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Substations (P37)

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).

PROJECT	2025 Accomplishments & Key Deliverables	2026 Plan
P37.101 Transformer Life Management	• Further extension of the transformer guidebook to guide utilities on developing monitoring strategies their entire fleet of transformers (**3002032893** EPRI Power Transformer Guidebook (Copper Book) 2025 update). • New oil markers to aid power transformer diagnostics. • Enhancements to the novel dry out technology that extends the life of transformers (**30022032896**). • Assessment of transformer online monitoring technologies to help members in specification development. • Application guidelines for new markers in the oil that can help the industry in better assessing the remaining life of a transformer.	• Further development and extension of the transformer guidebook to guide utilities on developing monitoring strategies their entire fleet of transformers. • Alternative fluids for transformers offer meaningful advantages, and the research planned for 2026 will provide guidance on how to maximize those benefits while more effectively anticipating maintenance needs. • Additions of new on-line monitoring technologies for evaluation – to guide selection and interpretation.
P37.102 Circuit Breaker Life Management	• Evaluated an online monitor at EPRI Lenox Substations laboratory to assess its reporting accuracy. • Continued expansion of leak sealing information and field trials (**3002032903** and web: https//transmission.epri.com/p37_substations/P37102_circuit_breakers). • New markers for circuit breaker dielectric assessments.	• Continue to evaluate online breaker monitors – large addition of new monitors added to the test setup in Charlotte. • Initiate development of leak sealing techniques for energized geometries and further expansion of temperature capabilities. • Initiate research to discover new chemicals in dielectric to aid non-invasive condition assessment.
P37.103 Protection and Control	• Joint Task for meeting and 2025 Digital Substation Workshop – space to share first-hand project experience and facilitate cross-functional collaborations. • Evaluation of Broken conduction detection technologies on high voltage transmission line (**3002032905**)	• Lab testing and evaluation of broken conductor detection technologies on high-voltage transmission lines for wildfire mitigation. • Lab testing and evaluation of relay performance in response to fault conditions during power swings. • Hands-on technology transfer at EPRI P&C lab.

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P37.104 Substation Corrosion Management	• Stray and Circulating Current Corrosion Control – how to locate, quantify and mitigate the corrosion effects of circulating currents within a substation. • Hands on workshop in the field with utility engineers to take concepts and apply in the field. • Update to the corrosion Management reference book – Rust Book **– 3002032909**	• Stray and Circulating Current Corrosion Control – how to locate, quantify and mitigate the corrosion effects of circulating currents within a substation. • Atmospheric Corrosion in Substations – modeling the service life of assets in highly corrosive environments. • Additional workshop opportunities to take learnings and apply it hands on in the 138kV research substation
P37.105 Balance of Substations	• Released report of multi-year research on surge arrester sensor to monitor pending arrester failure, including results of field testing at EPRI's 138kV research substation. **3002032926** – Arrester Condition and Failure Monitoring • Launch new web-based station ratings ampacity calculator tool to implement the guidance of EPRI's Increased Powerflow Guidebook **3002032786**). This assists utilities in creating required documentation for NERC compliance as it relates to most limiting series elements. • Robotics, Drones, and Imagery Day workshop was hosted in Charlotte in collaboration with overhead lines and distribution.	• Continue research tasks for assessment of robotics to aid in station inspections. • Research in Battery monitoring systems to aid in substation battery health evaluations. Included in 2026 are understanding what the manufacturer states as capabilities and identifying erroneous behaviors. • Additional expansion and research into ratings and the online calculator – potential areas include breakers and round bus • Continued updates to the Platinum Book.

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PROJECT	2025 Accomplishments & Key Deliverables	2026 Plan
P37.108 Gas Insulated Substation and Lines	• The Guidebook provides the practical application guidance on the key issues such as SF6 Alternatives, Diagnosis using gas analysis and GIS/GIL condition monitoring (**3002032930** EPRI Guidebook on GIS and GIL - 2024 Edition). • Valuable insights from the EPRI laboratory and case studies in the field – to guide specifications of GIS (**3002032932** Applying new GIS/GIL Technologies).	• In 2026 research will be conducted on using gas analysis to improve your diagnostics. • SF6 Alternatives for GIS/GIL will focus on guide specification and applications of the new SF6 GIS and GIL. • Additional research in 2026 will be on locating and trending partial discharge issues in the field.
P37.013 Polymer Bushing Life Management	• Continued research of resin impregnated synthetic bushings at an outdoor substation subjected to a large range of environmental conditions: **3002032936** - Performance of Dry Bushings Under Extreme Environmental Conditions. • Guide on general workings, considerations, known failure modes, and operations of polymer bushings: **300302935** - Guidelines on Specification and Maintenance of Polymer Bushings - 2025 Update. • Started research into the changes of polymer bushing sheds and insulation of resin impregnated synthetic bushings when exposed to a variety of environmental conditions in a field setting.	• Long term evaluations continue on the bushings in the 138kV research substation. • Continued evaluations in the environmental chamber with bushing exposed to a variety of environmental conditions. • Through thermal cycling, perform research of using accelerated aging of polymer bushings under full load to observe degradation characteristics. • Determine methods of cleaning polymer bushing sheds.
P37.014 Physical Security	• Evaluation of sensor fusion technologies for drone detection utilizing the 138kV Research substation (**3002032937**). • Understanding the role that AI plays with robotics in physical security evaluation in a substation.	• Continued research in drone detection technologies and advancements for substations. • Evaluation and continued research of detection technologies for substation physical security.

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PROJECT	2025 Accomplishments & Key Deliverables	2026 Plan
P37.016 HVDC: FACTS and Converter Stations	• HVDC Reference Book (Olive Book) was updated **300232880** - EPRI High Voltage Direct Current (HVDC) Transmission Reference Book (Olive Book): 2025 Update • HVDC workshop included topics on navigating HVDC integration: technologies, operation, and control. This allowed collaboration and was hosted at a utility site. • The EPRI gold book was updated with key insights learned through testing – EPRI Power electronics-based transmission controller reference book (**3002032939**).	• Provide updates to HVDC Reference Book (Olive Book) with most recent information on VSC converters and HVDC cables. • Develop novel VSC converter topologies for fault current limitation & document the latest developments in DC circuit breakers. • Comparison of FACTS technologies – performance vs costs with case studies. • New DC circuit breaker technologies.
P37.017 Using Voltage and Current Measurements for Monitoring Asset Conditions	• Voltage Transformer Teardown (**3002032943**) This research objective focused on understanding the physical characteristics of a health – but aged – VT. • Evaluation of voltage recording during VT failures. This is to understand and review with the goal of being able to identify VT/CCVT failure signals.	• Additional forensic analysis of VTs. • Accelerating aging of VTs – in 2026 – the research will focus on gather online signals and comparing to those results that were gathered in 2205. • Establish baseline for VTs including insulation levels, turns ration and secondary signals.

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