Overview

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 significantly improve 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.
- Significantly 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.

Approach

The Power Quality research program is actively and continually informed by member input and industry knowledge to identify research priorities. EPRI research in power quality yields a variety of expertise, software, analysis tools, and knowledge, and can take several forms including:

- Using PQ data to proactively assess grid health and to detect incipient equipment failure and misoperation before expensive and disruptive outcomes occur.
- Adaptation and application of advanced data analytical techniques to extract valuable information from existing data streams, including Statistical Process Control (SPC) and automated waveform identification using AI and Machine Learning. Electric Power Research Institute
- PQ data validation and visualization tools that maximize the value of data stores while reducing maintenance costs.
- Laboratory assessment of the PQ contribution and compatibility of DERs, including renewables, energy storage, and smart inverters.
- Laboratory assessment of the effect of DERs on power quality and the impact this new PQ environment has on end-use loads • Laboratory and field assessment of PQ mitigation technologies and end-use device sensitivity to common PQ phenomena with a special emphasis on the PQ-rich environment created by increased grid complexity.
- Evaluation of innovative approaches to the measurement of higher-order harmonics for both transmission and distribution, including approaches to repurpose existing voltage- and current-measurement infrastructure.

Accomplishments

The Power Quality program has delivered valuable research over the years that has helped its members, the industry, and society:

- Proactive PQ: Utilities employing the use of PQ data for proactive detection of incipient equipment failure and misoperation have reported US$ millions in cost savings from avoided grid-connected equipment failures
- Getting Maximum Value from PQ Data Streams: Utilities employing EPRI-developed automated PQ waveform identification and PQ performance benchmarking have identified low-cost performance improvement opportunities that would have otherwise been missed.
- Coping with Increasing Grid Complexity: Utilities applying EPRI-developed IEEE 1547 compliance verification techniques have reported a reduction in performance issues with grid-connected DER installations.
- Improving Customer Service and Satisfaction: Utilities have identified a direct correlation between grid PQ performance and the level of satisfaction from end-use customers. A number of utilities have further identified new business opportunities, leveraging PQ expertise to create new revenue streams.
- EPRI created the best-in-class PQ Investigator software integrating $2M in end-use device testing and facility investigation results and expertise, allowing funders to conduct expert-level facility assessments.
- EPRI created the first of its kind Grid-IQ software platform for estimating future PQ performance levels based on changing loads, grid configurations, and operational practices, including an open-source-based grid model database to allow quick and low-cost analysis. Most prominent among these tools are the Harmonic Evaluation Module (HEM) and Flicker Evaluation Module (FEM), tools which allow an analysis of current conditions and modeling of future conditions based on changes in grid configurations and end-use loads.
- EPRI's laboratory testing of many end-use technologies has enabled the development of a detailed load model library for new and changing loads such as compact fluorescent lamps (CFLs), light-emitting diode (LED) traffic lights, hybrid electric vehicle chargers, and rooftop photovoltaics (PVs).
- EPRI created the PQ Dashboard, a low-cost, easy-to-deploy open-source platform for visualization of PQ and other data and integration with other data resources, including Geographic Information System (GIS) information.
- Many of EPRI's past research developments have been implemented over time into PQView®, a multicomponent software system for building and analyzing databases of power quality and energy measurements that is jointly owned by EPRI and Electrotek Concepts.
- The Power Quality Online Resource Center, deployed on MyPQ.epri.com, is a member-focused website featuring more than 1,800 EPRI-authored PQ case studies, technology briefs, and other authoritative documents available from no other source.

Current Year Activities

In the coming year, this research program expects to accomplish these objectives:

- Develop readily deployable data analysis modules using PQ data for the near-time assessment of the health and detection of incipient failure for common grid-connected equipment.
- Automation of data analysis methodologies so that assessment of PQ data can occur in real- or near-time rather than only on a post-mortem basis.
- Perform laboratory testing for accuracy, precision, and usability of the PQ monitoring capabilities of grid connected devices incorporating PQ measurement capabilities, such as switches, relays, reclosers, breakers, and other devices.
- Evaluate the PQ sensitivities and contribution of new advanced manufacturing technologies as well as new DER technology such as Smart Inverters.
- Assess the impact on common end-use devices of the complex PQ environment created by increasing DER integration.
- Enhance search capability for the MyPQ.epri.com website, including additional technical resources for the PQ Online Resource Center comprising more than 1,700 documents

Estimated 2025 Program Funding

$2.5M

Strategic Sustainability Science

Posted

06/05/2025

Program Description

EPRI's Strategic Sustainability Science program identifies and develops tools, models, and analyses that utilities need in order to integrate a sustainability mindset throughout their organizations and throughout the communities they serve.

Expectations of power companies regarding sustainability commitments and performance are rising as customers, investors, employees, and other industry stakeholders become more committed to achieving an energy transition that benefits everyone and underpins ambitious economy-wide decarbonization targets. Corporate strategies are advancing beyond regulatory compliance to a comprehensive focus on driving value through economic, environmental, and social responsibility. As a result, electric power companies need ways to embed sustainable practices into day-to-day operations and strategic long-range planning.

To address these expectations, the program explores how a commitment to sustainability throughout electricity generation, delivery, and utilization can support a sustainable economy. This program serves as a resource nexus to bring sustainability thought leaders together and propel progressive scientific research and analysis.

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

Research Value

The Strategic Sustainability Science program seeks to provide the following benefits:

- Establishes a focal point for the present and future of sustainability-related research for the energy industry.
- Enhances utility's ability to operate more efficiently, better mitigate risk, and meet growing expectations of customers and other stakeholders.
- Enables utilities to enhance strategic planning, risk management, value analysis, and communications processes by engaging colleagues in these areas directly and developing tools to help root sustainability into these functions.
- Enriches the two-way interaction and dialogue on sustainability issues and solutions between various internal and external stakeholders, which drives timely, proactive engagement and improved understanding.
- Empowers better-informed utility decision making on a broad range of strategic topics by incorporating sustainability dimensions.
- Equips utilities to increase the maturity of their sustainability approach, thus demonstrating sustainability leadership.
- Supports strategic activity, but also informs day-to-day decision making, for example, through metrics research to inform sustainability reporting.
- Informs sustainability disclosure activities through identification of industry-level sustainability priorities, data on peer goals and reporting trends, collection of sustainability metrics, and opportunities for peer benchmarking.
- Ultimately helps in achieving the broad societal, economic, and environmental benefits associated with more sustainable companies and communities.

Approach

This program consists of four research streams:

- **Metrics and Reporting**: Advances an understanding of the multi-faceted value delivered through sustainable decision-making, from research on emerging and existing metrics for understanding corporate sustainability performance to exploring peer sustainability initiatives and their resulting value. This work helps companies identify and develop quantifiable strategic inputs to further understand and analyze the still nebulous topic of sustainability, as well as inform decision making grounded in peer, industry, and broader sustainability efforts.
- **Sustainable Business Strategy**: Builds on research findings to develop tools that support the advancement of sustainability maturity and strategic decision-making. These resources can be used across utility organizations, including strategic planning, risk management, financial analysis, communications, and other departments to help inform decision making and long-term planning. Additionally, evaluates emerging external frameworks to better understand their applicability and implementation by the electric power sector, and brings learnings and perspectives from other industries to inform development of energy industry sustainability strategies.
- **Enhancing Stakeholder Engagement**: Creates the resources needed to help companies advance a two-way sustainability dialogue with both internal colleagues and external stakeholders throughout the communities they serve. Each year the program identifies a key internal organization to focus on, taking a deep dive into existing relationships and activities, and identifying opportunities to enhance collaboration. Additionally, research also informs enhanced interaction with key external stakeholders, helping companies move beyond their annual corporate sustainability report to more timely, proactive, and truly engaging sustainability communications.

Key Activities

Research projects in 2026 may consist of the following, subject to program funding and informed by member prioritization:

- Sustainability by Design: Phase 2 to add additional depth or breadth.
- Measuring Sustainability Value: Expanded analysis of ways to quantify and communicate the multi-faceted yet hard to quantify types of value delivered through sustainability efforts.
- Cross-industry Sustainability Analysis
- Enhancing Stakeholder Engagement: Engineering & Design
- Sustainability Reporting Trends Survey and Data
- Peer Sustainability Benchmarking

Estimated Funding

$2.0M

Program Manager

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Boilers

Posted

06/12/2025

Program Description

Advancing the energy transformation involves enhancing the performance of existing assets and developing new solutions for the future. To help met today's energy needs with greater reliability and reduced operations and maintenance (O&M) costs, the Boilers program (P214) can use international collaboration to develop technology and guidance on safe management of boiler component life.

Efforts traditionally 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. Lately there has been an increased emphasis on development of tools for fitness-for-service and flaw evaluation.

Research Value

Power generators can better balance the risks and costs of operating power plants by using proven technologies to create solutions. EPRI's technical expertise and research results can be of value to better inform decision making. Plant owners, operators, and other participants may find value from the program results such as ways to:

- 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 more accurate 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.

Approach

Thermal power generation assets 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.

There are many areas where EPRI's R&D could be beneficial to the industry and the public. 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. The program plans to investigate techniques that can scan larger areas with greater speed and resolution. Improving the remaining life assessment of major boiler components is also an industry need. 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.

Program deliverables typically include technical guidelines, reports, software and tools applicable to all boilers. These are usually focused on efforts towards achieving optimal availability and performance, and may include topics such as ways to:

- develop boiler component inspection and monitoring techniques to reduce O&M costs and improve life-management options
- evaluate NDE developments in other industries to determine applicability to fossil plants
- develop analytical tools for boiler component life management
- provide a comprehensive approach to creating technical bases for minimizing in-service component damage and for component remaining-life assessment.

The non-proprietary results of this work may be incorporated into EPRI R&D and made available to the public, for purchase or otherwise.

Accomplishments

The Boilers program can support the industry in reducing boiler tube failures by understanding damage mechanisms, root causes, and corrective actions. Past accomplishments include development of a comprehensive suite of guidelines and analysis tools for boiler component life management, boiler tube failure reduction program training to help utilities reach availability goals, and Boiler Reliability Interest Group meetings for members to meet and discuss industry issues and the latest technologies.

Key deliverables for the program include:

- Boiler and Heat Recovery Steam Generator Tube Failures: Theory and Practices Volume 1: Fundamentals, Volume 2: Water-Touched Tubes and Volume 3: Steam-Touched Tubes, 3002010388
- Integrated Life Management of Grade 91 Steel Components: A Summary of Research Supporting the Electric Power Research Institute's Well-Engineered Approach, 3002012262
- Boiler Tube Failure Program Best Practices, 1023087
- Effect of Flexible Operation on Boiler Components: Theory and Practice Volume 1: Fundamentals, 3002001180
- Effect of Flexible Operation on Boiler Components Theory and Practice: Volume 3: Steam-Touched Components, 3002010385
- Field Guide: Boiler Tube Failure, 1017471
- EPRI Creep and Fatigue Lifing Calculator for Low Alloy Steel v1.2, 3002013475
- Impact of Operating Factors on Boiler Availability, 1000560
- An Informed Perspective on the Application of Replication in an Integrated Approach to the Life Management of 9%Cr Creep Strength Enhanced Ferritic Steel Components, 3002012592
- Effect of Flexible Operation on Boiler Components: Theory and Practice Volume 2: Water-Touched Components, 3002005871
- Boiler Condition Assessment Guideline, 1019628

Key Activities

The program R&D is expected to focus on developing life-assessment technologies for boiler metal degradation. Specific efforts may include R&D to:

- develop and research tools (e.g.: small sample removal) and testing procedures to predict remaining life of seamless pressure parts
- support metallurgical studies to understand behavior of fossil power plant materials
- conduct case studies to understand actual component operation and validate tools and approaches

- develop guidance to address damage from evolving operating modes within the current fossil fleet, including fuel switching, cycling, low load, environmental constraints, or other emerging issues
- advance technology and provide information to support reliable operation of new and advanced fossil boiler and boiler component designs.

Estimated Funding

$2.5M

Program Manager

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Piping

Posted

06/13/2025

Program Description

The rapid pace of transformation across the energy sector demands high performance from new and existing assets, and improving operations and reliability at the power plant-level involves examining opportunities across numerous components. Plants typically have many piping systems, and if they are not properly maintained, these systems may pose a risk to reliability and availability - and in severe cases a risk potential for personnel as well.

Using EPRI's Integrated Life Management (ILM) strategy, the objective of this program is to enhance safety, reduce risk, and maintain availability for power plant piping systems and components. EPRI's ILM strategy utilizes decades of research and development towards a well-engineered, and rigorous approach to plant life management. EPRI's ILM strategy can be summarized into seven parts:

1. Fundamentals
2. Service Experience
3. Specifications
4. Guidelines
5. NDE and Fitness for Service
6. Repair/Replace
7. Technology Transfer

Fully embracing EPRI's ILM strategy may help with enabling the efficient allocation of future resources for the operation and maintenance of power plant piping systems and components.

Research Value

EPRI has conducted decades of research related to power plant piping issues that have challenged the industry, including longitudinal seam weld failures, circumferential weld failures, general corrosion, and flow-accelerated corrosion (FAC) failures. A few of the past accomplishments which may prove valuable include:

- guidance, training, and analysis tools for FAC management in fossil plants
- NDE technologies for boilers, high-energy piping, and FAC
- technologies for life management of long-seam weld components in the power industry

Participants may also find value from EPRI's expected efforts to:

- reduce the risk of potentially high-consequence failures of high-energy steam and water piping systems by applying tools and guidance developed by this program
- seek eliminate FAC as a safety issue in fossil plants
- provide methods of reducing O&M costs, such as guidelines for risk-based inspection and techniques for reducing overly-conservative assumptions for technically well-informed run/repair/replace criteria
- address the risk of seam welded high-energy piping failures
- development a benchmarking tool to validate a utility's piping program
- provide guidelines and technologies to enable development and continuous improvement of HEP programs
- support with requirements (e.g.: ASME B31.1, NBIC, EU, ABSA, and/or local jurisdictions)
- emphasize approaches that consider the impact of design, fabrication, operation, and metallurgy on long-term performance
- develop case studies that empower the engineer to develop/maintain a best-practice HEP program specific to the type of system, material (e.g., CrMo vs. 9%Cr steel), and damage mechanisms

Approach

Piping systems within the program are generally categorized as either high energy piping (HEP) or non-high energy piping (NHEP).

Typical HEP systems researched include main steam or high-pressure steam, hot reheat steam or reheat steam, cold reheat steam, feedwater, and systems that operate above 400°C (750°F) or above 71 bar (1,025 psi). Typical damage mechanisms for HEP components can include creep, fatigue, thermal shock, and flow-accelerated corrosion (FAC).

NHEP research encompasses all other power plant piping systems, but broadly includes water piping (such as service and cooling water), fuel piping (such as gas and fuel oil piping), and chemical piping (such as ammonia and acid piping). Underground/buried piping, regardless of system, is also a research subject. Corrosion is the predominant damage mechanism for NHEP components.

The Power Plant Piping program currently has five main research focus areas, which are intended to support one or more of the parts that comprise the ILM strategy:

- root cause failure investigations and case histories
- understanding damage mechanisms as a function of past/present/future operation
- state-of-the-art technologies for assessing fitness for service
- integrated life management tools and methods
- technology transfer

These focus areas are used with the expectation to provide power plant operators the tools, methods, and knowledge to more effectively manage their piping systems, and helping to deliver safer, more reliable, and more affordable power production.

The non-proprietary results of this work may be incorporated into EPRI R&D and made available to the public, for purchase or otherwise.

Accomplishments

Some of the key deliverables for the program include:

- 3002012262 - Integrated Life Management of Grade 91 Steel Components: A Summary of Research Supporting the Electric Power Research Institute's Well-Engineered Approach
- 3002012592 - An Informed Perspective on the Application of Replication in an Integrated Approach to the Life Management of 9%Cr Creep Strength Enhanced Ferritic Steel Component
- 1016212, 1015505, and 1012201 - Fossil Plant High-Energy Piping Damage: Theory and Practice

- 3002011587 - 30-Plus Years of Long-Seam Weld Failures in the Power Generation Industry—Perspective and Continuing Challenges with Life Management
- 3002011588 - A Method for the Preliminary Assessment of a Seam-Welded Hot Reheat Piping System: Damage Estimation and Prioritization of Sections for Evaluation at Kansas City Power and Light Sibley Unit 3
- 3002007882 - Service Experience of Fabricated Wyes, Laterals, Branches, and Seam-Welded Components Manufactured from Grade 91 Steel
- 3002005874 - Root Cause Investigation of Failure in Long Seam-Welded Hot Reheat Pipe at American Electric Power"s John E. Amos Plant
- 3002009231 - Life Management of 9Cr Steels: Basic Approach to Risk Ranking Systems of Components
- 3002018026 - A Primer on the Integrated Life Management of Grade 91 Steel High Energy Piping (HEP): Main Steam and Hot Reheat Systems
- 3002005846 - Life Assessment Primer for Heat Recovery Steam Generator Internal and External Piping
- 1025326 - Guidelines for the Evaluation of Seam-Welded High-Energy Piping
- 3002018093 - Power Piping Support Inspection and Maintenance Guide
- 1009776 - Applications Guide for Guided Wave Inspection Technology
- 3002009848 - Underground and Buried Piping Fossil Power Plant Equipment Guideline
- 3002013485 - Guidance for A High Energy Piping (HEP) or a Covered Piping System (CPS) Program
- 3002013766 - Nondestructive Examination of Field-Removed Grade 22 Long Seam-Welded Pipe Samples by Modern Techniques: 2019 Status Update
- 3002016791 - Best Practice Guideline for the Solicitation of Nondestructive Examination Services
- 3002013475 - EPRI Creep and Fatigue Lifing Calculator for Low Alloy Steel v1.2
- 3002011051 - Life Management of 9%Cr Steels - Creep Continuum Damage Mechanics Assessment of a Large-Bore Branch Connection and a Proposal for an Improved Methodology for Their Design
- 3002014892 - Interim Report: Development of Nondestructive Evaluation Coupons in Grade 91 Welds: 2018 Technical Update
- 3002012592 - An Informed Perspective on the Application of Replication in an Integrated Approach to the Life Management of 9%Cr Creep Strength Enhanced Ferritic Steel Components
- 3002011053 - Life Management of 9%Cr Steels - Continuum Damage Mechanics Assessment of Novel Step Weld Geometry for Girth Welds in Thick-Section Components
- 3002010507 and 3002010410 - NDE Methods for the Detection in Grade 91 Welds
- 3002008519 - Assessment of Eddy Current Arrays for Detection of Hidden Seam and Girth Welds
- 3002009232 - Life Management of 9Cr Steels - Development of a Creep Continuum Damage Mechanics Constitutive Model for Creep Strength Enhanced Ferritic Steels
- 3002004091 - Damage Tolerance Analyses of Grade 91 Steel Welds
- 3002001179 - Analysis of Pipe Supports with a Trunnion Welded to the Main Piping Run
- 3002010386 and 3002019027 - Aged Grade 22 Materials and Welds
- 1022562 - Effect of Soft-Zone Size on the Creep Performance of Grade 91 Piping Components
- 3002005847 - Nondestructive Evaluation for Detection of Corrosion Under Insulation
- 1006308 - Torsional Guided Wave Examination of Buried Piping

Key Activities

The program's upcoming R&D efforts are expected to focus on developing integrated life management (ILM) strategies for power plant piping systems. Specific efforts may include:

- root cause failure investigations and case histories
- better of understanding damage mechanisms as a function of past/present/future operation
- developing and/or evaluating state-of-the-art technologies for assessing fitness for service
- integrated life management tools and methods

Estimated Funding

$2M

Program Manager

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Program 216: Gas Turbine Life Cycle Management

Overview

Gas assets play a crucial role in meeting 24/7 energy needs today and are central to an affordable and reliable energy transition. Gas turbines are a popular and cost-effective replacement for retiring thermal power plants, and provide the flexibility required to respond to variable grid demands due to increasing renewable generation. The Gas Turbine Life Cycle Management Program (Program 216) creates tools, information and processes to reduce maintenance costs, improve operations and assess component life, as well as improve quality related to repairs, field applications, component procurement and engineering support. Heavy-duty and aero-derivative model types in both the 50-Hz and 60-Hz worldwide markets operating in simple-cycle, combined-cycle or co-generation configurations are addressed. The Gas Turbine Life Cycle Management Program, together with EPRI's sister program, Gas Turbine Advanced Components and Technologies (Program 217), provides comprehensive coverage of key research areas for gas turbine owners/operators.

Research Value

This program's research delivers value to gas turbine owners/operators running units at base load, as well as those requiring flexibility, including support for variable renewable energy. The program provides research to address industry challenges for the benefit of customers, with guidance for cost effective maintenance, repair solutions, flexible operations, and life management of the assets.

Approach

The Gas Turbine Life Cycle Management Program focuses on the following research areas to assist owners/operators in the improvement of their gas turbine operations and maintenance activities and related cost reduction efforts:

- Capacity Enhancement and Performance Assessment
- Combustion System Optimization and Maintenance
- Compressor Availability
- Gas Turbine Health Monitoring
- Hot Section Life Cycle Management
- Outage Optimization and Field Quality
- Rotor Life Management

The program has developed a multi-year strategic R&D plan that addresses key industry issues to develop technologies aimed at improving gas turbine (GT) asset value in the near term and to shape future maintenance options for long-term R&D for improving designs and reducing operations and maintenance (O&M) costs.

Accomplishments

For more than 30 years, EPRI's gas turbine and combined-cycle research programs have provided technical evaluations and products to support better operation and maintenance of existing assets, and provide objective, timely, life cycle perspectives on technology choices and improved plant designs, including:

- Model-specific repair guidelines for widely used 50-/60-Hz machines
- Replacement part procurement guidelines for vintage and current models
- Compressor and rotor root cause analysis and O&M solutions
- O&M guidance for dry low NOx (DLN) combustor systems
- Selective catalytic reduction and CO catalyst deactivation assessment
- Improved combustor tuning for emissions and dynamics optimization
- Component durability analysis and damage tracking
- Performance monitoring and efficiency/capacity recovery

Current Year Activities

R&D projects for 2025 will seek to strengthen research in the areas of maintenance, life assessment, and reliability for gas turbines for near-term applications. Work may involve coordination with the Gas Turbine Advanced Components and Technologies (P217) program and other areas of Generation including the programs related to heat recovery steam generators (HRSGs), materials, nondestructive evaluation (NDE), monitoring and diagnostics, controls and flexibility. Specific activities and projects may include:

- Capacity enhancement techniques
- Performance assessments for frame and aero-derivative engines
- Assessment of GT-HRSG temperature interface impacts and operational optimization
- Performance recovery and improvement via monitoring and diagnostics
- Improved rotor NDE for extended life
- Guidelines for qualifying alternative parts
- New/updated GT hot-gas-path repair guidelines

- Management of dry, low NOx combustion systems
- Durability and reliability for current GT models

Estimated 2025 Program Funding

2.5M

Integrated Asset Management

Posted

06/12/2025

Program Description

Integrated Asset Management (IAM) program research enables organizations to develop and implement optimized maintenance and reliability processes with a specific focus on balance of plant equipment but applicable to all power generation assets. Research results are designed to be integrated into an overall fleet strategy. Recent and upcoming research is based on a Risk-based Asset Management (RBAM) approach that considers real-time equipment conditions to minimize intrusive tasks. This process also allows for special considerations for plants that are on a trajectory to be decommissioned. The focus on fleet-level asset management allows members to scale key processes and practices to varying power producing assets in their fleets, including net zero assets in the future.

Asset management combines the Equipment Reliability (ER) process, learnings from international asset management process models, and asset management tools, such as, EPRI's Preventative Maintenance Basis Database (PMBD) to streamline asset management processes. From a technological standpoint, this program intends to provide implementation guidance of applications such as a Computerized Maintenance Management System (CMMS) or Enterprise Asset Management (EAM) and how to maximize the application of asset condition-based technologies to improve the reliability of assets.

Program research is expected to be focused around balance-of-plant (BOP) equipment (motors, pumps, valves, etc.) guidance that is provided and developed consistent with immediate and long-term needs. Equipment guidance, mission-directed maintenance strategies and streamlining asset management activities also integrate enterprise system capabilities, seeking to leverage proven information technology approaches and improve equipment reliability and O&M costs. The research results can be deployed in common platforms and incorporated into CMMS or EAM systems.

Research Value

The intended focus of the Integrated Asset Management program is to provide collaborative and asset agnostic (coal, gas, hydro, wind, solar, etc.) research with a solutions-oriented approach that enables members to improve equipment reliability, which includes using benchmarking data to aid in the decision-making process of investments into assets (e.g.: labor, cost, resource, overhaul, etc.). The IAM Program expects to provide specific asset management or maintenance strategies based on varying maturity levels of each of the plants.

Participants may mind value from the scalability of existing maintenance practices to be implemented effectively for different generating assets and equipment at the plant and fleet level. Building off of the work around transitioning to proactive (i.e.: preventive/condition-based) maintenance (i.e. equipment guidelines, equipment inspection tools, and EPRI's PMBD) may help in reassessing current maintenance practices and strategies to improve the overall maintenance and reliability of assets throughout the plants and fleets.

IAM R&D has led to 200+ technical reports and guides that cover both strategic and tactical maintenance processes, and 150+ maintenance guides for balance-of-plant equipment and systems, which can provide diagnostics and troubleshooting for equipment, maintenance and repair guidance, optimal maintenance strategy and preventive maintenance tasks, and overviews of work planning and job planning templates for equipment. The programs AM roadmap, and parts inventory management guidance, may also prove to offer timely, relevant, and useful technical aid.

Other potential value could be realized from EPRI's R&D results in the IAM program to:

Standardize:

- organizational structure
- plant maintenance and reliability metrics
- asset management policy and governance
- job skill expectations
- asset hierarchy/taxonomy, and criticality ranking

Execute:

- maintenance and reliability basis
- work management
- risk-based Asset Management

Check:

- cost vs. reliability vs. resourcing
- asset performance vs. reliability
- root cause failure analysis
- reliability engineering

Improve:

- asset management assessments
- corrective action plans
- lifecycle analysis
- change management

Approach

The evolution of enhanced asset management processes and technology is an inherently collaborative activity, involving end users working with EPRI to apply customized approaches, check, and improve. EPRI's decades-long experience with solutions-focused approaches may enable participants to improve equipment reliability and long-term asset management through cost-effective integration of both proven and emerging strategies to help close the gaps between current issues and available solutions.

The program traditionally utilizes on-site and fleet-wide assessment results to direct the development of unique asset management strategies, and has developed a member-facing process that can typically be used for most generation types (e.g.: coal, gas, hydro, renewables, etc.).

The non-proprietary results of this work may be incorporated into EPRI R&D and made available to the public, for purchase or otherwise.

Accomplishments

Some of the notable accomplishments from the IAM program include:

- guide to prepare asset management programs before utilizing digital tools
- Solar Central Inverter and Wind Doubly Fed Induction Generator PM Guide https://pmbd.epri.com
- failure modes table for renewable assets
- asset hierarchy templates for coal, gas, solar, wind, and hydro plants
- web-based guide on RBAM https://rbam.epri.com/
- AM benchmarking (data and metadata)

Key Activities

Integrated Asset Management Program R&D efforts in 2026 are expected to include specific activities related to:

- **Asset management and equipment reliability process**
  - Streamlining activities
  - Integrating decision making tools based on analytics of empirical data (e.g.: WODATA, PMBD, etc.)
  - developing the RBAM process and guidance
  - evolving to adapt to the energy transformation process
- **Mission directed maintenance strategies**
  - updating the PMBD software to include renewables and net zero components
  - initial development of a scalable process for fleet wide asset management
  - enhancing long-term maintenance strategies through the development of EPRI software (e.g.: iOutage)
  - updating and developing new BOP equipment guides
- **Asset condition assessment monitoring and tools**
  - research on applying the latest condition monitoring technologies and solutions (e.g: vibration, thermography, acoustics, and lubrication)
  - improving system/component reliability engineering processes
  - research on leveraging data from asset monitoring tools for tangible results (e.g.: O&M cost, reliability, etc.)
- **Application integration**
  - developing approaches to leverage enterprise systems, such as CMMS & EAM, in the ER Process with operational best practices
  - developing the Asset Performance Management platform (i.e.: a website with AM tools)
  - industry benchmarking information based on data available from EPRI's Work Order Database (WODATA)
  - analyzing WODATA for statistical insights to make functional and fleet wide business decisions
- **Framework for automating and simulating maintenance and reliability activities**
  - work request triggers
  - process simulations
  - effective daily and outage scheduling and planning
  - work management process
  - PM and inspection routes and work execution
- **Maintenance and reliability processes**
  - consolidation and research of power industry and other industry best practices
  - research strategies to transition to condition-based maintenance
  - leveraging digital solutions to optimize asset management processes
  - benchmarking key M&R metrics (i.e.: leading and lagging indicators)

In 2026, anticipated program deliverables include:

  - technical brief on the value proposition to asset management
  - guidance on fleet-wide asset management strategies
  - website of asset management tools
  - AM benchmarking data and interface for member access
  - case studies, lessons learned, and success stories
  - iOutage software to optimize outage/overhaul process
  - spare parts optimization guide update
  - electrolyzer system (i.e.: hydrogen production) guide in PMBD
  - AM and equipment reliability for energy storage

Estimated Funding

$2.0 M

Program Manager

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Plant Management Essentials

Posted

06/13/2025

Program Description

Powering the transition to a cleaner, more diverse energy system while maintaining safe and reliable operations requires harnessing the strength of people, processes, and technology. Organizations on the leading edge of the energy transformation are evaluating and implementing enhanced processes and technologies to allow their personnel to continue providing safe and reliable power production. A key aspect of the energy transformation is the efficient use of personnel and how their activities are integrated with new technology to improve operational processes, advance knowledge rapidly, and maintain the highest level of safety.

The objective of EPRI's Plant Management Essentials program is to provide a comprehensive research portfolio focused on solutions and guidance for the management of power plants, ranging from new construction to plant closure. The program intends to support the rapidly evolving power industry by utilizing research that's beneficial to a plant's overall operations, instead of simply focusing on individual components or technologies.

Three critical focus areas for the Plant Management Essentials program are people, processes, and technology. The program seeks to provide knowledge and awareness of how plant operations can be improved, and how these three focus areas can be best integrated to increase productivity and achieve safe, reliable, and environmentally responsible power generation. The base research results can typically be applied and implemented to accommodate the personnel and process needs for varying types of generating plants.

The power industry continues to change and evolve with new societal demands, new technology, and new environmental challenges. Power plant management and operation is continually shifting due to reasons such as:

- continued increase in low-carbon power generation and bulk energy storage
- load growth
- decarbonization commitments
- changing environmental regulations
- climate events
- supply chain challenges
- changes to infrastructure and assets (e.g: new, modified, and aging)
- new technology (i.e.: artificial intelligence, augmented reality, virtual reality, etc.)
- workforce transition
- system reliability concerns

These changes in the power industry create challenges for successful plant management. A systematic and integrated plant-wide approach is important to successfully identify and implement solutions that can be easily incorporated into the plant organization.

Research Value

Participants may find value from P225 Plant Management Essentials R&D aimed at improving plant safety, operational effectiveness, and reliability by addressing key tactical and strategic issues facing plant management. This collaborative program can provide focused forums for members to jointly resolve issues, improve processes, implement technologies, and identify research gaps. Program research areas are expected to include:

- Conduct of plant operations (O&M)
- Plant management
- Plant flexibility and strategies
- Technology implementation and use
- Knowledge capture and training

As part of the value proposition, EPRI's Plant Management Essentials program traditionally produces a range of deliverables, including:

- Technical reports and guidelines
- Web-based tools
- Mobile applications
- Videos (training and guidance)
- Technical meetings/webcasts
- Onsite workshops for site specific needs within the scope of the program

Site visits, member conferences, and industry surveys are consistently utilized to understand challenges facing members, develop solutions, and identify best practices, which creates a culture of collaboration and learning.

The Plant Management Essentials program works with other EPRI programs to gain the full advantage of the institute's collaborative model. Cross-sector research projects include studies in plant safety, the use of drones/ROVs, mobile-device applications, artificial intelligence for streamlining labor intensive processes, augmented and virtual reality technology, advanced generation cycles, advanced nuclear design, human-factored control room designs, human performance in safety and transmission organizations, and high-performance control system graphics.

Approach

The Plant Management Essentials program intends to address key needs via R&D aimed at finding solutions for the challenges impacting plant sites. Areas of research may include topics such as best practices in:

- operations - shift turnover, operator rounds, operator workarounds, control room conduct, operator logs, operator aids, communications, plant status management
- maintenance - work planning and scheduling, work management, outage management, configuration control, foreign material exclusion (FME), lifting and rigging, crew briefs
- overall Plant - emergency management, plant flexibility, human performance (HP) tools and processes, plant procedures and work instructions, lockout tagout (LOTO), DCS alarm management and graphics, plant/fleet seasonal readiness, corrective action programs, plant labeling
- plant staff development - training, knowledge capture, peer-to-peer forums

These areas all play a significant role in overall plant management and plant performance, and effective integration of wide-ranging skills and knowledge, effective processes, and design are to plant success. The Plant Management Essentials program coordinates with other EPRI programs to gain the full advantage of the institute's collaborative model. Cross-sector research pro

may include studies in plant safety, the use of drones/ROVs, mobile-device applications, artificial intelligence for streamlining labor intensive processes, augmented and virtual reality technology, advanced generation cycles, advanced nuclear design, human-factored control room designs, human performance in safety and transmission organizations, and high-performance control system graphics.

The non-proprietary results of this work may be incorporated into EPRI R&D and made available to the public, for purchase or otherwise.

Accomplishments

EPRI's Plant Management Essentials program has rich history of research results and deliverables. Some of the key accomplishments include:

- over a dozen plant flexibility projects resulting in savings of millions per year in avoided/unnecessary maintenance costs
- reported results from one fleet cited:
  - $2.7 million in O&M savings
  - 37% reduction in equipment failures
  - 88% forced outage reduction
  - 45% reduction in safety and human errors
- human factor procedure writer's training workshops to help reduce errors and traps inadvertently written into procedures
- guidelines (e.g.: DCS alarm management to help improve operator responses to abnormal conditions, seasonal readiness and EOP-012 compliance, etc.)
- 25 short training videos in the "What does good ____ look like?" series

Key Activities

The program R&D for 2026 expects to continue its focus on plant personnel, technology, and plant process improvement. Potential activities in Plant Management Essentials may include:

- semi-annual Plant Manager Forum (March and October)
- annual Operations and Maintenance Conference (June)
- updates to existing research guides
- technology transfer activities
- workshops (i.e.: human factors procedure writer's, human performance improvement, DCS alarm management)
- plant site assessments (i.e., O&M assessments, LOTO, operator rounds, etc.)

Estimated Funding

$1M

Program Manager

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Boiler and Turbine Steam and Cycle Chemistry

Posted

06/13/2025

Program Description

As the power sector continues on the path of clean energy transition with low-carbon and renewable resources, firm capacity from thermal generation maintains a critical role in meeting current energy needs, and is expected to continue to play a key role for safe, affordable, and reliable energy supply. The objective of EPRI's Boiler and Turbine Steam and Cycle Chemistry Program (Program 226) is to conduct targeted research on key corrosion and deposition damage mechanisms, and develop practical solutions to mitigate risks. Research results are traditionally used to create guidelines and training materials intended to help plant operators and utilities manage cycle chemistry to reduce unplanned outages and O&M costs, to address the effect of flexible operation on cycle chemistry, and offer guidance on proper selection and optimization of unit-level cycle chemistry programs.

EPRI's R&D is intended to advance knowledge of water and steam cycle chemistry applicable to thermal power plants, including combined heat and power cogeneration systems, and to overcome future technical challenges. Corrosion and deposition in the water-steam cycle can reduce plant efficiency, cause availability loss from major equipment damage, and increase operating and maintenance (O&M) costs. Optimal cycle chemistry is also essential for the efficient and reliable operation of power plants using water-saving technologies, such as dry cooling, and enables the long-term value of this technology. Plant safety risks are higher when corrosion and deposition-related failure mechanisms are not properly addressed. Unit-specific cycle chemistry monitoring, treatment, and control programs must be designed and properly implemented to prevent boiler and/or heat recovery steam generator (HRSG) tube failures, steam turbine blade/disc failures, and flow-accelerated corrosion (FAC).

Renewable generation, which require dispatchable generation for load-following, has required thermal power plants to operate with more flexibility, including extended periods of low-load operation and more frequent unit shutdowns and startups. These demands are raising additional cycle chemistry issues, including the dynamic effects on plant systems and the preservation of equipment during offline periods. Operators must recognize and mitigate the increased risk of corrosion damage and component failures resulting from these operating modes.

Research Value

Unplanned loss of power generation can result in higher costs for electricity and is often detrimental to the environment. The industry is challenged to find the optimal balance between managing risks of chemically influenced equipment degradation and asset preservation efforts with O&M cost reduction and sustained production. By using this program's R&D results, participants may find value and help to:

- improve overall unit availability and flexibility by reducing equipment exposure to damaging corrosive conditions from improper response to cycle chemistry excursions
- reduce steam turbine availability losses by properly managing steam chemistry to avoid salt deposition, offline corrosion, and metal oxide deposition
- reduce chemically influenced boiler and HRSG tube failures and the need to conduct chemical cleaning for deposit removal
- 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 the generation of boiler chemical cleaning waste --- and the cost for its treatment --- by reducing the rate of iron oxide transport to the boiler

Approach

The program intends to utilize a two-fold approach consisting of both scientific research as well as practical application guidance aimed at reducing the risk of chemistry-influenced issues. Program results are usually shared communicated through reports, webcasts, periodic updates, an assessment results database, and direct communication (e.g.: webcasts and meetings). This program's approach is typically planned to:

- Conduct laboratory-scale experiments that simulate various condensate, feedwater, boiler water, and steam conditions in thermal plants
  - gain a better understanding of chemistry-influenced failure mechanisms
  - quantify how exposure to different corrosive contaminants impacts the onset of damage in major components
  - optimize how treatment applications may reduce risk
- Develop practical guidelines based on program research results and industry experience
  - operationalized action level limits to inform alarm management for critical cycle chemistry parameters
  - cycle chemistry instrumentation and monitoring
  - selection and optimization of feedwater treatments to minimize FAC and iron transport in high-energy piping and air-cooled condensers
  - shutdown, startup, and layup best practices
  - condensate polisher and make-up water treatment operating guidance
- Integrate human and organizational performance science to develop improved strategies for prompt identification and response to significant cycle chemistry excursions
- Assessments and benchmarking processes to provide fossil power plant operators with a concise plant-specific summary of their cycle chemistry program strengths and opportunities for improvement

The non-proprietary results of this work may be incorporated into EPRI R&D and made available to the public, for purchase or otherwise.

Accomplishments

Recent program accomplishments include:

- 40+ unit-specific cycle chemistry assessments and smart cycle chemistry alarm applications in the past 3 years, with learning incorporated into program research results and guidelines
- research under simulated boiler water conditions to gain valuable intelligence on chloride and sulfate threshold concentrations for active corrosion initiation
- customizable cycle chemistry alarm response procedure templates for various unit types and chemistry treatments
- lab experiments under simulated offline steam turbine conditions to gain insight into the impact on pitting corrosion on LP turbine steel coupons with various salt concentrations and loadings
- a guideline for a plant level self-assessment process to determine preparedness for proper response to a cycle chemistry excursion

Key Activities

Program activities in 2026 will largely revolve around improved application of the comprehensive cycle chemistry guideline revisions. Other specific activities may include:

- transitioning cycle chemistry guidelines to concise, modular, web-based application guides
- criteria for taking mitigating actions based on steam turbine salt deposit levels and specific deposit species
- cycle chemistry assessments and benchmarking
- a risk management tool to assist HRSG owners in decision making (e.g.: high-pressure evaporator deposition management to prevent underdeposit corrosion failures)
- monitoring emerging low-carbon technologies and providing technical support for high-purity water requirements

Estimated Funding

$2.5M

Program Manager

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Water Treatment Technologies

Posted

06/17/2025

Program Description

An affordable and reliable energy transition depends on a comprehensive mix of energy resources and technologies that predominantly depend on water. From electricity generation, to energy storage, to low-carbon energy carriers, to changes in climate and weather patterns, water touches the power sector broadly and worldwide. Utilities taking action to meet current and future energy needs in a clean, reliable, and affordable manner are challenged to better manage water use and treatment.

EPRI's Water Treatment Technologies program (P238) aims to uncover new water solutions by identifying, evaluating, and demonstrating the performance, operability, and reliability of technologies designed to treat process water and wastewater streams for reuse or returning to its original source.

Program research is intended to help stakeholders develop effective water treatment, management, and conservation strategies through independent performance, operation, maintenance, techno-economic evaluation, as well as user groups. For applications where technologies are not available or not currently able to demonstrate applicability, the program may conduct fundamental research (often in-house), seek emerging technologies, evaluate new processes, and identify pathways for potential improvements to the availability of practical options.

The program's research traditionally covers multiple application areas. Examples of research includes utilization and treatment of alternative intake waters for multiple applications, cooling intake water and effluent treatment, water treatment to facilitate hydrogen electrolysis and carbon capture, influent water treatment for boiler makeup, algae treatment in source waters, evaporation pond management. groundwater ex-situ remediation, element specific pollutant removal (e.g.: boron and selenium), evaporation pond brine and sludge management, flue gas desulfurization (FGD) wastewater, bottom ash transport water, and landfill leachate and CCR water treatment.

Many different types of technologies and topics have been researched by the program, such as next-generation monitoring and controls, chemical precipitation, clarification and filtration, biological treatment (active and passive), filtration, electro-chemical separation, membrane separation, wastewater and byproduct encapsulation, and desalination.

Research Value

Program research helps stakeholders develop effective water management, treatment, and conservation strategies. The program seeks and evaluates new processes and identifies pathways to advance the technology readiness level of various options to increase system resilience and flexibility. In-depth evaluations of currently available approaches enable the industry in their decision-making with greater confidence on available near-term options.

The program provides a forum for members to discuss issues and challenges they face in their daily activities, as well as to share solutions that they have utilized and implemented. Such a forum has provided a platform for inter-company collaborations and industry-level discussions that have led to changes in operational standards, challenged the supporting engineering and equipment providers to become more innovative, and in general provided a forum for water professionals to network and discuss matters in a timely fashion.

Regular webinars conducted by the program allows members to stay current with treatment technologies, newly developing practices within the industry, and communicate the programmatic research. Some of the events the program sponsors allow members to earn professional development hours (PDH) that may be used toward their PE, PMP, or other professional accreditation renewals.

A sentinel role of the program is the generation of end-user guidelines. Through user groups that focus on real time issues and solutions that are being encountered at sites, as well as research results from studies, collected knowledge and new learnings are consolidated into guidelines that summarize and archive intuitional knowledge to provide information for use by operators, engineers, chemists, and environmental personnel in daily operations.

Program results are communicated through updates to members, webcasts, user groups, focused symposia, and published reports. This program delivers:

- Independent, objective evaluations of process water and wastewater treatment systems, including overall treatment performance and technoeconomic analysis
- Evaluation and demonstration of the potential benefit of integrated process control and monitoring of water systems
- Assessments of the ability to integrate non-traditional source waters and reuse treated wastewaters within the plant and associated performance and economic evaluations
- A database of emerging water treatment or conservation/reuse technologies of potential applicability to the industry worldwide, to be used for R&D planning and informing the industry of potential options
- Encapsulation, stabilization, and effective dewatering and paste technologies for water and wastewater treatment solids, brine, and residuals management
- Technoeconomic assessments for full-scale water and wastewater treatment systems

Approach

This program historically screens and assesses new water and wastewater treatment technologies to inform and support reduced operating and capital costs, reduced water consumption, and reduced pollutant discharge concentrations. The program expects to evaluate development of technologies and provide independent science-based appraisals on the performance and efficiency associated with water treatment processes. The program intends to conduct R&D to:

- facilitate early-stage research in areas that aim to improve fundamental science and knowledge which could translate to applied R&D
- develop and use advanced modeling techniques for water management, thermoelectric cooling, and process and wastewater treatment technologies and systems analysis
- screen technologies for application opportunities via laboratory tests and preliminary technical and techno-economic reviews
- demonstrate proof of concept for individual components and subsystems
- conduct pilot and field research testing in relevant real-time applications for systems and integration analyses
- evaluate full-scale technology applications and consolidate research results into guidance targeting optimization of reliability, operations, and maintenance practices

EPRI has a fully equipped chemistry laboratory at its Charlotte, North Carolina campus, with capabilities ranging from preliminary jar studies, to electrocoagulation and membrane/thermal treatment evaluations, to final waste byproduct encapsulation, and may also utilize the Water Research and Conservation Center (WRCC) at Georgia Power's Plant McDonough-Atkinson. These facilities support early-stage research, proof-of-concept evaluations, pilot tests, and near- commercial-scale system studies. Additionally, tests may also be performed at other utility locations to provide real-time conditions for technology demonstrations.

The non-proprietary results of this work may be incorporated into EPRI R&D and made available to the public, for purchase or otherwise.

Accomplishments

Some of the past accomplishments of the program include technology evaluations, operating guidelines, user group engagement, water treatment performance and reliability support, and technology transfer efforts resulting in improved water treatment performance and treatment system designs.

Key deliverables for the program include:

- Conference Proceedings: Water-Energy Transformation (WET) Forum (3002027163)
- Coal Combustion Product Landfills: Resources and Practical Approaches to Monitoring Water (3002027781)
- Executive Summary: The Role of Water in Hydrogen Production (3002028458)
- Algae Present in Power Plant Operations: A Review of Remediation Options (3002028869)
- Conference Proceedings: Water-Energy Transformation (WET) Forum (3002025421)
- Real-Time Monitors Detect Deposition in Heat Exchangers and Membrane Systems (3002020387)
- Membrane Treatment Guidelines (3002011342)
- Thermal Water/Wastewater Treatment Systems Chemistry Guidelines (3002018776)
- Considerations for Concentrate Management from Wastewater Volume Reduction Technologies (3002024773)
- Coal Combustion Product Landfill Terminology and Water Management Fundamentals (3002021923)
- Potential Challenges in Landfill Water Management (3002024772)
- Landfill Leachate Treatment Study: Evaluations of Membrane, Evaporation, and Encapsulation Technologies (3002006087)
- Quantifying Leachate Volumes at Four Coal Combustion Product Landfills in the Southeastern United States (3002023091)
- Wet Flue Gas Desulfurization Wastewater Physical/Chemical Treatment Guidelines (3002008515)
- Biological Treatment for Wet Flue Gas Desulfurization Wastewater (3002016780)
- Wastewater Encapsulation and Testing Reference (3002010778, 3002010779)
- Stormwater Permitting and Management for Decommissioning Power Plants: Best Management Practices (3002020768)
- Conference Proceedings: Virtual Selenium Summit (3002026171)
- Microbiological Monitoring of an Operational Full Scale Biological Treatment System for Wet Flue Gas Desulfurization Waste Water (3002028058)

Key Activities

Program R&D for 2025 will focus on water/wastewater treatment applications for power plants and emerging low-carbon technologies. Specifically, the research may:

- Seek novel water management technologies that improve pollutant removal and/or water conservation
- Identify and study interactions between all environmental quality control systems (air, water, and solids/waste), in collaboration with other EPRI programs, to maintain a holistic vision
- Find, assess and test technologies that target trace metals reduction (e.g., selenium, mercury, and arsenic), nutrients, and soluble species (e.g., boron and bromine) from various water/wastewater applications
- Determine the effectiveness of monitoring and controls techniques (e.g., machine learning) that enable corrective action to be taken before a problem occurs
- Prepare treatment and design consideration guidelines for treatment of degraded water supplies, such as high salinity/brackish water and municipal effluent, that could be alternative water sources for existing freshwater uses
- Conduct evaluations and support development of enhanced test methods and models for wastewater byproduct encapsulation applications, including those at power plants where coal combustion byproducts are combined with water/wastewater and other materials for landfill applications
- Quantify and identify treatment options for water and wastewater streams applicable to emerging low-carbon technologies such as electrolysis for hydrogen production, carbon capture systems (CCS), and direct air capture (DAC) systems

Anticipated deliverables include:

- Technical briefs and white papers describing the role of water in the low-carbon energy transformation
- Technology evaluations for water treatment in power plant and desalination applications
- Concepts and frameworks for enabling machine learning in water treatment systems
- Updated guidelines documents for thermal, membrane, and/or physical/chemical/biological treatment systems
- Technology reports describing water treatment capabilities, gaps and potential research opportunities

Estimated Funding

$1.5M

Program Manager

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Groundwater and Land Management

Posted

06/16/2025

Program Description

Energy companies on the leading edge of the clean energy transition are taking action to identify and address environmental impacts of power system operations. The objective of EPRI's Groundwater and Land Management program (P242) is to provide technical research focused on the release, transport, and remediation of inorganic constituents that can be encountered at power plants. The program research may include constituents that drive environmental risk, such as arsenic, chromium, and selenium, as well as constituents that have the potential to drive corrective action, even if the environmental risk is low, such as boron and lithium.

The focus areas of this research are on the development of information, data, techniques, and tools for potential use in the:

- characterization of potential sources such as coal combustion products (CCPs), coal piles, and low volume wastes
- 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

Participants in this program may find value from EPRI's technical research aimed at:

- providing methods and data to understand groundwater transport and risk
- informing remediation system designs tailored to the unique suite of constituents that can be released at power plants and CCP management sites
- independent research on solid waste management and associated environmental characterization at power plants and CCP sites to inform science-based evaluation of regulatory proposals

Examples of potential value from previous research in this program include:

- numerous characterizations of CCP leaching for a variety of source coals and management environments
- evaluations of methods to characterize groundwater-surface water interactions, and associated geochemical changes as groundwater discharges to surface water, which provides data to evaluate functional equivalence decisions
- a framework for evaluating the relative risk of closure of CCP units in place versus closure by removal, and a geochemical modeling study illustrating that remediation for a unit closed in place with intersecting groundwater can often be as effective as closure by removal, which showed that closure decisions may provide the greatest benefit to the public when made on a site-specific basis
- creation of a holistic decision support tool to provide a structured approach for selecting a corrective action remedy that can include sustainability and environmental justice considerations
- bench and pilot scale testing of reactive media for in-situ remediation of inorganic constituents such as boron, lithium, and molybdenum, as well as constituents that have received little attention in the past such as cobalt, and environmental risk drivers such as arsenic, chromium, and selenium
- research to redefine the groundwater monitoring paradigm, tailored to the inorganic constituents commonly monitored at power plants and CCP sites, which can streamline long-term groundwater sampling programs

Approach

The suite of inorganic constituents that can be released at a power plant is unique, particularly in the case of CCPs, and each constituent has its own transport and risk properties. Conversely, corrective action planning often needs to consider remediation technologies, or combining technologies, to treat multiple constituents at the same time. Research performed under this program is intended to inform improved tools and techniques for characterizing transport and risk, and implementing corrective action when necessary, at power plants and CCP sites. This research is expected to include:

- examining literature to present the state of understanding for the occurrence, geochemistry, and health and ecological risks associated with key constituents encountered at power plants and CCP sites
- state-of-the-science knowledge and field experience to provide information on applicable remediation technologies, construction and implementation considerations, and cost information
- groundwater and geochemical modeling to understand how power plant operations and releases from CCP sites can affect groundwater geochemistry, and the resulting potential for risk to human health and the environment
- bench top testing of treatments for in-situ remediation
- implementing remediation technologies in the field at pilot test scale to understand and document effectiveness in applications, and considerations to improve field construction and implementation
- case studies of corrective actions performed at power plants and CCP sites to share lessons learned and provide proof-of-concept documentation
- collaborating with related EPRI programs to fully evaluate issues such as groundwater-surface water interactions, landfill management, and CCP leachate treatment
- facilitating early research on risk and remediation at power plant and CCP sites by universities and government entities to improve fundamental science and knowledge and build the basis for future applied research

The non-proprietary results of this work may be incorporated into EPRI R&D and made available to the public, for purchase or otherwise.

Accomplishments

Some of the past accomplishments from EPRI's technical R&D in this area include:

- comments to the U.S. Environmental Protection Agency (EPA) prior to release of the 2015 Coal Combustion Residuals (CCR) rule, and for multiple proposals to amend the rule from 2018 to 2024
- research to understand physical and geochemical interactions at the groundwater-surface water interface
- a series of chemical profiles that describe the occurrence in nature and in CCPs, environmental health risks, geochemistry, and remediation technologies applicable to inorganic constituents of interest at power plants
- an interactive tool providing easy access to chemical profiles relevant to CCP sites
- characterizing the effects of coal piles on groundwater for use in alternative source demonstrations
- identifying geophysical tools to aid in delineation of CCR management units
- a framework for evaluating the relative risk of closure of CCP units in place versus closure by removal and a companion geochemical modeling study

- testing and evaluation of media and reagents for in-situ remediation of groundwater
- a holistic decision support tool to help stakeholders incorporate sustainability and environmental justice into corrective action planning
- a series of remediation profiles documenting applicability, implementation considerations and relative cost for groundwater remediation technologies such as in-situ stabilization/solidification, groundwater extraction and treatment, and permeable reactive zones
- evaluation of innovative tools with the potential to support Alternative Source Demonstrations (ASDs)

Key Activities

Key activities for the program in 2026 may include research topics such as:

- groundwater-surface water interactions, which can be used to inform decisions on functional equivalence
- environmental characterization and monitoring at new and existing CCP landfill units
- long-term leaching characterizations of coal ash landfills and impoundments
- methods for in-situ source control
- techniques for in-situ remediation of intransient inorganic constituents and environmental risk drivers

Anticipated deliverables are expected to include technical reports, technical briefs, webcasts and interactive tools to present research results, a summer meeting with detailed presentations and peer-to-peer discussions on technical topics associated with program research, and educational workshops to train utility staff on application of program research results.

Estimated Funding

$2.0M

Program Manager

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Executive Summary

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

The Research Vision document presents the motivation for the LCRI, research questions that address the initiative's focus areas, and preliminary research plans aimed at advancing critical technologies in support of the LCRI's objectives. This vision is a living document and will be updated over the life of the initiative based upon learnings from the research under the LCRI as well as developments in the broader energy community.

> **Vision for a Low-Carbon Energy Economy**
>
> Achieving net zero emissions across the economy by 2050 will require accelerating a safe, affordable, reliable, and environmentally responsible energy transition and advancing a variety of clean energy technologies and options.
>
> EPRI and GTI have created LCRI to evaluate pathways for deployment of alternative energy carriers in support of decarbonization across the energy economy by mid-century.
>
> The LCRI is focused on a vision of the future global energy system that is decarbonized, consumer-focused, sustainable, and resilient.

Last updated: May 20, 2022

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Accelerating Innovation to Achieve Net Zero Emissions →