 - Cyber Security for Power Delivery and Utilization

Project: EPRI Program 236 – Air Quality and Health
Project: EPRI Program 209 - Cyber Security for Generation Assets
Project: EPRI Program 235 - Air Quality Assessments and Multimedia Characterization
Project: EPRI Program 41 - Nuclear Power
Project: EPRI Program 39 - Transmission Operations
Project: EPRI Program 206 - Wind
Project: EPRI Program 203 - Air Quality and Multimedia Characterization, Assessment and Health
Project: EPRI Program 77 - Continuous Emissions Monitoring
Project: EPRI Program 65 - Steam Turbines - Generators and Auxiliary Systems
Project: EPRI Project: EPRI Program 193 - Renewable Generation
Project: EPRI Program 49 - Coal Combustion Product Management
Project: EPRI Program 54 - Fish Protection
Project: EPRI Low Carbon Resource Initiative
Project: EPRI Toxics Release Inventory for Power Plants User's Group
Project: EPRI Environmental Data Management and Reporting
Project: EPRI Battery Energy Storage Fire Prevention and Mitigation
Project: EPRI Alarm Management and HMI
Project: EPRI Efficient Electrification: State & Utility Assessment for Missouri
Project: EPRI Energy Storage Analysis Finding, Designing, and Operating Projects
Project: EPRI Energy Sustainability Interest Group
Project: EPRI Generation Advanced NDE Development
Project: EPRI Pole RF Sensors for Distribution Poles
Project: EPRI MMVT - Modeling and Model Validation Tools User Group
Project: EPRI E1 Electromagnetic Pulse Hardening of Substations: Design and Implementation Support
Project: EPRI Incubatenergy
Project: Hexalayer Graphene Cells
Project: Missouri University of Science & Technology Power Program
Project: Missouri University of Science & Technology Microgrid Consortium
Project: University of Missouri -Columbia Student Training in Engineering Problem Solving (STEPS)
Project: University of Missouri - Columbia Power Electronics Research Center (PERC)
Project: NEETRAC Membership (Nat'l Electric Energy Testing Research & Apps Center)

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Union Electric Company d/b/a Ameren Missouri's Tariffs to Adjust Its Revenues for Electric Service.	)))	Case No. ER-2021-0240

AFFIDAVIT OF JASON WIBBENMEYER

STATE OF MISSOURI)
) ss
CITY OF ST. LOUIS)

Jason Wibbenmeyer, being first duly sworn on his oath, states:

My name is Jason Wibbenmeyer, and on his oath declare that he is of sound mind and lawful age; that he has prepared the foregoing *Rebuttal Testimony*; and further, under the penalty of perjury, that the same is true and correct to the best of my knowledge and belief.

Jason Wibbenmeyer

Sworn to me this 11th day of October, 2021.