

# AT A GLANCE



## Substations

### Program 37

#### Research Value

- Implement predictive maintenance practices to help reduce outages.
- Extend equipment life by using maintenance guidelines.
- Improve awareness and decision-making based on third-party, unbiased findings.
- Reduce maintenance times and costs via condition-based maintenance.

#### Member Benefits

- Field pilots in utility substations will continue to validate the technology and refine the concepts
- Detect-and-deter research in supporting physical security attacks on substations.
- Developing a course curriculum that allows utility personnel to develop and test their skill sets for maintaining substation ground grids.
- Updated versions of reference guides on transformers, circuit breakers, and bushings, plus webinars on additional technical topics related to substations.
- Guidelines for relay maintenance, configuration, and settings management.

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). Several other projects are focused on industry issues, including online monitoring technologies, sulfur hexafluoride [SF<sub>6</sub>] replacements, SF<sub>6</sub> leak sealing, alternative fluids, and physical security in substations. The program delivers a blend of short-term tools—software, reference guides, field guides, and technology assessment results—and longer-term research, such as new materials, component aging tests, and the development and evaluation of monitoring techniques.

EPRI's Power Delivery laboratories provide unique capabilities to investigate substation assets. Researchers use these laboratories to perform failure analyses, aging, and performance tests. Dedicated research areas include a full 138-kV research substation in Lenox, Massachusetts.

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## Research Highlights

- **P37.101: Transformer Life Management** – Research covers the wide spectrum from novel materials such as alternative fluids all the way through to new techniques to cost-effectively keep transformers dry. Research is conducted in EPRI’s full-scale research substation and provides deep and long-term insights into the performance of on-line monitoring technologies (2022 update: [3002024564](#)). Research results are conveyed in ways that make for easy application in the industry—such as through the Transformer Guidebook and technical webinars to support the Guidebook.
- **P37.102: Circuit Breaker Life Management** – This research supports best practices in high-voltage circuit breaker life management through a better understanding of operating stresses, underlying failure modes, and degradation rates to ensure satisfactory circuit breaker life-cycle performance. In addition, there is a focus on SF<sub>6</sub> leak sealing, it identifies promising materials, repair techniques for full-scale laboratory tests, and the results from controlled field testing (2022 update: [3002024576](#)).
- **P37.103: Protection and Control** – Configuration management guiding principles and processes to protection and control systems for effectively managing relay settings and relay firmware changes are introduced (2022 update: [3002024595](#)) and the Life Cycle Management of Relay Settings: Tools Assessment ([3002021364](#)).
- **P37.104: Substation Corrosion Management** – Evaluation of many of the commercially available inspection meters, developing an inspection technology based upon electrochemistry that is worker-friendly and the process of developing a course curriculum that allows utility personnel to develop and test their skill sets for maintaining substation ground grids ([3002024603](#)).
- **P37.105: Balance of Substations** – The project objectives are to help engineers and asset managers better understand the maintenance and issues associated with different vintage assets, provide guidance for more effective inspection, assessment, and maintenance, and help them make informed decisions about the required ratings and how to optimize the maintenance of these assets and maximize their service lives. This includes research on arresters, battery monitoring systems, and substation ratings.
- **P37.108: Gas Insulated Substations and Lines** – This research investigates SF<sub>6</sub> alternatives, methods to reduce SF<sub>6</sub> emissions, and approaches to manage GIS equipment. The research results are readily conveyed and applied through an ever-growing EPRI Guidebook for Gas Insulated Substations and Lines. The report provides a summary of GIS condition monitoring tools and the latest on SF<sub>6</sub> replacements worldwide ([3002015690](#)).
- **P37.113: Polymer Bushing Life Management** – This project produces industry guidelines on selection, application, operation, and diagnostics for new technologies by performing offline diagnostic tests as well as field experiments on polymer and oil-filled bushings at full rated voltage and current in different environmental conditions in EPRI’s Lenox Laboratory’s 138-kV yard.
- **P37.114: Substation Physical Security** – This research investigates and evaluates tools and technologies that aid in situational awareness of the substations environment, including drones and robotics. Other research tasks investigate ballistic performance of assets and physical protection systems.
- **P37.116: HVDC Converter Stations and Flexible Alternating Current Transmission System (FACTS) Devices** – Many FACTS installations are approaching or exceeding 30 years of service, and components are aging. Utilities need to make repair/replace decisions. This report provides best utility practices for operation, maintenance, and life extension strategies for existing FACTS controllers ([3002021404](#)).
- **P37.117: Using Voltage and Current Measurements for Monitoring Asset Conditions** – This project explores which substation assets are ideal candidates for this cost-effective solution and what signatures of voltage and current most revealing for asset condition, using EPRI’s full 138kV research substation. The key research questions are which assets in the substation would be ideal candidates for this solution and how to determine the condition of those assets from voltage and current measurements.

Scan the QR code or visit [https://trans-andsubs.epri.com/p37\\_substations/](https://trans-andsubs.epri.com/p37_substations/) to see more about this research.



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