Technology Innovation Projects - 2024

Technology Innovation Project

Project Brief

TIP 23: EPRI P35: Overhead Transmission

Context

Transmission providers are focused on improving safety and reliability, while looking for ways to reduce operations and maintenance costs. Increasing transmission capacity without making large capital investments and reducing capital expenditures for new/refurbished equipment are major priorities. BPA is partnering with the Electric Power Research Institute (EPRI) to address these needs.

This project is an organizational effort to coordinate BPA/EPRI research activities for increased efficiency and productivity. BPA's strategy for involvement with EPRI Program 35 is to promote R&D through program projects and supplemental projects that are directly applicable to BPA's business lines and agency obligations.

This is a programmatic effort to formalize BPA's collaboration with EPRI so that engagement is more focused with careful attention to a project's value added.

Research Questions: "What ways can we increase transmission capacity without making large capital investments?

How can we reduce capital expenditures for new and refurbished equipment?"

Description

The Electric Power Research Institute's Program 35, *Overhead Transmission*, addresses research needs of transmission asset owners. It includes projects focused on specific components (e.g., insulators, compression connectors and cross arms) as well as projects focused on transmission-related issues (e.g., lightning and grounding, live working and transmission capacity). It delivers a blend of short-term tools such as software, reference books and field guides, together with longer-term research, such as component aging tests and the development of sensors for monitoring line components and performance. The program consists of multiple projects that are added or concluded during each program year.

This program also performs long-term laboratory experiments aimed at better understanding the aging and failure mechanisms of structures and line components. Corrosion laboratories create environments to better understand the impact of corrosion above and below ground; insulators are tested for aging and degradation to learn more about their long-term performance characteristics.

Why It Matters

Overhead transmission is a major area of responsibility for meeting BPA's strategic objectives. This program encompasses and addresses the technology needs described in the Transmission Technology Roadmap. BPA's continued participation assures the agency's representation in this program's governing body.

Collaboration with other EPRI member utilities affords opportunities to leverage agency interest, share information and, in particular, avoid the very high costs associated with independently conducting this research. BPA's membership in this program includes access to EPRI's laboratories and testing facilities.

Goals and Objectives

BPA's participation will add the results of current EPRI R&D projects to Transmission Engineering design and analyses practices as well as provide BPA's contribution to EPRI member utilities in the following areas:

- Foundation analysis and design practices at BPA
- Conductor compression fittings and other advanced conductor work at BPA
- BPA's subgrade corrosion management practices
- BPA practices and techniques for live working
- BPA's work with polymer insulators and other composite components
- Lightning performance and analyses on BPA transmission lines and structures

TIP 23: EPRI P35: Overhead Transmission

Project Start Date: January 1, 2009

Project End Date: Continuing

Key Activities:

In the coming year, the Overhead program expects to accomplish the following:

- New research on advanced line design and emergency restoration
- Updated reference books, guidelines, and field guides
- Evaluation of new and emerging inspection technologies
- Development of an inspection tool for subgrade corrosion on structures, foundations, and anchors
- Forecasted transmission line ratings methodologies
- Determination of dynamic load impact factors for overhead lines
- Development of a software tool for estimating the lightning impulse strength of transmission lines
- Evaluation of the vibration performance of high-temperature low-sag (HTLS) conductors
- Continued research on:
  - Transmission line resiliency
  - Line switches
  - HVDC lines
  - Selection, application, and maintenance of composite structures
  - Accelerated tests of polymer insulators
  - Selection of overhead line tension
  - Accelerated aging tests of compression connectors

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Links

Program 35: Overhead Transmission | Program Home (epri.com)

Technology Innovation Project Project Brief

TIP 23.3: EPRI P35: Field Trial of ACCC Carbon-Fiber Core and ACSS HS285 Ultra-High Strength Conductors

Context

Utilities are concerned about the performance of **Aluminum Conductor Composite Core (ACCC)** conductors during prolonged exposure to temperatures above 150ºC, as well as their sag characteristics under ice loads. Developed in 2009, there is little experience with ACSS HS285 conductors under extended high-temperature operations and heavy weather loads.

Advanced High-Temperature Low-Sag (HTLS) conductors are being considered by the electric power industry as an alternative to conventional **ACSR (Aluminum Conductor Steel-Reinforced)** conductors. An HTLS conductor can tolerate higher temperatures and produce lower sags than conventional ACSR conductors. These features potentially enable overhead power lines to attain higher power transfer capacities on the same corridor.

Currently, a number of high-temperature low-sag conductors are commercially available. Industry experience with each HTLS conductor varies. **Aluminum Conductor Steel-Supported (ACSS)**, Gap, and Invar conductors have been around much longer than the other HTLS conductors. Gap conductors have been used in Japan for more than ten years, where the need for increased power flows occurred sooner than that need in North America. Invar conductors have been used in Asia for a number of years. Although ACSS conductors have been around for a long time, they have not been used extensively. Composite-core HTLS conductors such as ACCC were developed in recent years, and consequently, the power industry has the least experience with these conductors.

Research Question: How do these conductors perform under extreme electric and mechanical loading conditions in a real operating system?

Description

Evaluation methodologies for each HTLS conductor differ and are dependent on experience with the technology and materials used for the conductor. To assess the risk of using HTLS conductors, EPRI is conducting research to address the following issues:

- Handling and Stringing
- Operating and Maintaining
- Material Behavior
- Long-Term Performance
- Life Expectancy Prediction; and
- Specifications

Hydro One Networks has a site in Ottawa, Canada, that is available to EPRI members for field trials of HTLS conductors. At that site, the circuit normally carries a large amount of power. It also experiences heavy ice loads and cold temperatures at this location. It is therefore an ideal location for field trials of HTLS conductors.

ACCC and ACSS HS 285 conductors will be installed at the Hydro One test site in Ottawa, Canada. The line at this site carries a large amount of current from Ottawa to eastern Ontario customers, and is exposed to extreme ice, wind, and cold temperature. Instrumentation will be installed to monitor conductor performance continuously by recording key line parameters and weather data. The information will be transferred by cellular communication to EPRI for evaluation and assessment of line performance.

Through this project, the performance of these conductors and associated splices and dead-ends will be evaluated, based on field trial evidence and laboratory tests.

Why It Matters

Research results on ACCC and ACSS HS285 conductors can enhance industry's understanding of these conductors and offer the potential for line designers to assess the risks and apply these conductors appropriately, leading to increased power transfer as well as improved public reliability and safety.

Strategic Alignment

The project aligns with **BPA's Strategic Plan**: Enhance the Value of Products & Services; Objective 7. Transmission Investments to Integrate Load & Resources

Goals and Objectives

The objective of this field trial is to determine the performance of these two conductors under extreme electric and mechanical loading conditions in a real operating system by monitoring their behaviors in order to gain confidence in the applications of these conductors.

Deliverables

There will be four deliverables.

- Performance of ACCC and ACSS HS285 Conductors under Extreme Electric and Mechanical Loads
- Specifications and Recommendations for Design, Testing and Installation of ACCC and ACSS HS285 Conductors
- Installation Procedure for ACCC and ACSS HS285 Conductors
- Field Trial of ACCC and ACSS HS285 Conductors

TIP 23.3: EPRI P35: Field Trial of ACCC Carbon-Fiber Core and ACSS HS285 Ultra-High Strength Conductors

Project Start Date: January 2014

Project End Date: Continuing

Reports & References

Links

Overhead Transmission (epri.com)

This is a specialized project with limited membership. It is not listed on the EPRI website.

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Participating Organizations

EPRI
Hydro One
National Grid UK
CenterPoint Energy
Duke Energy
Con Edison
Manitoba Hydro

Technology Innovation Project Project Brief

TIP 23.5: EPRI P35: High-Temperature Low-Sag Conductor-Connector Systems

Context

Advanced High-Temperature Low-Sag (HTLS) conductors are being considered by the electric power industry as an alternative to conventional **ACSR (Aluminum Conductor Steel-Reinforced)** conductors. An HTLS conductor can tolerate higher temperatures and produce lower sags than conventional ACSR conductors. These features enable overhead power lines to attain higher power transfer capacities on the same corridor.

Research Question: Are there additional types of high temperature conductor-connector systems that allow BPA to expand knowledge and enable us to apply new technologies safely, reliably, and cost effectively to meet rising power demands?

Description

The HTLS conductor-connector systems were designed with the intent to increase the capacity of a line through re-conductoring without the need for new structures or additional right-of-way (no rebuild). This project will collect more information on the anticipated benefits, risks, strengths, and weaknesses of these systems, which potentially could result in more/less need for maintenance activities or new maintenance methods.

A continuation of the "Evaluation of High-Temperature Conductor and Connector Systems" project, this Phase II aims to evaluate additional types of HT conductor-connector systems to expand knowledge and enable utilities to apply these new technologies safely, reliably, and cost effectively to meet rising power demands.

Technical Approach:

- Submit conductor-connector samples to high temperature cycling
- Monitor and evaluate thermal stability and resistance of connectors
- Forensics of the materials following testing

Project tasks include:

- Evaluate the long term performance of **Aluminum Conductor Steel-Supported (ACSS)**, and **ACSS-HS285 (High Strength core)**
- Evaluate the effect of conductor cleaning methods on HT performance – standard brushing vs. "ConductaClean".
- Evaluate swage and helical wrap connectors.
- Evaluate mitigation devices for ACSS conductors such as Helical and Clampstar shunts.

Through this project, the performance of these conductors-connectors and associated splices and dead-ends will be evaluated, based on field trial and laboratory tests.

This work will result in a Service life prediction model for HTLS conductor-connector systems and a test protocol for high temperature connectors (ANSI C119.7)

Transmission line designers can use the model when making conductor selection decisions and to evaluate options for a line. For instance, a longer/shorter service life is a critical component from a life cycle cost perspective. The model can also be used to test results based on the type of conductor cleaning used to develop installation instructions for connectors.

Line designers will be able to reference ANSI C119.7 as a qualification test in BPA material specifications for HTLS connectors.

Why It Matters

Research results on ACSS and ACSS HS285 conductors can enhance industry's understanding of these conductors and offer the potential for line designers to assess the risks and apply these conductors properly, leading to improved public reliability and safety.

This project has future term applications addressing: Line capacity limitations, clearance limitations, right-of-way limitations, budget constraints for upgrades and rebuilds, and growing adverse public reaction to additional transmission lines

Strategic Alignment

The project aligns with **BPA's Strategic Plan**: Enhance the Value of Products & Services; Objective 7. Transmission Investments to Integrate Load & Resources

Goals and Objectives

Three objectives of this project are to develop:

- A tool to evaluate performance of high-temperature connectors,
- A guide to operate an overhead line reliably within given limits,
- A methodology to improve on high-temperature connector designs.

Deliverables

Three objectives of this project are to develop a tool to evaluate performance of high-temperature connectors, a guide to operate an overhead line reliably within given limits, and a methodology to improve on high-temperature connector designs.

TIP 23.5: EPRI P35: High-Temperature Low-Sag Conductor-Connector Systems

Project Start Date: January 1, 2014

Project End Date: Continuing

Links

Overhead Transmission (epri.com)

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Participating Organizations

Electric Power Research Institute (EPRI)

Technology Innovation Project Project Brief

TIP 23.7: EPRI P35: ACSR Conductor-Connector Systems at High Temperatures

Context

Over the past 20 years, utilities have been operating older lines at 100°C that were originally designed for a maximum temperature of 49ºC. Recently there has been a move to raise operating temperatures even further to well above 100°C in order to achieve higher power transfer capacity. Utilities are concerned as to how fittings on the existing lines will behave at the higher temperatures.

Between 2005 and 2009, EPRI conducted tests to evaluate the performance of compression fittings at elevated temperatures. Test results confirmed that certain fittings experienced temperature runaway above 100°C with subsequent reduction in their mechanical strength.

This project, previously called "Mitigation Measures for Compression Fittings for High-Temperature Operations" investigated different methods that can be applied to "high risk" compression fittings operating at high temperatures. While the investigated mitigation measures showed promise, the complete mitigated system must be well understood before these measures can be applied successfully. Further research to address these knowledge gaps will support practical application of these mitigation measures with confidence.

Research Question: When operating at high temperatures, does the aluminum of an ACSR conductor go into compression, adding tension to the steel core?

Description

This project builds on previously completed EPRI work evaluating shunt devices. BPA spearheaded this work and has since put it in to action by upgrading some lines to a maximum of 175ºC.

In this phase, the project will correlate surface temperature with the core temperature which controls conductor sag and clearances. IEEE 738 determines conductor surface temperature based on electrical loading and ambient weather conditions.

EPRI has already established a temperature window in which we know steel core wire galvanizing begins to break down. This work will narrow the window in order to increase confidence in operating aluminum-conductor steel-reinforced (ACSR) cable at high temperatures.

The project will study if, when operating at high temperatures, the aluminum of an ACSR conductor goes into compression, adding tension to the steel core.

Because a clean conductor is essential to establish an electrical connection between a shunt and conductor, this work will develop a device to chemically clean an un-cut conductor in a manner similar to EPRI's conductor cleaner used for splices and DE fittings.

The current equations used for predicting how quickly the aluminum will anneal were developed more than 50 years ago. Over that time the manufacturing process for aluminum strands has changed, and recent preliminary tests suggest that the equations may no longer hold true. This work will help develop updated equations that hold true to today's conductors.

Why It Matters

BPA needs to know how high we can rate conventional conductors to operate in a safe, reliable. By applying proper mitigation measures and understanding the complete mitigated system, utilities will be able to achieve an increase in transmission capacity without risking overhead line failures.

Results from this project will allow the setting of knowledgeable limits for many different conductor types providing expanded options for upgrading lines.

Strategic Alignment

The project aligns with **BPA's Strategic Plan**: Enhance the Value of Products & Services; Objective 7. Transmission Investments to Integrate Load & Resources

Goals and Objectives

The goal of this project is to correlate surface temperature with the core temperature which controls conductor sag and clearances.

The project also intends to narrow the temperature window to increase confidence in operating aluminum-conductor steel-reinforced (ACSR) cable at high temperatures.

Deliverables

- Galvanized Core Coating Study
- Annealing Equations Review
- Radial Thermal Gradient Study
- Resistance Evaluation at Elevated Temperatures
- Develop Dead End shunt with sufficient mechanical strength
- Elevated Temperature Creep
- Knee-Point Field Study (Predicted Sag-Tension vs. Aluminum Compression)

TIP 23.7: EPRI P35: ACSR Conductor-Connector Systems at High Temperatures

Project Start Date: January 2013

Project End Date: Continuing

Links

Overhead Transmission (epri.com)

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Technology Innovation Project Project Brief

TIP 25: EPRI Program 37 – Substations

Context

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. BPA partners with the **Electric Power Research Institute (EPRI)** to accomplish these goals.

EPRI Program 37 (Substations) membership provides an organizational effort to better coordinate research activities to address BPA's needs. Knowledge from data gathered is gained through this affiliation; but the primary focus is on finding and promoting EPRI projects that directly apply to bulk power transmission owners like BPA. BPA participants use their expertise in a particular area as well as the relevance of that subject to BPA needs and are expected to facilitate the involvement of other Subject Matter Experts (SMEs) in projects that can produce a demonstrable return on BPA investment.

This is a programmatic effort to formalize BPA's collaboration with EPRI so that the effort is more focused, with careful attention to a project's value added.

Research Question: How can we increase transmission capacity without making large capital investments? How can we reduce capital expenditures for new and refurbished equipment?

Description

BPA participates in EPRI's Power Delivery and Utilization sector of which we fund research in their program 37 *Substations* R&D portfolio. The R&D projects under this program consist of single and multiple year projects that are added or concluded during each program year.

BPA uses EPRI Program 37 for the following functions: Transformer life management; circuit breaker life management; substation maintenance management; SF-6 environmental management; emerging technology for protection and control; and other miscellaneous projects within the program portfolio.

The program offers a complete portfolio of tools and technologies along with resources such as failure databases and aging models to improve transformer and circuit breaker life management along with providing operation and maintenance engineers access to research results for developing strategies in extending equipment life, optimizing maintenance costs and reducing outages.

Why It Matters

BPA's participation in Program 37 allows the agency to collaborate with other national and international experts. Membership also provides access to a substantial library of written resources and technical reports; networking opportunities EPRI member utilities from around the world; and assures agency development of maintenance and design practices with a broader view of what issues, problems and/or limitations need to be addressed.

Goals and Objectives

Through Program 37, BPA expects to accomplish the following objectives:

1) Manage program involvement against a detailed annual plan that captures the information obtained from advisor and council meetings, and tracks actions determined out of task force meetings. This plan will also guide developing actions for BPA to leverage better value and applicability of EPRI R&D.

2) Continue to add the results of current EPRI R&D projects to BPA maintenance and asset management practices.

3) Contribute BPA's expertise to EPRI collaboration model in the following areas: Sulfur hexafluoride (SF6) management, transformer health and life expectancy management, condition-based substation equipment maintenance, switching safety, and protective relaying configuration management.

4) Report program status to management and the Collaborative Working Group.

5) Retain ability to become involved in future EPRI R&D projects, which is only available to active members.

Strategic Alignment

The project aligns with **BPA's Strategic Plan**: Enhance the Value of Products & Services; Objective 7. Transmission Investments to Integrate Load & Resources

TIP 25: EPRI Program 37 – Substations

Project Start Date: January 1, 2009

Project End Date: Continuing membership

Reports & References

Project Sets:
P37.101: Transformer Life Management
P37.102: Circuit Breaker Life Management
P37.103: Protection and Control
P37.104: Substation Corrosion Research
P37.105: Balance of Substations: Batteries, Arresters and Ratings
P37.108: GIS (Gas-Insulated Substations) & GIL (Gas-Insulated Lines)
P37.113: Polymer Bushing Life Management
P37.114: Substation Physical Security
P37.116: HVDC Converter Stations and Flexible Alternating Current Transmission System (FACTS) Devices
P37.117: Using Voltage and Current Measurements for Monitoring Asset Conditions

Links

Program 37: Substations | Overview (epri.com)

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BONNEVILLE POWER ADMINISTRATION

Technology Innovation Project Project Brief

TIP 272: EPRI Program 170 - Grid-Edge Customer Technologies

Context

The Grid-Edge Customer Technologies program evaluates and assists the development of end use technologies in the residential, commercial, and industrial sectors, conducting research and technology transfer through laboratory and field evaluation, as well as economic research.

Program expertise ranges across all non-transportation areas, such as air conditioning, water heating, appliances, lighting, motors and industrial devices, data centers and computer systems, water movement and processing, and the application potential of all such devices.

The program's research informs stakeholders that seek to facilitate customer adoption through utility incentive programs. This manifests through policies and initiatives supporting energy efficiency, demand response, decarbonization, equity, efficient electrification, and productivity improvements. Emerging end use loads with advanced capabilities, such as grid-interaction, power draw flexibility, resilience, customer controllability and real-time data creation, create both new opportunities and challenges.

Research Question: How can energy efficiency and demand response help maintain reliable, affordable service while reducing carbon emissions?

Description

TIP 272 covers the base membership in the EPRI Program 170 which is focused on the assessment of technologies, as well as research and analysis to understand end use loads of customers, and forecast the potential for energy efficiency and demand response.

The program consists of four project sets containing multiple projects each. The specific focus of each project is determined at the beginning of each year, informed by member input:

- Project Set A: Load Analytics and Grid Insights
- Project Set D: Technology Transfer and Education
- Project Set E: Efficiency and Decarbonization Evaluation
- Project Set X: Next-Gen Technologies and Demand Flexibility

Why It Matters

BPA has determined that in order to meet its energy efficiency goals cost effectively over the long term, it is necessary to conduct ongoing R&D and emerging technology research. This includes development and adoption of energy-efficient and demand response technologies to accelerate their adoption into utility programs, influencing the progress of codes and standards, and ultimately creating market transformation.

BPA's participation in EPRI Program 170 allows BPA to use the results of EPRI's research (available only to funding members), apply the results toward program offers to utilities, and to contribute to setting the agenda for their research. In addition, BPA is able to offer opportunities to PNW utilities to participate in research projects.

Strategic Alignment

The project aligns with **BPA's Strategic Plan**: Enhance the Value of Products & Services; Objective 6. Regional Carbon Reduction Efforts

Goals and Objectives

Objectives for this membership and associated staff support include the following:

- Reduced research cost to BPA, through shared costs of strategically influenced national research
- Development of additional measures ready for program implementation
- Development of strategies that meet both Energy Efficiency and Demand Response needs

TIP 272: EPRI Program 170 - Grid-Edge Customer Technologies

Project Start Date: January 2014

Project End Date: Continuing

Participating Organizations

Electric Power Research Institute (EPRI)

Links

Program 170: Grid-Edge Customer Technologies | Program Home (epri.com)

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BONNEVILLE POWER ADMINISTRATION

Technology Innovation Project Project Brief

TIP 367: EPRI P37: Power Transformer Through-fault Risk Assessment

Context

Transformers are designed to withstand certain levels of stress (number of through faults, fault magnitude and duration) based on their application. Over time as the transformer experiences multiple through-fault events the resulting stress impacts the transformer's survivability. BPA has substation busses with significant fault duty, in excess of 20 times normal rated current during a through-fault event, which can cause over 400 times the normal force on the winding.

In spite of these large forces on the transformer winding, very little research has been performed on quantifying the degradation during through-faults. By contrast, significant research has taken place and continues to take place on evaluating degradation of transformer insulation as the result of heat generated in the transformer during normal and abnormal transformer loading. However, on BPA's Transmission system the mechanical degradation from through-faults is likely as large if not a larger driver of transformer reliability than thermal degradation of paper insulation.

EPRI, with support from member utilities, initiated the development and testing of methodologies that use test, maintenance, nameplate, and historical failure performance to assess transformer condition.

Research Question: Is there are better methodology to assess the susceptibility of a power transformer to a through-fault failure?

Description

The project approaches the power transformer as a system of major subcomponents, including main body, load tap changer, dielectric fluid, bushings, cooling, and other auxiliaries. Transformers are designed to withstand certain levels of stress such as number of through-faults, fault magnitude, and duration. Over time, as the transformer experiences through-faults, the resulting stress impacts the transformer's future survivability.

The project encompasses the following tasks:

• Catalogue readily available pertinent data

• Develop an assessment methodology

• Develop algorithms

• Investigate transformer application and operational considerations

• Apply algorithms with utility data and review results

• Make appropriate enhancements

• Document methodology approach, results, and findings

The scope of work can be accomplished within approximately 18 months of project kickoff. However, actual scope and progress will be dependent upon funding level.

Why It Matters

Project results may help utilities reduce capital costs and maintenance through the application of analytics-based approaches for transformer asset management. This project will:

- Improve assessment of transformer susceptibility to through-fault failure.
- Enhance replacement strategies.
- Reduce capital and maintenance costs.

Strategic Alignment

The project aligns with **BPA's Strategic Plan**: Enhance the Value of Products & Services; Objective 7. Transmission Investments to Integrate Load & Resources.

Goals and Objectives

The objective of the research is to develop a new methodology to assess the susceptibility of a power transformer to a through-fault failure. The goal is to understand the impact as function of number of through-faults, fault magnitude and duration using readily available data and use results in utility transformer replacement strategy.

Deliverables

A comprehensive final report documenting the underlying methodology, approaches, and results of the above tasks will be delivered at the end of the project. Interim status reports and findings for individual tasks will be provided periodically.

TIP 367: EPRI P37: Power Transformer Through-fault Risk Assessment

Project Start Date: May 2016

Project End Date: December 2024

Participating Organizations

Electric Power Research Institute (EPRI)

Links

Web page not available for this project

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BONNEVILLE POWER ADMINISTRATION

Technology Innovation Project Project Brief

TIP 399: EPRI P34 Transmission Asset Management Analytics

Context

Transmission companies face challenges such as aging infrastructure, stringent operating requirements, financial constraints, and retiring expertise that make maintaining and managing assets difficult. In response, many electric utilities are considering or already have moved toward more analytically-based decision processes to minimize equipment life-cycle costs and risks. However, the data, analytical tools and models required for power delivery equipment risk assessment and management are not well-established. Diligent actions for maximizing performance and minimizing equipment life-cycle costs should be based upon risks associated with actual equipment condition and historical performance.

Research Questions: How can we base our actions for maximizing performance and minimizing equipment life-cycle costs upon risks associated with actual equipment condition and historical performance?

How can we develop better data analytical tools and models required for power delivery equipment risk assessment and management?

Description

The research agenda in this program focuses on: designing, developing, populating, maintaining, and extracting information from Industry-wide databases for substation equipment that will help quantify historical performance; developing condition assessment algorithms to understand and quantify existing performance; developing metrics to better assess and evaluate equipment performance; and constructing tools and methodologies to project future performance and manage risk. These elements can be designed as, and integrated into, a comprehensive decision support framework. The results of this research may support resource allocation decisions and other fleet management tasks and provide utilities with new knowledge and data vital for effective equipment asset management. Research results could be transferred to members in scientific reports, easy to use software tools, reference guides and workshops.

Research activities include:

- Develop data models that guide utilities on what data are important for developing failure rates, quantifying present condition (health) of in-service assets, prioritizing which assets need attention, formulating spares policies etc. ;
- Design, develop and populate an industry wide-database with failure and performance data for T&S assets, develop analytics using industry-wide data to uncover asset characteristics and metrics to support maintenance and capital planning strategies;
- Develop asset health assessment algorithms and risk mitigation strategies (e.g. spares policies, substation, bay, circuit and feeder risk assessments)
- Develop a consistent analytical basis for making capital and O&M decisions;
- Produce reference books, guidelines, and technology transfer workshops and
- Provide collaborative environments for sharing lessons learned and best practices.

Why It Matters

Decision support analytics and methodologies require new knowledge, tools and methodologies to help with the best allocation of O&M and capital resources for Transmission and Substations (T&S) asset.

This research can enhance asset management decision making processes and improve their results by providing data, tools and methodologies that can be used by T&S asset and maintenance managers for improved decision support.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Preserve Safe, Reliable System Operations; Objective 17. Compliance to Changing Requirements

Goals and Objectives

The objective of this program is to develop asset knowledge enablers, such as failure rates and asset health assessment algorithms, to help utilities make better T&S equipment life cycle management decisions.

Deliverables

In the current year the program expects to:

- New versions of - Power Transformer Expert System software
- New versions of - Industry-wide T&S Failure and Performance Database
- New versions of - T&S Asset Health Software
- New versions of - T&S Asset Management Guideline
- Reports documenting results and key findings from data mining and analysis of field inspection and assessment data on wood poles, overhead transmission line conductors, protection and control, CCVT's and underground transmission assets
- Asset Analytics Workshop.

TIP 399: EPRI P34 Transmission Asset Management Analytics

Project Start Date: January 2018

Project End Date: December 2024

Participating Organizations

Electric Power Research Institute (EPRI)

Links

Program 34: Transmission Asset Management Analytics | Overview (epri.com)

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Technology Innovation Project

Project Brief

TIP 408: Power Plant Control Optimization for Essential Reliability Services

Context

This project is a continuation of a multi-year collaborative effort between BPA Transmission and US Army Corps of Engineers (USACE) in the area of generator modeling, monitoring and control optimization. The project is continuation of the work started in earlier Technology Innovation RD&D projects referred to as Phase 1 (TIPs 274 and 313*) and Phase 2 (TIP 350*).

The first phase of generator model validation was successfully completed and developed tools adopted by USACE and BPA staff for improving generator models while reducing NERC compliance costs. The second phase completed in Sep. 2018 covers the state of PMU-based model validation and performance monitoring tools.

With the completion of phase 2, we can now report the dynamic performance of the entire FCRPS fleet. BPA's success was greatly publicized within the industry (NERC, WECC, NASPI).

Research Question: How can BPA advance the applications for power plant dynamic performance monitoring?

Description

The project is a continuation of a multi-year collaborative effort between BPA Transmission and US Army Corps of Engineers in the area of generator modeling, monitoring and control optimization. This project completes work started under TIP 313 and focuses on the optimization of generator primary controls (AVR, PSS, governors) to provide essential reliability services.

Phase 3 – Control Optimization for Essential Reliability Services will be accomplished in four tasks:

Task 1: Governor tuning for stable black-start operation (NERC EOP-005-3 Standard). Black-start is the essential reliability service. Tuning hydro-governors is challenging because of the water inertia effects. We experienced several cases when hydro generators failed to pick-up load in islanded conditions. We tested "proof-concept" tuning at Hills Creek and Chief Joseph plants. Under this project, we will continue development of analytical tools and performance tuning of FCRPS hydro-governors for isolated operations.

Task 2: Voltage control optimization and PSS tuning (WECC VAR Standards). Voltage control is an essential reliability service. Recent automatic voltage regulation (AVR) and power system stabilizers (PSS) performance issues at Libby and Chief Joseph, as well as oscillatory interactions between PSS and UEL at multiple power plants highlight the need for AVR optimization to meet voltage control and oscillation damping requirements. We started development of analytical tools and performed initial tests at John Day. Under this project, we will continue development of tools, test procedures to enable USACE HDC staff to perform AVR / PSS/ UEL control tuning and optimization at FCRPS plants

Task 3: Governor tuning to optimize frequency response (NERC BAL-003 Standard). There is trade-off between how fast governor responds and system stability. While we want to maximize the availability of frequency responsive reserves, we need to make sure that fast response does not result in the oscillation problems. We will study the trade-off from plant and the system perspectives to recommend the on-line governor response strategy (PID settings, use of load versus speed governor mode, etc.)

Task 4: Coordination between primary controls (governors), secondary plant controls (GDACS) and BA controls (BPA AGC). This task provides an interface between the BPA Grid Modernization project and this project.

Why It Matters

The benefits of the BPA generator modeling, monitoring and control optimization projects are indisputable. This work will reinforce FCRPS position to provide essential reliability services. DOE and FERC have emphasized the need essential reliability services like voltage and frequency controls, damping of power oscillations and black-start.

Results from this project will support:

- optimization of FCRPS generator controls to provide essential reliability services,
- reduced costs and risks of reliability compliance,
- optimized transmission capacity and reliability margins,
- improved equipment condition monitoring,
- promote professional development, and improve decision making.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Preserve Safe, Reliable System Ops; Objective 17. Compliance to Changing Requirements

Goals and Objectives

There are three main objectives for this project:

- improve Cost Management Discipline,
- modernize federal power and transmission system operations and supporting technology, and
- address load service, congestion, and new transmission service requests.

Deliverables

At the conclusion of this project, we will have a fully operational system with the following features:

- Governor tuning for stable black-start operation (NERC EOP-005-3 Standard). We will also provide analytical tools and performance tuning of FCRPS hydro-governors for isolated operations.
- Voltage control optimization and PSS tuning (WECC VAR Standards) We will provide tools and test procedures to enable USACE HDC staff to perform AVR / PSS/ UEL control tuning and optimization at FCRPS plants.
- Governor tuning to optimize frequency response (NERC BAL-003 Standard). This will include a study of the trade-offs between plant and the system perspectives to recommend the on-line governor response strategy (PID settings, use of load versus speed governor mode, etc.)
- Coordination between primary controls (governors), secondary plant controls (GDACS) and BA controls (BPA AGC).

TIP 408: Power Plant Control Optimization for Essential Reliability Services

Project Start Date: October, 2018

Project End Date: September 2024

Related Technology Innovation Projects

TIP 52: Generating Facility Performance Measures and Model Validation

TIP 274: Development and Demonstration of Applications for BPA and FCRPS Compliance with Modeling Standards and Performance Monitoring

TIP 313: Power Frequency Control: Phase 1- Model Development

TIP 350: Power Plant Dynamic Performance Monitoring Center

Acronyms:

- AGC – Automatic Generator Control
- AVR – Automatic Voltage Regulator
- DOE – Department of Energy, United States
- FCRPS – Federal Columbia River Power System
- HDC – Hydroelectric Design Center
- NERC – North American Reliability Corporation
- NASPI – North American Synchro Phasor Initiative
- PMU – Phasor Measurement Unit
- PSS – Power System Stabilizer
- RD&D – Research, Development and Demonstration
- UEL – Under-Excitation Limiter
- VAR – Volt Amperes Reactive
- WECC – Western Electricity Coordinating Council
- GDACS –Generic Data Acquisition and Control System

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Participating Organizations

US Army Corps of Engineers (USACE)
US Bureau of Reclamation (USBR)

Technology Innovation Project Project Brief

TIP 420: EPRI P183 - Cyber Security for Power Delivery and Utilization

Context

The landscape of cyber security activities in the electricity sector involves numerous industry, government, and regulatory groups. Although tracking these groups can be a daunting effort, it is critical for utilities to be up-to-date on key industry activities. This research area provides members with an up-to-date view of industry activities and supports technical contribution to these groups. It also supports white papers and working groups on key cyber security topics.

With increased attention focused on securing the electric sector, numerous industry groups and public-private partnerships have been created to develop new security requirements and technologies. Additionally, working groups of organizations such as the North American Electric Reliability Corporation (NERC), International Council on Large Electric Systems (CIGRE), Institute of Electrical and Electronics Engineers (IEEE), and the International Electrotechnical Commission (IEC) will continue to have a direct impact on utility operations.

These groups are addressing specific needs in the industry; however, utility personnel are often unavailable to support all of these efforts. This lack of availability can lead to two key issues. First, utilities are less aware of changes that might impact the industry. Second, manufacturers of security products may lack the perspective of the electric sector.

Research Question: How can we protect the electric grid from attacks by terrorists and hackers, and to strengthen grid resilience against natural disasters and inadvertent threats, such as equipment failures and user errors?

Current Key Activities

In 2024, this program expects to accomplish the following objectives:

- Collaboration: Track industry and government activities and provide technical contributions to key working groups.
- Incident Management: Improve the electric sector's ability to scan for devices and vulnerabilities in OT areas and better understand the true risks associated with those activities.
- Threat Management: Develop strategies and guidelines for using the latest generation of intrusion detection and prevention systems on the market designed to operate in the OT space.
- Cyber Security Forensics: Create additional ICS forensics field guides for OT devices and deploy a mobile field guide application for the guides.
- Transmission and Distribution Control Center Security: Develop a comprehensive control center model to determine cyber security requirements and solutions.
- Transmission and Distribution Substation Security: Develop a secure IED management guidebook that provides a comprehensive assessment of management requirements for intelligent substation equipment with a recommended substation management strategy.
- DER Security: Update the DER Cyber Security Guidebook to include considerations for cyber security engineering approaches for securing DER systems. Develop cyber security guidelines for DERMS to provide security architects and engineers with risk-informed and practical approaches for securing DER management systems.
- DER Technologies: Provide guidelines for deploying intrusion detection and prevention technologies (IDS/IPS) with DER systems. Develop security reference architectures for microgrids with a focus on the integration of community microgrids.
- Data Applications: Develop additional cyber security metrics, including resiliency metrics. Support metrics adoption and enabling benchmarks of relevant cyber security program performance. Develop data management strategies and strategies for utilizing machine learning and artificial intelligence.

This program provides monthly email updates to the members to summarize EPRI's industry activities and the status of its research projects.

Strategic Alignment

The project aligns with BPA's goals in the ***2024-2028 Strategic Plan:*** Modernize Business Systems and Processes; Objective 19. Strengthen Information & Operational Security

Why It Matters

The reports developed by this program provide BPA a reference point to track the detailed efforts of several industry groups. This program also increases the relevance and utility of the security reports, controls, and technologies that are being developed by these groups.

Goals and Objectives

BPA will use its membership in this program to gain a better awareness of industry and government collaborative efforts, where members can "plug in" to current activities; evaluate techniques for assessing and monitoring risk; evaluate tools and metrics to better assess security posture and return on investment; identify practical approaches to mitigating the risk of operating legacy systems; study early identification of security gaps through laboratory assessments of security technologies; and obtain technologies which support the management of cyber incidents and increase the cyber security and resiliency of the grid.

Deliverables

The Cyber Security Program focuses on developing security requirements, creating new security technologies, and performing laboratory assessments of existing, relevant technologies. The products may be used to enhance the current cyber security posture of the grid and increase the security of systems that are deployed in the future.

Key deliverables in this program include:

- Newsletters and whitepapers to address high-impact issues;
- Tools to support improved automation of incident and threat management processes;
- Security forensics field guides for industrial control systems;
- Integrated solution for device identification, configuration monitoring, and password management;
- Cloud security reference architectures for real-time applications;
- NERC CIP automation reference model;
- Security tools and guidelines for Distributed Energy Resources (DER) smart invertors, secure communications, and microgrid integration; and
- Guidance and tools for operationalizing EPRI's security metrics and Metrics Hub.

TIP 420: EPRI P183 - Cyber Security for Power Delivery and Utilization

Project Start Date: January 2020

Project End Date: December 2024

Links

EPRI Program 183: Cyber Security for Power Delivery and Utilization

Participants

Electric Power Research Institute (EPRI)

BPA Sponsoring Orgs: JB-Cyber Security, J-Information Technology

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Technology Innovation Project Project Brief

TIP 434: Dynamic Load Modeling Research

Context

Load models are a fundamental part of power system planning and operating studies. Better modeling enhances the identification of system needs, so that the correct corrective action plans can be put into place.

This project is a continuation of a multi-year effort among DOE, NERC, WECC, EPRI, and many other utilities in the North America to advance the state of dynamic load modeling. BPA has been one of the industry leaders in developing dynamic load models since 2002. The initial work was done in collaboration with DOE CERTS program, California Energy Commission, Southern California Edison, Pacific Gas and Electric, EPRI and many WECC utilities. The Phase One dynamic load model has been used in WECC since 2014, and is now required by TPL-001-4 Reliability Standard.

BPA TIPs 283 and 314 supported earlier efforts and the recently completed TIP 371 considerably advanced the model. *(Note: Acronyms are defined on the following page.)*

***Research Question**:* How to understand the load characteristics of commercially available level 2 and 3 electric car chargers and air source heat pumps that are designed to operate in extremely cold weather? How to understand their impact on system performance as we move towards low system strengths and low inertia systems?

Description

This project builds on and updates the Phase 1 composite load model. The work includes development of additional load composition data sets, collection of load disturbance data, and further model development and validation.

The project plan includes the following tasks:

Task 1 - Power electronic loads. Develop models for power electronic drives and electronically commutated models. We then work with software developers to implement the models in grid simulators working through NERC and WECC channels.

Task 2 – Load Composition Model. Update Load Composition Model with RBSA and CBSA information from BPA Energy Efficiency & NEEA. Scale up and apply Load Composition Model to major West-Side load centers at substation level by placing PPSMs with utility partners.

Task 2B – Conduct studies to determine the implication of significant electrification on transmission capacity needs to provide load service.

Task 3 – Load monitoring. Collect point-on-wave data for load model research and data analytics.

Why It Matters

The project leverages USDOE funded research (Lawrence Berkeley National Labs, Stanford Linear Accelerator Center, Idaho National Lab, PNNL) to improve BPA's load analytics and dynamic load monitoring capabilities in preparation for the ongoing transformation of end-use loads (DOE estimates 80% of electricity will flow through power electronic devices by 2030). The information from these improved models will guide BPA to make appropriate transmission investments to manage these changes.

Updated models will:

- lead to better Transmission investment decisions by addressing load service, congestion, and new transmission service requests,
- lead to better operational limits and real-time transient stability studies, and
- produce better forecasting and understanding of electrification on demand; supports Power Services resource adequacy studies and long-term capacity planning.

Strategic Alignment

The project aligns with BPA's goals in the ***2024-2028 Strategic Plan:*** Preserve Safe, Reliable System Operations; Objective 15. Grid Reliability.

Goals and Objectives

The goal of this project is to update BPA load models to reflect increasing electrification of economic sectors. This goal is supported by the following project objectives:

- The electronic loads test results will feed into development of the second-generation dynamic load models that is scheduled to start in 2021.
- Load data analytics using historic temperature and SCADA data will be used to validate and fine tune the Load Composition Models. The models are used in Transmission planning and operating studies.
- The project also collects the data needed to determine whether it is possible to target energy efficiency and electrification upgrades in a way that optimizes the need for transmission reinforcements and benefit customers.

Deliverables

Project deliverables are listed by the associated task.

Task 1 – Updated load profiles representing dynamic behavior of power electronic drives and ECMs.

Task 2 – Updated Load Composition Model with RBSA and CBSA information.

Task 2B – Significant electrification uses cases for the current WECC model.

Task 3 – Point-on-wave data from Load monitoring.

TIP 434: Dynamic Load Modeling Research

Project Start Date: October 2020

Project End Date: December 2024

Reports & References / Links

NERC TPL-001-4 Reliability Standard, www.nerc.com

WECC MVWG Load Model Report ver. 1.0, June 2012,

Related Projects

TIP 314-Load Research: End-Use Model Development

TIP 328-Real-Time Load Composition Estimation

TIP 371- Load Composition Analysis and Monitoring

Acronyms:

CERTS: Consortium for Electric Reliability Technology Solutions

CBSA: Commercial Building Stock Assessment

DOE (and USDOE): United States Department of Energy

ECM: electronically commutated motor

EPRI: Electric Power Research Institute

NEEA: Northwest Energy EfficiencyAlliance

NERC: North American Electric Reliability Corporation

PPSM, portable power station monitor

RBSA: Residential Building Stock Assessment

SCADA: supervisory control and data acquisition

WECC: Western Electricity Coordinating Council

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Participating Organizations

USDOE National Labs: Pacific Northwest National Laboratory (PNNL), Lawrence Berkeley National Labs, Stanford Linear Accelerator Center, Idaho National Lab,

Partner Utilities: Portland General Electric, Puget Sound Energy, PacifiCorp, Clark PUD, Cowlitz PUD, Snohomish PUD

TIP 435: EPRI TC – Power in Pollinators

Context

Bees, bats, butterflies, and birds provide critical pollination services to ensure that our food production is robust and abundant. In fact, one in every three bites of food that humans eat depends on pollinators. Many ecological webs are connected to the health of pollinator species, for example healthy vegetative communities that stabilize soil, support water filtration, and produce seeds for other wildlife. Serious declines in pollinator populations are causing global alarm for financial, health, and cultural reasons.

In response, domestic and international organizations including the **International Union for the Conservation of Nature (IUCN)**, U.S. Fish and Wildlife Service, U.S. Department of Agriculture and U.S. Environmental Protection Agency are leading research, defining conservation goals, and considering new policies.

Because of global concerns, the electric power industry is seeing increasing pressure from regulatory agencies, customers, and other stakeholders to consider pollinators in their operations. Since electric utilities manage large real estate holdings across vital pollinator habitat and migration paths, there is tremendous ecological potential not only to reduce impacts, but also to enhance pollinator habitat through well-designed and cost-effective actions.

Research Question: How can we reduce our impact to pollinator habitats and migration paths through well-designed and cost-effective actions?

Description

In late 2017, the Electric Power Research Institute (EPRI) created a collaborative initiative to accelerate the pace, scale, and effectiveness of electric power companies' pollinator projects. This effort is now the largest collaboration in North America designed specifically to support power companies and pollinators.

The Power in Pollinators initiative will develop tools to identify, catalogue, and quantify meaningful pollinator projects and commitments that;

- Identify opportunities for electric power companies to collaborate on specific conservation goals;
- Track agency actions and new scientific research findings on pollinators to inform decision making;
- Stay current with the latest pollinator science and the implication to power companies;
- Consider risk of action and inaction, the benefits of conservation programs, and the business case for justifying investments; and
- Network with leading scientists, land managers, and relevant regulators.

Why It Matters

The electric power industry has an opportunity to work together with other environmental organizations and industry groups on joint research and conservation efforts that result in greater measurable benefits to pollinator species.

An industry-level collaboration provides mutual benefits that can better enable corporate risk management, respond to stakeholder engagement, and structure long-term strategic asset management.

Goals and Objectives

EPRI is leading this initiative to encourage collaboration among members and outside experts to develop tools, metrics, and communication resources for programs supporting pollinators. Power companies, electric industry groups and other interested organizations will be able to use these tools and resources to pursue maximized benefits for pollinator ecosystems and the public.

Deliverables

Over the course of this collaboration, power companies will develop and have access to:

- Webcasts to advance technical work, host pollinator experts, and share best practices.
- Annual workshop to advance technical work, connect with other industries, organizations, agencies, and leading scientists.
- Technical briefs to provide easy-access information on key pollinator topics (i.e., business case) for executives and stakeholders.
- National Pollinator Week resources for power companies to utilize and customize to promote National Pollinator Week every June.
- Pollinator Project Database with a public-facing component to catalog your pollinator conservation efforts to and roll-up industry-level efforts.
- Industry-Level GIS Prioritization Tool to identify conservation opportunities using basic information related to land ownership, species ranges, and habitat types.

- Pollinator metrics identified and defined science-based metrics for guiding company investments, establishing goals, and tracking progress.

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TIP 435: EPRI TC – Power in Pollinators

Project start: January 2019

Project end: December 2024

Links

www.epri.com/pollinators

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EPRI Pollinator Portfolio

Pollinator Field Studies

EPRI's Transmission and Distribution: Environmental Issues (Program 51), has sought to understand the diversity of pollinator species in utility corridors. This multi-year research developed a preliminary field study protocol and testing on study sites in New York with the New York Power Authority, Ohio with FirstEnergy Corporation, and Alabama with The Southern Company and Alabama Power.

Insect and Vegetation Management Research

EPRI is now ready to apply the field study protocol developed in Transmission and Distribution: Environmental Issues research program to many more sites to build a national database of pollinator data that will inform Right-of-way management for pollinators.

The Monarch Butterfly

EPRI is working with the Xerces Society, a renowned international nonprofit organization that protects wildlife through the conservation of invertebrates and their habitats, to develop a report describing the conservation actions for monarch habitat protection, management, enhancement, and restoration that are compatible with transmission line vegetation and re-vegetation practices as well as more general power company properties.

National Pollinator Week

National Pollinator Week in June provides a chance to raise awareness with our colleagues, customers, and community about pollinators and sustainability. EPRI coordinates industry–wide participation through the Power-in-Pollinator Initiative. In collaboration with Pollinator Partnership, EPRI supports member companies to brainstorm and execute company-specific activities to demonstrate utility leadership and interest in pollinator conservation. Each company determines their own level of involvement. Activities can be as simple as including an article in a monthly employee newsletter or as complex as hosting customer-facing plantings and corporate headquarter displays.

Technology Innovation Project

Closing Project Brief

TIP 438: EPRI Supplemental – Forest Grove-Tillamook 115kV Outage Monitoring

Context

EPRI has developed a suite for radio frequency (RF) monitors for both substations and overhead line applications. There are multiple types of RF monitors that can be selected in any combination to monitor a line or substation depending on the use case.

Project Description

This project supports BPA's Forest Grove–Tillamook No. 1 (115 kV) Outage Investigation, where a number of unknown outages have occurred.

By deploying two types of the EPRI RF monitors, Leakage Current and Conductor RF Monitors, the root cause could be identified, and certain root causes eliminated, thereby allowing the identification and selection of mitigation approaches. If adopted, the results of this research may also support the future design of transmission lines in the area.

RF Monitors were installed to identify any impacts to the phase conductors from trees and limbs; measure any excessive conductor motion; and measure leakage currents on insulators due to contamination.

In addition, local weather parameters were measured to determine the conditions under which the outages occurred. Analyzing and correlating this data with outage occurrences may offer insights into the root causes.

Two monitoring locations were installed based on a review of the outage report. The RF monitors and base stations were installed, and the data monitored on EPRI IT and data visualization systems for an extended period. This allowed sufficient time to acquire information that would support decision making on whether to engage in more widespread deployment.

Research Questions: "What is causing the outages on transmission lines?

What mitigation approaches provide insight into the RF monitor measurements and their impact on informed decision making?

Benefits

Understanding of the root causes of outages promotes the reliability of the electric transmission and distribution system to supply energy in the region. Adoption of the research results from this study may also aid in the future of transmission line design, and thereby improve performance and safety in bringing electric power to the public.

Strategic Alignment

The project aligns with BPA's goals in the ***2024-2028 Strategic Plan:*** Preserve Safe, Reliable System Operations—Objective 14. Risk-Based Decisions & Portfolio Optimization.

Accomplishments

This project successfully accomplished its two main goals:

1. Increase understanding of the unknown outages on transmission lines under study and the potential mitigation approaches.
2. Provide insight into the RF monitor measurements and their impact on informed decision making.

Application:

Adoption of the research results from this study will aid in the future of transmission line design, and thereby improve performance and safety in bringing electric power to the public.

Deliverables

The project provided sensor equipment as well as visualization and analytical tools to support the work.

1. Twelve Leakage Current RF Monitors, Twelve Conductor RF Monitors, Four Cameras, and Two Base Stations (Physical Deliverables)
2. Data Hosting and Visualization: Visualized data on EPRI's Data Visualization website for twelve months with alarms.
3. Brief Summary Report of Conclusions and Recommendations

The non-proprietary results of this work were incorporated into EPRI R&D Program 35, and made available to the public, for purchase.

TIP 438: EPRI Supplemental – Forest Grove-Tillamook 115kV Outage Monitoring

Project Start Date: January 2020

Project End Date: September 2024

Links

Electric Power Research Institute

www.epri.com

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Conclusion:

Monitoring of the application of project deliverables continues.

After some delay due to personnel changes, EPRI produced two reports:

Monitor the Issue, Solve the Issue (Report No. 30020172) describing the EPRI Radio Frequency (RF) Monitor Suite, a collection of monitors that provide information on the health of a range of transmission line and substation assets.
Leakage Current RF Monitors (Report No. 3002020173) describing two types of leakage current monitor; one for long rod, composite and substation post insulators, and another for glass or porcelain disc insulators.

These reports are available to the public on the EPRI website.

Technology Innovation Project Project Brief

TIP 439: EPRI - Methods to Improve Climate Modeling for Transmission Ratings

Context

Utilities rely on accurate knowledge of weather conditions and conductor properties to estimate transmission line ratings and capacity. When values used in this analysis are not precisely known, utilities resort to using fixed assumptions. Utilities aim to leverage the best available data when making decisions regarding their ratings; however, this data typically does not come from transmission corridors. Therefore, despite being the best available, the data may not well represent the specific conditions to which a transmission line is exposed.

To alleviate the issue of insufficient data, utilities can deploy monitoring technologies on their systems. However, there are significant costs to fully instrument large transmission systems. There is a clear need for developing ways to improve the efficiency of monitoring using computer modeling.

Research Question: How can we develop ways to improve the efficiency of monitoring using weather conditions and conductor properties to estimate transmission line ratings and capacity?

Project Description

This research seeks to better understand the modeling approach and weather models developed by **Idaho National Laboratory (INL)** and the **National Oceanic and Atmospheric Administration (NOAA)**. This can lead to an improved understanding of accuracy and risk of this new approach. These findings are expected to provide information on the required number of ground-based measurements are needed to reliably provide a line rating.

The following tasks are planned under this project:

1. Site modeling and weather data collection
Deploy monitoring and develop models required for later tasks. There will be three weather stations installed by Funder, with EPRI guidance and support. Line specifications and nearby topography will be used to develop local models needed for weather modeling efforts.

2. Line rating risk analysis
Identify what (if any) risks exist to transmission assets if they were operated to rating values provided by the **Computational Fluid Dynamics (CFD)-**enhanced weather model as compared to direct measurements of weather conditions. This should include any known margin of error and information on risk tolerance provided by the utility.

3. Technology transfer / reporting
The technology transfer and reporting activities under this project are listed under Deliverables.

Strategic Alignment

The project aligns with BPA's goals in the ***2024-2028 Strategic Plan:*** Mature Asset Management; Objective 13. Asset Management Data and Systems.

Why It Matters

Improved weather information can lead to more accurate line ratings. This can allow utilities to relieve congestion and postpone system upgrades, which makes more efficient use of existing systems. The weather information can also be used to reduce risks of pushing transmission assets beyond design limits, resulting in a safer more reliable power grid for the public.

Goals and Objectives

The goals for this research are:

- Demonstrate how weather monitoring and modeling can be used in conjunction to determine real time conditions of transmission lines, and provide access to real-time data.
- Provide a transparent non-biased assessment of the CFD-enhanced modeling approach developed by INL and NOAA.
- Identify methods to reduce the number of monitors required to safely and accurately determine the operating condition of transmission lines.
- Provide improved information on line ratings, ratings risk, and system capacity without the need for extensive monitoring.
- Identify approaches that may reduce the amount of monitoring required.

Deliverables

The intended deliverables include:

1. PowerPoint interim report
2. Monthly status updates (written or presented via webcast)
3. Remote access to EPRI field data (i.e., weather data collected under Task 1)
4. Final report detailing the analysis and results.

TIP 439: EPRI Methods to Improve Climate Modeling for Transmission Ratings

Project Start Date: September 2020

Project End Date: April 2024

Links

EPRI webpage for this project not available.

Participants

Electric Power Research Institute (EPRI)

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Technology Innovation Project Project Brief

TIP 442: EPRI P40C: Methods and Frameworks for Advancing Transmission Planning

Context

Traditional power system planning methods and tools are increasingly challenged in today's power system environment. Transmission operators not only need to plan for future demand growth and increasingly uncertain generation portfolios, but also to provide transmission services for scenarios with distributed resources and central generation resources that include significant portions of variable generation (VG) technologies that have significantly different dynamic behavior from synchronous generation.

Additionally, the electric power industry is experiencing rapid physical, institutional, and regulatory changes that increase uncertainty and may have ramifications for reliability and the cost of providing reliable electric service.

As such, it is becoming more difficult for planners to evaluate all near- and long-term reliability considerations when considering planning projects. The existing deterministic planning processes and tools are not adequate to address these challenges and may result in a failure to study a particular scenario that may have reliability implications, or they support the tendency to over-build the system to account for the uncertainty.

Research Question: How can a risk-based planning method provide a framework that can address the dimensionality introduced by the uncertainties in data and forecasts?

Project Description

This project will develop new risk-based analysis methods and tools that can be integrated with existing planning processes to explicitly consider many of these uncertainties for optimum planning decisions.

The project comprises of the following work streams:

1. Resilient System Investment Framework (RSIF)

RSIF is a research-grade investment framework to assess impact of different projects on system resiliency. The task will also collaborate with EPRI's Energy Systems and Climate Analysis (ESCA) team to use the framework to evaluate issues associated with climate-related extreme events.

2. Risk-Based Framework for Assessing Transmission Reliability & Investment Decisions

This a risk-based investment framework addressing several uncertainties to compare various system reinforcement options for improving system reliability. As a part of Scenario Builder tool, it will identify critical power flow scenarios to capture variability in generation and loads, impact of generation retirements, and planned outages.

In addition to other capabilities, it will extend the existing deterministic planning process to compute probabilities of transmission planning contingencies as defined in the NERC TPL-1-4 standard using forced outage statistics.

3. Outage Statistics and Data Analysis

Outage data is a critical piece of information needed for risk-based analysis. This task focuses on updating the generic data used in the Outage File Creation Tool (OFCT) from NERC"s TADS and GADS databases for transmission and generation outages respectively.

4. Coordinated Expansion Planning

This task improves the research grade coordinated expansion planning framework tool developed for BPA by Iowa State University and Johns Hopkins University incorporating user-friendly features and easy to understand documentation. Other improvements will increase modeling fidelity for representing temporal dynamics (for example, hourly and sub-hourly intertemporal couplings in expansion models).

Why It Matters

In addition to providing transmission planners with modernized methods and tools that can cope with the changing generation and transmission landscape, this project supports the resiliency and hardening of the power system’s infrastructure in the face of increasing threats from natural disasters (hurricanes, tornados, earthquakes, GMD, etc.) and man-made events (cyber attacks, terrorism, electromagnetic pulse, etc.)

Strategic Alignment

The project aligns with **BPA’s 2024-2028 Strategic Plan**: Preserve Safe, Reliable System Ops; Objective 15. Grid Reliability

Goals and Objectives

The goal of this project is to improve transmission planning capabilities in three areas: Provide a unique framework to compare how various transmission reinforcement options impact system reliability; Help planners extend their deterministic transmission planning process to progressively include probabilistic concepts to better quantify the impact of uncertainties; And provide a practical framework to look at potential benefits of coordinated expansion planning in making optimal economic, reliability and resiliency decisions.

Deliverables

The deliverables from this project include:

- improved EPRI Risk Based Planning Scenario Builder planning tool.
- modified and updated Resilient System Investment Framework (RSIF) and
- upgrades for Risk-Based Framework for Assessing Transmission Reliability & Investment Decisions tool.

Other deliverables include:

- technical white papers documenting content for dashboards, various visualization technologies, and describing underlying data sources that may inform technology selection.
- guidelines for developing RFPs; addressing what questions utilities may need to ask; and guidelines vendors may use to incorporate utility requirements into their platform design.
- templates of asset modeling and performance information with attribution definition for two assets that may simplify data gathering across industry applications.
- technology transfer workshops
- utility experience sharing; e.g., asset health system evaluation, implementation and business case examples.

TIP 442: EPRI P40C: Methods and Frameworks for Advancing Transmission Planning

Project Start Date: January 2021

Project End Date: December 2024

Links

EPRI Program 40: Transmission Planning

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Technology Innovation Project Project Brief

TIP 448: EPRI – Low Carbon Resource Initiative (LCRI)

Context

The energy system is rapidly transforming. The change is driven by economic growth, dynamics in the relative costs of regional fuel supplies, growing deployment of renewable resources, diversity of generation sources, and increasing societal demands for clean and sustainable energy.

Looking forward, economy-wide decarbonization is emerging as a key focus for the energy systems of nations, regions, cities, corporations and individuals. Economy-wide decarbonization, however, requires substantial technology advances, a refocusing of energy investment and a dramatic acceleration of the current pace of change.

The **Electric Power Research Institute (EPRI)** and the **Gas Technology Institute (GTI)** are addressing the need to accelerate development and demonstration of zero- and low-carbon energy technologies.

The Low-Carbon Resources Initiative (LCRI) is targeting fundamental advances in a variety of low-carbon electric generation technologies and low-carbon energy carriers. These carriers—such as hydrogen, ammonia, synthetic fuels, and biofuels—are needed to enable affordable pathways to economy-wide decarbonization by mid-century.

Research Question: How can we assist efforts to accelerate development of technologies that enable safe, affordable, reliable, resilient, and sustainable economy-wide decarbonization?

Project Description

The LCRI brings together diverse organizations in the energy industry with their unique perspectives on decarbonization goals. Their collective support will assist efforts to accelerate development of technologies that enable safe, affordable, reliable, resilient, and sustainable economy-wide decarbonization.

This five-year initiative provides a centralized, collaborative platform to identify and accelerate development of promising technologies from around the world, to demonstrate and assess the performance of selected key technologies and processes and identify possible improvements, and to inform key stakeholders and the public about technology pathways and options.

The Bonneville Power Administration (BPA) is a sponsor of the initiative and joined the **LCRI Board Working Group (BWG)** in an advisory capacity to share its unique perspective and provide input on issues and direction.

Additionally, BPA supports LCRI initiatives with a comprehensive platform to test and integrate new technologies that expand grid flexibility and understanding of potential market transactions.

Why It Matters

Accelerating the development and demonstration of low-carbon energy technologies for large-scale deployment to 2030 and beyond will help reduce long-term environmental consequences.

This initiative may help reduce the public costs and risks in the transition to a low-carbon energy system by guiding effective energy investments in new and repurposed assets, potentially leveraging established infrastructure, and accelerating development of the new technologies needed to make the transition viable and affordable.

By participating in this initiative, BPA will gain strategic awareness of issues addressed by the LCRI.

BPA will focus on LCRI research areas that:

- Provide insight into customer options and their potential decisions
- Inform of latest zero- and low-carbon technology developments and policies surrounding clean energy sources
- Support awareness for Transmission Planning on interconnection of low carbon generation sources and potential customer uses.
- Create understanding of zero- and low-carbon generation profiles/characteristics, and its dispatchablility as a resource for grid stability, demand response, etc.
- Sends a signal that BPA supports customer utilities' desire for local, renewable, energy resources
- Responses to climate change (and the potential for drought conditions)) that will require additional sources of zero- and low-carbon generation and necessitate new planning to account for possible impacts to BPA's transmission system.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Preserve Safe, Reliable System Ops; Objective 16. Resiliency for High Impact Events

Goals and Objectives

The Low-Carbon Resources Initiative is a five-year, focused R&D commitment to develop pathways advancing low-carbon technologies for large-scale deployment. The goal of the initiative is to enable a risk-informed understanding of options and technologies enabling significant economy-wide decarbonization through global partnerships and demonstrations, applied engineering developments, and technology acceleration of the most promising options.

Deliverables

The following key deliverables will be produced by the LCRI in Phase 1 and made available to members through reports, forums and other media.

1. Industry and Stakeholder Forums
2. Stakeholder Communication Plan
3. Current State Review and Gap Analysis: Roadmap to low-carbon future to understand the past and current R&D in the technical area
4. Integrated Energy System Analysis
   a. Updated REGEN
   b. Economy-wide Decarbonization Assessments
5. LCRI: State of Technology Series
6. Defined R&D plan for each technology area that will consider technology acceleration, bench-marking, and pilot-scale demonstrations with defined milestones, metrics and a stage-gate processes.

TIP 448: EPRI – Low Carbon Resource Initiative (LCRI)

Project Start Date: October 2021

Project End Date: December 2025

Links

EPRI Home/LCRI

LCRI-Earth Week 2021 (YouTube)

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Technology Innovation Project

Project Brief

TIP 449: EPRI – Demonstration of Geomagnetic-Induced Current (GIC) Real-time Monitoring and Measurement System

Context

Solar storms that strike the earth are called **Geomagnetic Disturbances (GMD)**. These phenomena can cause **Geomagnetically Induced Currents (GIC)** in the transmission system that can result in half cycle saturation of transformer cores, which in turn may result in transformer overheating, harmonics and VAR consumption. These in turn may result in unexpected outages or transformer failures impacting the reliability and resiliency of the transmission system.

While power system disruption by GMD is a known and ongoing concern with regional impact implications, the ability to directly measure what is actually occurring in real time on a transmission grid during a solar storm is extremely limited. Measurements needed at the **high voltage (HV)** connection of transformers are not possible because sensors that operate at system voltage are still in development and are not commercially available.

The lack of real time GIC measurement severely hinders system operators from effectively managing GIC flow to minimize the adverse impact to our power transformers. Live GIC measurement would enable the ability to better manage actions taken to reduce GIC impacts during GMD events, and to know if the action taken was effective.

EPRI and BPA designed and tested prototype sensors in 2020 – 2021 in the first phase of this project (TIP 403). Phase 2 captures learnings obtained from Phase 1, and intends to validate the refinements made to sensor operating characteristics, expanded application configurations, and their ability to provide live measurements to system operators.

Research Questions: How can we effectively manage GIC flow to minimize the adverse impact to our power transformers?

Description

In order to address the limitations of measuring GIC currents only on the neutral line of transformers, EPRI developed a "clamp on" sensor that is attached to the energized terminals of a transformer with application and functionality demonstrated in Phase 1. This Phase 2 project, will demonstrate the additionally refined GIC measurement sensors to evaluate how they addressed shortcomings and learnings out of the phase 1 demonstration project. The expectation is that BPA will be able to deploy these sensors as a component of our GIC measurement system.

Further, this project will demonstrate application, economic value, and usefulness of a ***sensor suite*** that provides direct measures of GIC current, harmonics, and transformer vibration in HV locations where real-time information during a GMD event in needed by system operators. It will also demonstrate value in use for post event analysis, and open the door for potential economic value in the area of disturbance monitoring and event reporting for compliance with regulatory entities as a contracted service over using an in-house resourcing approach. The project also adds demonstrating use as real time measurement input to system operators via SCADA.

If successful and deployed as a standard component of our GIC measurement system, it will also address the present problem of short life expectancy and unreliable operation the GIC neutral sensor we are currently using. The failure rate and unreliable operation of the presently used GIC sensors is a significant risk that they will not be operation at times we need them.

Why It Matters

Direct measurement of GIC flow through interconnections with foreign owned facilities and networks will provide a known value instead of assumed and estimated values presently derived using simplified and un-calibrated models. In addition to improving system operating decisions, direct measurement data from HV locations within a transmission network will be extremely valuable in calibrating network modeling for recently developed GIC study software tools. Successful deployment of this technology will lead to developing more effective software modeling of network boundaries and enable GIC study results with closer representation of actual GIC conditions impacting transformers.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Preserve Safe, Reliable System Ops; Objective 16. Resiliency for High Impact Events

Goals and Objectives

The goal of this project is to bridge the gap in measurement needs by producing what will be commercially available GIC sensors that operate at system voltage and supports improvements to BPA's GIC measurement system.

Application

This project provides actual measured values the science, assumptions, and modeling used in the mathematical computations that can be validated and refined. Because the installation is of a modular configuration using non-wired clamp on sensors, it also demonstrates the possibility of using a single system to assess multiple transformers over time within a station or at other locations of interest.

Deliverables

The non-proprietary results of this work will be incorporated into EPRI R&D Program 37 Substations. Equipment and devices installed for this project will provide deliverables as follows:

- Tillamook Substation: 2 bus or conductor type GIC sensors; 1 Neutral; and 1 vibration
- Tillamook base station with 4-20mA base SCADA interface and enable faster data rate
- Bell substation: Upgrade 2 existing RF Monitors to Bus GIC sensors for Phase A, use existing tank wall vibration sensor (1). 2 new Bus type GIC Sensors on B-phase, replace conductor sensor on B-phase 500 kV 4-cable bundle connection (to assess equal current split on bundle), 1 Neutral GIC RF Monitor, and 1 vibration.
- Upgrade Bell base station to collect faster data and integrate 4-20mA interface to BPA SCADA
- Develop and test 4-20mA integration solutions
- 1 year of monitoring

TIP 449: EPRI – Demonstration of Geomagnetic-Induced Current (GIC) Real-time Monitoring and Measurement System

Project Start Date: October 2021

Project End Date: June 2025

Related Projects

TIP 403: EPRI P40: GIC RF Sensor Demonstration

TIP 398: NRCanada: Geomagnetic Induced Current Simulator

Links

EPRI webpage for this project not available.

Participating Organizations

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Technology Innovation Project Project Brief

TIP 452: EPRI P40A Model Development, Validation, and Management

Context

Rapid changes to power generation and transmission operations resulting from increased **Distributed Energy Resources (DER)** and alternative energy supply has become available long-term transmission planning becomes more critical and complex. This program provides planners with new tools and continues development of existing tools.

Furthermore, the ongoing coordination function with peers and regulatory agencies conducting similar work ensures BPA is up to date.

Proper modeling of power plant equipment and transmission devices **like High Voltage Direct Current (HVDC)** and **Flexible Alternating Current Transmission System (FACTS)** is a critical part of power system simulation studies.

Research Question: How can transmission planners stay up to date on new tools and continued development as more DER and alternative energy supplies have become available?

Project description

This research project leverages multidisciplinary subject matter expertise within EPRI as well as well-known experts from the industry to develop, refine, and benchmark various generic models as needed by the transmission planners.
Testing - EPRI's tried and tested vendor engagement is pivotal ***i***n working closely with software vendors to implement the generic models they developed as standard library models in their respective platforms.
Demonstration - The efficacy of the developed models is ascertained through pilot studies performed with this project. Additionally, the project team collaborates with utility members to perform case studies via supplemental projects for widespread usage of the models.
Industry Collaboration - Lastly, the project team actively engages with industry groups like **Western Electric Coordinating Council (WECC)** and North American Electric Reliability Corporation (NERC) Load Modeling Task Forces, WECC **Renewable Energy Modeling Task Force (REMTF)**, WECC HVDC TF, and NERC System Planning Impacts of DER (SPIDER).

Why it matters

The core value of this research lies in developing better representation of power system components that will help transmission system planners make judicious planning decisions, in particular:

1. Modeling for power flow and dynamic studies forms the backbone of transmission planning to ensure reliability as well as judicious investment decisions. The research performed in this project ensures fidelity of the standard library models that are widely used for reliability assessments and investment decisions.
2. Comprehensive, reliable, easily accessible one-stop repository of the latest industry developments on various activities related to model development, refinements, benchmarking, and use cases for load, DER, power-electronics based transmission technologies, and synchronous power plants.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Mature Asset Management; Objective 14. Risk-Based Decisions & Portfolio Optimization

Goals and objectives

The goal of this project is to advance the state-of-the-art on models and model validation approaches used for transmission planners across the world.

Specific objectives include but are not limited to:

- Helping utilities with modeling of DERs for transmission stability studies including assessment of interconnection requirements such as the IEEE Std 1547-2018
- Benchmarking new or refine generic models related to HVDC, FACTS, DER, synchronous power plant components across major software platforms used by utilities in North America and around the world
- Developing succinct guidelines, use cases for T&D co-simulation, network reduction techniques and other modeling related topics to help planners gain insights
- Technology and knowledge transfer through various EPRI forums as well as other meetings organized by industry stakeholders such as NERC, WECC, IEEE, and NATF.

Additionally, BPA is interested in developing understanding of hyper scale data center loads – load composition, and demand response capabilities.

Application

Primary application is to enhance long-term development and growth of the BPA Transmission program. Current models will be updated and validated. New models may be incorporated.

Deliverables

In 2022 the program goals include:

1. Refine DER_A model to include features such as extended dynamic voltage support and active anti-islanding schemes;

2. Use laboratory testing as well as field measurements (if available) to better characterize inverter behavior across different vendors and inverter types for validation of DER_A model;

3. Continue to refine and enhance DER modeling guidelines for transmission planning studies;

4. Explore the development of a DER aggregation framework that can be used to collect DER related data from distribution operations and planning and be used to parameterize the DER_A model;

5. Explore the application of T&D co-simulation framework to identify and analyze the interactions of DERs with the loads and leverage the framework for guiding engineers on using aggregated models to capture the effect of distribution dynamics with high fidelity;

6. DER representation in transmission system in the context of FERC Order 2222 and with increased presence of distribution connected energy storage devices.

TIP 452: EPRI P40A Model Development, Validation, and Management

Project start date: April 2022

Project end date: December 2024

Links

EPRI Program 40: Transmission Planning

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TIP 453: EPRI Climate READi – Power Resilience and Adaptation Initiative

Context

Energy companies, regulators, policymakers, and other industry stakeholders require science-based insights about the future power system and the environment in which it will operate to identify optimal adaptation and resilience investments.

EPRI recognizes the many risk management tools, processes, standards, and guidelines used by power sector organizations today. However, to meet society's electricity decarbonization and climate resilience needs, the power sector must coalesce around a standardized and consensus-based framework to inform infrastructure investment and Deployment.

Research Question: How can BPA inform infrastructure investment and deployment while addressing climate-related risk as it evolves?

Project description

Climate READi™: Power (REsilience and ADaptation initiative) enables global energy companies, climate scientists, regulators, and other stakeholders to proactively analyze and apply climate data, allowing for the planning, design, and operation of resilient energy systems of the future.

The three-year project facilitates analysis and application of appropriate climate data among all stakeholders providing a broadly accepted Common Framework that will embody among the most comprehensive approaches to physical climate risk assessment.

- COLLABORATIVE approach to driving stakeholder alignment on adaptation objectives with power system requirements, how to apply cost-benefit analysis for managing climate risk and identify efficient and effective resilience investments.
- CONSISTENT approach for power system stakeholders to apply climate-related information, including extreme weather and localized climate data trends and projections at the asset level, with guidance for specific asset/system vulnerability analyses.
- COMPREHENSIVE guidance on the specific climate and secondary physical data needs, datasets, variables, specification, suitability, and interpretation to facilitate a vulnerability assessment of the power system including characterization of how to treat the inherent uncertainty in climate and ecosystem modeling for applications.

Why it Matters

What were 1-in-50 or 1-in-100-year extreme events of the past are now increasing in frequency, and as society increasingly turns to electricity as an alternate to fossil fuels, the **Electric Power Research Institute (EPRI)** is strengthening the power sector's collective approach to managing climate risk to power systems. The Climate READi Initiative can provide valuable insights and capabilities to proactively strengthen and reinforce power systems against the disruptive impact of extreme weather events.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Enhance the Value of Products & Services; Objective 6. Regional Carbon Reduction Efforts

Goals and objectives

Climate READi will provide a platform that enables a comprehensive, consistent framework to ensure a resilient energy system.

The goal of this project a standardized and consensus-based framework to inform infrastructure investment and deployment while addressing climate-related risk as it evolves.

Collaboration across the electric industry is emphasized for investment in resilience on behalf of the customers and communities served.

Application

Primary application is to enhance climate-related risk planning and impact of regional electrification for long-term investments and growth of the **Federal Columbia River Power System (FCRPS).** Current models will be updated and validated. New models may be incorporated.

Deliverables

Planned deliverables include:

- Published guidance and educational resources for using climate data for specific power system assets and system vulnerability assessments, including how to treat the inherent uncertainty in climate variables.
- Guidance on available data resources and how to apply it considering the spatial and temporal uncertainty, and current capabilities, in climate and ecosystem information.

- Methodologies to understand the ability of existing assets, which have been in-service for decades and were designed to different standards, to withstand future extreme events.

TIP 453: EPRI Climate READi – Power Resilience and Adaptation Initiative

Project start date: September 2022

Project end date: December 2024

Links

EPRI Climate READi Initiative

Participants

Electric Power Research Institute (EPRI)
Pacific Northwest National Laboratory (PNNL)
National Oceanic & Atmospheric Administration (NOAA)
National Center for Atmospheric Research (NCAR)
There are approximately 100 participants from the Electric industry and other interested organizations.

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Initiative Work Plan

Workstream 1: Physical Climate Data and Guidance

Major Tasks:

- Identify climate hazards and data required for different applications
- Evaluate data availability, suitability, and methods for downscaling & localizing climate information
- Address data gaps

Year 1 Planned Deliverables:

- Climate 101
- Conceptual Framework
- Climate Data Inventory-PHASE 1

Workstream 2: Energy System & Asset Vulnerability Assessment

Major Tasks:

- Evaluate vulnerability at the component, system, and market levels from planning to operations
- Identify mitigation options from system to customer level
- Enhance criteria for planning and operations to account for event probability and uncertainty
- Literature Review Series
  - Nuclear
  - Non-Nuclear Thermal
  - Renewable Generation
  - Transmission & Distribution
  - Distributed Energy Resources
  - End Use
  - Cross-cutting Operations

Workstream 3: Resilience / Adaptation Planning & Prioritization

Major Tasks:

- Assess power system and societal impacts: resilience metrics and value measures
- Create guidance for optimal investment priorities
- Develop cost-benefit analysis, risk mitigation, and adaptation strategies
- Literature Review

Technology Innovation Project Project Brief

TIP 457: EPRI Supplemental— Screening and identification of need for grid-forming in future BPA network

Context

An increase in the percentage of **Inverter-based resources (IBRs**) in the **Western Electric Coordinating Council (WECC)** territory and the Pacific Northwest, as well as varying levels of availability of hydro generation have triggered a need to understand whether **Grid forming (GFM)** capabilities may be needed. And, if these capabilities can be provided by energy storage elements such as batteries to ensure reliability and security of future power supply.

Further, a potential reduction of gas generation levels around the cities of Portland and Seattle can result in low short circuit areas. In these regions, there could potentially be a need for dynamic VAR devices such as STATCOMs, which could also provide grid forming capability.

Research Questions: What is BPA's need for grid forming resources in our operations territory? What is the technical minimum capability that may be desired and standardized with GFM technology?

Project description

This project specifically studies the following:

1. Identification of location and size of required GFM devices in BPA footprint to improve reliability and stability of future power system,
2. Ascertain the value of interconnecting GFM at an earlier stage of the power network transition, and
3. Evaluation of the use of generic GFM models.

Project Tasks include:

Task 1: Data Collection

- **Positive Sequence Load Flow (PSLF)** file of future network with increase in inverter-based resource penetration and reduction in hydro and gas generation; preferably two or three different percentages of IBRs in increasing order
- Contingency list to observe change in system strength and stability,
- PSLF .dyd file of the network,
- Details regarding already planned grid firming upgrades/projects that can influence results.

Task 2 System Strength evaluation

Carry out a system strength evaluation of the BPA area for a high inverter percentage case, including a variation of IBR penetration levels.

Task 3 Positive Sequence Dynamic Analysis

Carry out positive sequence stability analysis for the various IBR penetration levels using a conservative **grid-following (GFL)** resource representation for new IBRs.

Task 4 Additional analysis

Based on results of tasks 2 and 3, generic GFM models will be used to represent the positive sequence stability behavior of GFM devices at the identified locations.

Task 5 (Optional): Development of 3-phase **electromagnetic transient (EMT)** model of a portion of the network and Analysis

Carry out EMT studies of a portion of the network to validate positive sequence results.

Why it Matters

NERC recently published its Inverter-Based Resource Strategy Document, where they emphasize the need for comprehensive modeling, control performance, and monitoring of IBRs (see Links below). This project is well aligned with **North American Electric Reliability Corporation (NERC)** objectives by developing vendor-agnostic guidelines for seamless integration of GFM technologies via system-theoretic constructs that outline desired performance and describe pertinent phenomena at the point of grid interconnect. This will facilitate coordinated operation of a plurality of GFM technologies from multiple vendors, while ensuring stability and reliability.

The project also comports with the Department of Energy's **Universal Interoperability for Grid-Forming Inverters (UNIFI) Consortium** set up to collaboratively pursue advances in a broad range of GFM inverter technologies. The consortium is co-led by the National Renewable Energy Laboratory, the University of Washington and EPRI.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Enhance Value of Products & Services; Objective 7. Transmission Investments to Integrate Load & Resources

Goals and objectives

This project aims to ascertain the need, the location, and the size of grid forming resources in the BPA operations territory. It will also identify technical minimum capability that may be desired and standardized with GFM technology. This will allow for specifications of interconnection requirements that can define specific services required from GFM technology.

Application

This supplemental project will inform BPA's approach to the interconnection requirements for Grid-Forming technologies. The project provides the opportunity to develop a methodology for application of Grid-Forming resources on BPA grid.

Deliverables

The primary deliverable will include a report that summarizes:

- Results of screening the scenarios for weak locations, using various metrics and data analysis showing correlations among various metrics,
- The positive sequence modeling and simulation results as well as sensitivity analysis carried out regarding use of improved positive sequence models for GFL devices, and
- Sensitivity study results with variation in size of GFM devices.

The EPRI report will provide technical background documentation supporting the study methodologies.

Throughout the course of the project, EPRI will provide regular updates to BPA. Further, BPA will review and provide inputs to the draft report. A webcast or face-to-face meeting will be scheduled to present the findings of this study upon completion of the technical work.

The non-proprietary results of this work will be incorporated into EPRI R&D Program 173, and made available to the public, for purchase, or otherwise.

TIP 457: EPRI Supplemental— Screening and identification of need for grid-forming in future BPA network

Project start date: January 2023

Project end date: December 2023

Links

NERC Inverter-Based Resource Strategy: *Ensuring Reliability of the Bulk Power System with Increased Levels of BPS-Connected IBRs*

EPRI: Modeling, Control, Demonstration, and Standardization of Grid Forming Inverters-UNIFI Consortium

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Participants

Electric Power Research Institute (EPRI)

Technology Innovation Project

Project Brief

TIP 458: EPRI Supplemental— Mineral Oil Spill Evaluation System-Multi Phase (MOSES-MP)

Context

BPA needs a modeling tool to help develop Spill Control, Containment, and Countermeasure plans for its substation operations program. The model needs to predict the movement of mineral oil spills from transformers through the environment.

Research Question: How can we predict the movement of mineral oil spills from transformers through the environment?

Project description

The MOSES-MP software offered by EPRI, is used to determine whether a spill of mineral oil from electrical equipment is likely to reach nearby surface water via overland flow or to migrate through the subsurface to underlying groundwater. The software can provide estimates of oil loss in response to a leak or electrical equipment fire. And it can be used to compare and evaluate containment options.

The program consists of two integrated modules: the **Mineral Oil Spill Evaluation System (MOSES)** module calculates the probabilities and volumes of oil reaching a water body, and the **Multiphase (MP)** module simulates transport through soils to groundwater.

In addition to the calculations, the software provides a **Spill Prevention, Control, and Countermeasure (SPCC)** Wizard and a customizable SPCC Plan template. These features make it easy for users to prepare a SPCC Plan, required for many electrical substations under the Oil Pollution Prevention, Spill Prevention, Control, and Countermeasure (SPCC) Rule (40 CFR Part 112).

Recent improvements introduced in Version 4 of MOSES-MP include better handling of large volume spills and steep slopes, and improved estimation of oil losses during fires and explosions. Version 4 brings the software up to date with current operating systems and updates the SPCC template to reflect changes to the U.S. regulations.

Why it Matters

Use of the software will promote more rapid response to oil spill incidents, allowing users to provide timely information to their management, regulators, and the public. MOSES allows users to standardize SPCC evaluations and planning across their systems, while providing cost savings for substation owners who must prepare SPCC plans for multiple sites.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Mature Asset Management; Objective 13. Asset Mgmt Data and Systems

Goals and objectives

This project evaluates and implements the MOSES-MP software, for use at BPA. The software provides a standardized SPCC evaluation tool that can predict the spill plum movement of leaking mineral oil as well as generate plans that document accurate and defensible decisions that are protective of the environment.

Application

The tested software will be integrated into systems to support BPA's ability to:

- Calculate the probability of spills from substations reaching surface waters or infiltrating to groundwater
- Quickly calculate volumes of oil retained onsite or on land or that reaches waterbody or that is consumed by fire
- Provide template for preparation of SPCC Plans.

This product is supported by an active utility-based user group that works with EPRI engineers to develop improvements to the software on an ongoing basis. User training is included in the program.

Deliverables

The primary deliverables will include a customized software package that will:

- Prepare Spill Prevention, Control, and Countermeasures (SPCC) plans
- Predict oil migration to waterbodies and groundwater and provide information on likely fate of oil after spill incidents
- Evaluate planned design and containment structures for new substations
- Enhancements and improvements of the MOSES-MP software
- Training and support for using MOSES-MP

TIP 458: EPRI Supplemental— Mineral Oil Spill Evaluation System-Multi Phase (MOSES-MP)

Project start date: January 2023

Project end date: December 2025

Links

Mineral Oil Spill Evaluation System - Multiphase: v5 User Group (epri.com)

Reports & References

Murarka, I P. MOSES: Mineral Oil Spill Evaluation System. United States: N. p., Web.

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Technology Innovation Project Project Brief

TIP 459: PGE-Demonstration of Grid Services by a 380 MW Wind, Solar, and Battery Storage Combined Power Plant with Mixed Grid-Forming and Grid-Following Technologies

Context

The rapid interconnection of I**nverter-Based Resources (IBR)** to the **Bulk Power System (BPS)** is the most significant driver of grid transformation today and poses a high risk to BPS reliability. IBRs can include wind, solar PV, battery energy storage systems, hybrid power plants, high voltage direct current networks, **Flexible AC Transmission System (FACTS)** devices, etc.

The speed of this change continues to challenge grid planners, operators, protection engineers, and many other facets of the electricity sector. Implemented correctly, inverter technology can provide significant benefits for the BPS; however, the new technology can introduce significant risks if not integrated properly.

Research Questions: Can a hybrid power plant (Wind, PV and batteries) provide gird services and black start capabilities? How will this impact BPR's transmission grid?

Project description

Portland General Electric's (PGE) Wheatridge Renewable Energy Facility is the first development of its scale in North America to co-locate wind and solar with battery storage. This uniqueness makes the plant an ideal site to demonstrate how wind, solar, and battery storage can provide grid services collaboratively.

This project uses the Wheatridge hybrid plant to demonstrate the provision of various types of grid services with appropriate upgrades.

The project team will upgrade a portion of wind and battery storage from conventional **Grid-following (GFL)** control to the advanced **Grid-forming (GFM)** control to demonstrate and compare the grid services provided by them. The hybrid plant controller will be redesigned to integrate and study IBRs connected with different energy sources (in this case, wind, solar, and battery storage) and controlled in different modes.

Grid services to be studied include frequency control, **Automatic Generation Control (AGC)**, fast frequency response, voltage control, active power control, fault current contribution, and others. The specific metrics will adhere to the latest published IEEE 2800 standard.

Moreover, the project team will seek to demonstrate GFM's advanced features in the following areas: mitigation of system oscillations, weak system operation, and potentially islanded operation and black start. The dynamic responses of GFM and GFL inverters to system events will be monitored, and their performances analyzed to understand how these technologies can impact power system stability.

Why it Matters

PGE and BPA are currently considering including requirements for grid-forming capabilities in their interconnection standards. This demonstration project will provide first-hand experience to guide the requirements in developing these standards. Experience learned from this project can also help utilities and system operators better understand the benefits and drawbacks of both GFM and GFL technologies.

Goals and Objectives

This project demonstrates advanced and emerging grid services, using mixed GFM and GFL technologies at the Wheatridge Renewable Energy Facility in Oregon. Grid services to be studied include frequency regulation, voltage regulation, AGC, black start, and others, using mixed grid-forming and grid-following technologies.

Strategic Alignment

Participation in this project aligns with **BPA's 2024-2028 Strategic Plan** Preserve Safe, Reliable System Operations. Objective 15. Grid Reliability

Application

The BPA team will help to create a weak system, perform an interconnection study; install a site monitor that includes **Portable Power System Monitor (PPSM)** continuously recording point-on-wave data at the specified sample rate; and collect both **Phasor Measurement Unit (PMU)** data and PPSM data.

Deliverables

A report describing GFM asset model and instructions for use of the model.
A series of reports summarizing:

- grid-forming grid service definitions,
- results of the GFM BESS sizing study, and
- results of internal readiness reviews regarding GFM technology.

A series of reports documenting findings from:

- a preliminary analysis of demonstration results,
- a comprehensive analysis of demonstration results,
- a comprehensive cost-benefit analysis, and
- an engineering internship program review.

TIP 459: PGE-Demonstration of Grid Services by a 380 MW Wind, Solar, and Battery Storage Combined Power Plant with Mixed Grid-Forming and Grid-Following Technologies

Project start date: June 2023

Project end date: June 2026

Links

State of Oregon: Facilities - Wheatridge Renewable Energy Facility East

Participants

Portland General Electric (PGE)
Pacific Northwest National Laboratory (PNNL)
Bonneville Power Administration (BPA)
Portland State University (PSU)
University of Texas (UT-Austin)
GE Research
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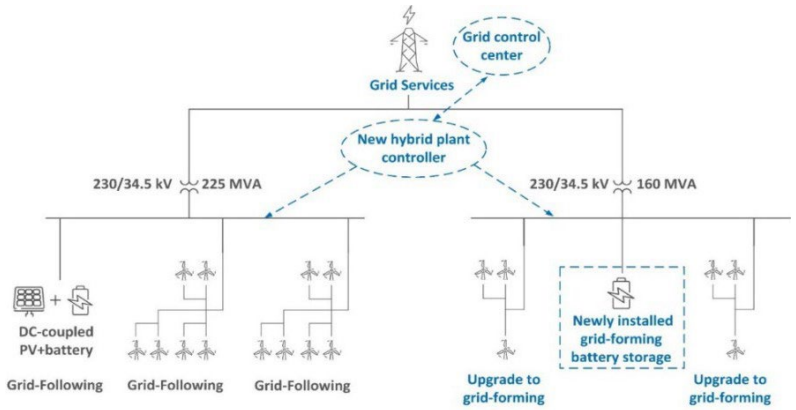
One line diagram of the Wheatridge Renewable Energy Facility



Technology Innovation Project Project Brief

TIP 460: PNNL- Cavitation Testing Improvements for Cold Spray Sample Applications

Context

The United States hydropower industry was primarily developed from the 1930s to 1970s, with many of the original hydropower turbines still in service. Damage associated with cavitation is a common wear mechanism that drives costly repairs and downtime. An alternative repair process, cold spray metal coating, is being developed to repair cavitation-damaged turbines to extend hydropower turbine life and reduce downtime. BPA is working with **Pacific Northwest National Laboratory (PNNL)** to test various cold spray applications for future use at **Federal Columbia River Power System (FCRPS)** hydroelectric facilities.

Research Question: Can cold spray applications extend the lifetime of existing components subject to cavitation damage?

Project description

The project supports PNNL research to improve and refine cold spray material application samples and cavitation testing for better test repeatability. Results will ultimately inform application decisions for use at the Little Goose Dam demonstration in FY 24.

In previous testing, comparing data from 304SS plates and rods, we observed large differences in performance. This is likely due to high amount of cold working and the drawing process used to create the rod stock. By using heat treatments to normalize microstructures and enable creation of a calibration standard coupon to quantify and validate reproducibility of results across equipment and programs. Selecting materials for comparison with significant control of chemistries is important and guidance will be developed.

The project will develop the following:

- Improved nozzle machining methods,
- Material normalization procedures for calibration coupons
- Enable coupons not significantly affected by metal fabrication method, form factor, or heat-to-heat chemical variances.
- Produce a dataset for 3-5 base metal alloys of interest to hydropower.
- Produce data across multiple test campaigns at different times and with different operators to demonstrate high degree of reproducibility and repeatability with improved methods.

Why it matters

Results from this research will help BPA understand the lab tested performance of different cold spray materials to help determine the best candidate for field demonstration. Further, the confidence in cold spray applications for cavitation repair for hydroelectric equipment. Refining results to share with the US Army Corps of Engineers and Bureau of Reclamation, encouraging connection and collaboration, and cooperative future investment.

Goals and Objectives

This project focuses on techniques supporting the standardization of sample coupons and nozzles to understand the impacts on the repeatability of performance of cold spray application.

The two goals for this testing are:

1. Understanding if the inconsistency in previous tests was due to variability in sample coupon composition and nozzle structure.
2. Review cold spray sample performance for best application at the demonstration at Little Goose Dam scheduled for FY24.

Strategic Alignment

Participation in this project aligns with **BPA's 2024-2028 Strategic Plan** Mature Asset Management. Objective 13. Asset Management Data and Systems

Application

In the near term, this research will inform the decision-making process regarding the application of cold spray technology in turbine ring and blade cavitation repair at the Little Goose demonstration project funded by the Department of Energy.
Long term, BPA hopes this technology can be deployed at more FCRPS hydroelectric facilities to increase hydropower reliability and extend the lifetime of existing equipment.

Deliverables

The primary deliverables will include a final report of findings and results, and a presentation to BPA.

TIP 460: PNNL- Cavitation Testing Improvements for Cold Spray Sample Applications

Project start date: July 2023

Project end date: September 2024

Links

Pacific Northwest National Laboratory | PNNL

Portland District, US Army Corps of Engineers

Participants

Pacific Northwest National Laboratory (PNNL)

US Army Corps of Engineers (USACE)

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Technology Innovation Project Project Brief

TIP 464: EPRI P62 Enterprise-wide Occupational Health and Safety

Context

Workplace injuries affect employee health, quality of life, productivity, and job satisfaction, while increasing the cost of doing business. Occupational risks areposed by poor ergonomic design of equipment, human factors such as distraction or physiological fatigue, and long-term or repetitive physical and chemical exposures. Safety outcomes are also influenced by organizational culture, work practices and procedures, often considered with the framework of human performance.

Project description

EPRI's Enterprise-Wide Occupational Health and Safety research is driven by the overarching goal of reducing **serious injuries and fatalities (SIFs)** across the entirety of the electric utility industry. To accomplish this, the program provides a holistic perspective on the varied industry safety risks and produces actionable mitigation tools and strategies to help reduce worker accidents and injuries.

The research in this program focuses on strategies, tools, and insights to reduce injuries, illnesses, and productivity losses. The work focuses on specific elements of job exposures to various hazards as well as safety management practices related to human performance, predictive analytics, and ergonomic interventions. As generation, transmission, and distribution systems evolve, P62 works to characterize new occupational risks and develop and evaluate new interventions (e.g., wearables and monitors) to assess their role in enhancing workplace safety.

Program activities develop cost-effective safety management tools (including ergonomic interventions and/or designs); produce insights into reducing SIFs through applications of human performance and predictive analytics; supports work to integrate hazard recognition into Safety-by-Design; and evaluates driving safety technologies and management, including work zone intrusion reduction strategies; apply industry-leading databases and analyses, including predictive analytics, to one safety initiatives and track the effectiveness of injury reduction and human performance initiatives.

***Research Question*:** How can BPA improve occupational health and safety and reduce serious injuries and fatalities?

Why it Matters

Products from this program have the potential to improve workforce morale and retention, if effectively integrated within utility safety management systems. Fact-based scientific information on safety issues will benefit the interests of all stakeholders including utilities, regulators, the research community, and society overall.

Strategic Alignment

The project aligns with goals in **BPA's 2024-2028 Strategic Plan**: Invest in People

Objective 1. Become the safest utility in North America by continuously improving the physical and psychological safety of the BPA workforce.

Objective 2. Attract, retain, and develop a resilient workforce capable of achieving BPA's mission and strategy in a changing environment.

Goals and objectives

The goal of this program is to provide guidance needed for informed decisions on strategies for injury prevention, safety program targets, exposure controls, regulatory compliance, and intervention and training methods, data and evidence that can lead to reduced costs associated with lost productivity and medical expenses from occupational injuries.

Application

Results from this program can be used to evaluate the latest worker safety technology products and methods to inform purchase decisions and guide implementation, as well as to provide access to fellow program members and safety professionals for benchmarking and information sharing.

Deliverables

Deliverables for this project will derive from participation in the following key activities:

- Developing cost-effective safety management tools for *Ergonomics, Human Performance, and Driving Safety*.
- Characterizing exposures and developing industrial hygiene processes for *Occupational Exposure and Health Studies.*
- Further development of industry-leading databases and analyses including *Occupational Health & Safety Databases and Predictive Analytics*.
- Participation in *Thought Leadership Webcast Series* where leading worker health and safety researchers and practitioners share their expertise, including those from universities, leading consultancies, and government research organizations, as well as researchers from across EPRI working on asset-specific safety projects.
- Participation on *Executive Peer Innovation Committee (EPIC) for Occupational Health and Safety* that provides guidance to EPRI on strategic direction of health and safety research needs across the Institute, not just Program 62. Members also share learnings on innovative practices, as well as hear from external subject matter experts and EPRI researchers.
- Benchmarking with peer organizations in the utility industry on best practices, practical applications of research and strategic endeavors.

TIP 464: EPRI P62 Enterprise-wide Occupational Health and Safety

Project start: January 2024

Project end: December 2024

Links

Enterprise-Wide Occupational Health and Safety (epri.com)

Participants

Portland General Electric Co. (PGE)

Alabama Power Co.

Hydro One Networks Inc.

Lower Colorado River Authority

Salt River Project Agricultural Improvement and Power District, (et al.)

BPA Sponsoring Orgs: NF-Safety

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Technology Innovation Project

Project Brief

TIP 465: EPRI P40E Analytics for Emerging Transmission Planning Needs

Context

In recent years, **High Voltage Direct Current (HVDC)** has emerged as a superior solution for integrating large amounts of offshore wind generation, as well as remote variable renewables for inland loads. However, annual reliability assessments for HVDC systems are labor intensive for analyses across planning entities. Manual validation and set up of thousands of contingency events and simulations are required. This burden will increase as planners are asked to evaluate the reliability and stability of more initial conditions (power flow scenarios) as variability and uncertainty of generation and load both increase. Creating automated platforms to build node-breaker topologies, define contingency events, run simulations, and evaluate stability impacts will support massive savings in engineering time and allow planners to efficiently evaluate the stability impacts across many cases.

Additionally, the advent of **Grid-Enhancing Technologies (GETs)** offers transmission planners alternatives to traditional transmission reinforcements that can increase the flexibility and adaptability of the transmission network, improving the ability to respond to rapid changes in the system, and reducing the risks of stranded assets.

Research Question: How can transmission planners efficiently evaluate the stability impacts across many cases while creating massive savings in engineering time?

Project description

As HVDC becomes more prevalent, there is the need to furnish transmission planners and operation engineers with relevant and handy information about the technical principles of the technology, the benefits, industry and application trends, implementation considerations, and operation challenges. It is also necessary to provide systematic approaches, tools, and guidelines for planning and assessment of HVDC systems.

This program provides a comprehensive process to compare the benefits, costs, and integration aspects of GETs with traditional reinforcement options. Further, it aims to continue development of the existing **Advanced Reliability Toolset (ARTS)** framework to facilitate automated processes.

Why it Matters

This research program can help planners to navigate through the transformative changes in the power system and to plan for a grid that is safe, reliable, resilient, and economical to operate. It also provides innovative methods and tools for safe, reliable, and economic integration of new energy resources into the grid and support end-use loads.

Strategic Alignment

Participation in this project aligns with **BPA's 2024-2028 Strategic Plan:** Mature Asset Management. Objective 14. Risk-based Decisions & Portfolio Optimization

Goals and objectives

The goal of this project is to provide insights into the technical, operational, and economic characteristics of traditional and emerging grid-enhancing technologies, their potential uses, and operation practices. It also develops a framework and software tool to evaluate and design cost-effective solutions for transmission reinforcement that considers GETs along with traditional expansion projects such as new/upgraded lines and substations.

Application

Using the project's tools, methods, and key insights transmission planners will be provided with options that will save time, mitigate risks, and reduce costs while maintaining reliability and resilience.

Deliverables

This program continues to work on delivering the following products:

- Refinement to Advanced Reliability Toolset (ARTS);
- Explore use of **High Performance Computing (HPC)** for reliability assessments;
- Guidelines on assessing impact of increasing HVDC links in transmission system;
- **Consideration of Multi Terminal dc (MTDC)** grids in transmission planning;
- Assess use of HVDC to provide ancillary services;
- Updates to the HVDC planning guide;
- Refine **Controlled Planning Framework (CPLANET)** tool for integrating Grid Enhancing Technologies (GET) in transmission systems;
- Updates to GET reference guide.

TIP 465: EPRI P40E Analytics for Emerging Transmission Planning Needs

Project start: January 2024

Project end: December 2024

Links

Program 40: Transmission Planning | Projects (epri.com)

Participants

Electric Power Research Institute (EPRI)

Program 40E members: 13

BPA Sponsoring Orgs: TPP Transmission Planning, TPPA Transmission Reliability Planning

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Technology Innovation Project

Project Brief

TIP 466: EPRI P228 Monitoring and Advancing Data Analytics

Context

Annual reliability assessments are labor intensive analyses across planning entities. Manual validation and set up of thousands of contingency events and simulations are required. This burden will increase as planners are asked to evaluate the reliability and stability of more initial conditions (power flow scenarios) as variability and uncertainty of generation and load both increase. Creating automated platforms to create node-breaker topologies, define contingency events, run simulations, and evaluate stability impacts will create massive savings in engineering time and allow planners to efficiently evaluate the stability impacts across many cases.

Research Question: How can analytic algorithms be practically applied in the daily function of a utility's plant and/or fleet?

Project description

EPRI's **Monitoring and Advanced Data Analytics program (Program 228)**, focuses on the integration of sensing, monitoring, diagnostics, and applied analytics research, which are integral to this multifaceted approach. Developing the basis for intentional data collection, via online sensors and other data sources, is key to providing valuable inputs into diagnostic and prognostic models for equipment health and process performance.

The program leverages data analytics and machine learning approaches for power plant asset monitoring, diagnostics, and prognostics for improved reliability and efficiency. It involves research and investigations in the areas of digital infrastructure platforms to support data integration and management, as well as to analyze data sets and determine how analytic algorithms can be practically applied in the daily function of a utility's plant and/or fleet. In collaboration with other EPRI programs, national laboratories, and research institutions around the world, this program will develop, test, and support deployment of new sensor technologies that align with equipment health and plant performance.

Among these goals, the project aims to further develop the existing **Advanced Reliability Toolset (ARTS)** framework to facilitate automated processes.

Why it Matters

Expanding the application of analytics in power generation requires targeted yet multidisciplinary approaches in the areas of data collection, digital infrastructure, analytics, and data management. In this process of digital transformation, careful consideration for compatibility with legacy systems and growth opportunities is also warranted. Technology advances in this area hold the potential to improve safety, reliability, monitoring, maintenance cost, and performance of the power plant. Utilization of advanced analytics, such as artificial intelligence and machine learning, has the potential to expand the value that the output would provide to an organization's generating fleet.

Strategic Alignment

The project aligns with BPA’s goals under the Strategic Plan: Preserve Safe, Reliable System Operations. Objective 17. Compliance to Changing Requirements

Goals and objectives

BPA’s goal for this project is to support the development of automated platforms to create node-breaker topologies, define contingency events, run simulations, and evaluate stability impacts will create massive savings in engineering time and allow planners to efficiently evaluate the stability impacts across many cases. This project continues development of the existing ARTS framework to facilitate these processes.

Application

BPA will use the guidance and support testing of monitoring, diagnostics, and prognostics, and the approaches for using analytic data for risk-based decision making and planning activities.

Deliverables

This program continues to work on delivering the following products:

- Investigation and research around improving intentional development and use for a better understanding and improved reliability/performance at a fleet level;
- Continue development of equipment-specific **continuous online monitoring (COLM)** quick guides;
- Exploration of **remaining useful life (RUL)** approaches both from the data analytics side along with sensor technology to improve upon and enhance the RUL algorithm;
- Development of fault signatures for power plant assets that can assist in data analytics approaches for diagnostics and prognostics;
- Development of roadmaps for members that are pursuing improvements around data analysis and digital technology implementation;
- Continued development of projects within the Digital Demonstration Facility supplemental project looking at both improved technology (software and hardware), along with reevaluating plant processes;
- Collaborative research to identify measurement gaps, support development of sensors and demonstration;
- Continued collaboration with utilities members and the U.S. Department of Energy on sensing and analytics.

TIP 466: EPRI P228 Monitoring and Advancing Data Analytics

Project start: January 2024

Project end: December 2024

Links

Program 228: Monitoring and Advanced Data Analytics Overview (epri.com)

Participants

Electric Power Research Institute (EPRI)

BPA Sponsoring Org: PG Generation Asset Management

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Technology Innovation Project

Project Brief

TIP 471: EPRI Power Transformer Spare Strategy Evaluation Model Development

Context

Transmission Companies desire to minimize adverse effects of power transformer failures. All utilities maintain inventories of spare substation equipment. These spares are used to mitigate the effects of equipment failures by reducing the replacement time through the elimination of costly procurement and delivery delays at the time of failure.

There are also significant costs associated with spares inventories including capital, storage, and, for some equipment, maintenance, and testing. These costs and the potential benefits from spares are a function of the number and type of individual spares maintained. Maintaining too few spares may prolong outages, reducing availability, operating flexibility and possibly revenue. Too many spares would increase capital and operating costs.

Currently, no industry standards or guidelines are available to help utilities determine the appropriate number or mix of spare power transformers.

***Research Questions*:** How can BPA better manage the evaluation of transmission spares? Can an enhanced analytical methodology be developed suitable for application at BPA?

Project description

EPRI is developing a power transformer spare strategy evaluation methodology, the set of decisions around the purchase and utilizations of equipment spares.

The project will develop an analytical methodology that relates the strategy metric(s) to various user defined inputs (e.g. reordering criteria, spares inventory) and system specifications (e.g. number and type of installed transformers by station) to allow for scenario and what-if studies. To provide views of a strategy's and its constituent decisions' impact by various categories, for example metrics by fleet, station, transformer type, circuit or criticality group. The analytics will allow the user to take into account the stochastic nature of age dependent transformer failure rates. The spares strategy analytics may be designed to generate a queriable output table. Suitable queries may be designed to aid scenario driven data extraction and presentation in spreadsheet-based tools.

Strategic Alignment

The project aligns with BPA's goals in the ***2024-2028 Strategic Plan:*** Mature Asset Management; Objective 13. Asset Management Data and Systems.

Why it Matters

The outcomes of research could provide BPA a sound technical basis for power transformer inventory management. This will help BPA to evaluate risk exposure as a function of variables such as: certain number of spares on hand, type and number of mobile transformers, transformer failure hazard rates, variable transformer manufacture lead times, different distances from spare location to substations, and the utility spare/replacement strategy.

Goals and objectives

The goal for this project is to develop an enhanced analytical methodology for determining or evaluating spares strategies suitable for application at BPA.

Application

The methodology will be applied in conjunction with BPA to develop a recommended new restoration guide and spares database founded on BPA fleet characteristics and risk management criteria.

Deliverables

Deliverables for this project will include the following:

- Enhanced analytical techniques for determining or evaluating substation transformer spare scenario modeling results;
- Documentation of scenarios designed with guidance from BPA for enhanced analytics application;
- Documentation on how to apply enhanced analytical techniques;
- Periodic status updates;
- Technology transfer workshop.

TIP 471: EPRI Power Transformer Spare Strategy Evaluation Model Development

Project start: January 2024

Project end: December 2025

Participants

Electric Power Research Institute (EPRI)

BPA Sponsoring Orgs: TEVE-Transmission Test & Evaluation, TEVA- Transmission Application Engineering & Analytics

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Technology Innovation Project

Project Brief

TIP 472: BOR Improved Techniques in Turbine Air Injection and the Detection, Monitoring, and Analysis of Cavitation and Hydraulic Phenomena in Operating Hydraulic Turbines

Context

Across the hydropower industry, cavitation and adverse effects of operating generators in turbine rough operating zones is a costly and complex problem. When hydropower turbines operate at off-design conditions, the resulting dynamic hydraulic phenomena can produce undesired cavitation effects such as erosion on the turbine runner, excessive pressure pulsations and high vibration in the machine.

The Bureau of Reclamation seeks to further develop cavitation detection systems to optimize maintenance and planning, reduce and prevent turbine damage, and unit operation.

Research Question: Can current cavitation detection and monitoring tools, based on pressure, vibration and acoustic emissions, and the use of forced air injection, be optimized to provide Reclamation with advance tools for cavitation damage avoidance, O&M planning, and better optimize operation?

Project description

BPA entered a joint research agreement with the **Bureau of Reclamation (BOR)** and **General Electric (GE)** to investigate cavitation through testing and monitoring, turbine air injection, a noise assessment, and residual stress research. 2024 funding will be used by the Bureau of Reclamation research engineers to support the ongoing collaboration with GE on cavitation research on the Grand Coulee Nathaniel Washington Powerplant G24 generator/turbine. Additionally, further research data will be collected by Reclamation on units G-19 through G-21 at Washington Powerplant depending upon availability. These tests will be used to further establish Reclamation's built cavitation detection, machine condition monitoring systems, and air injection methods.

The following tasks will be completed to meet this objective:

- Perform analysis of additional operating parameters collected by Reclamation and GE cavitation monitoring systems.
- Identify improvements to both GE and BOR's cavitation monitoring systems.
- Continue test data collection at the Grand Coulee Nathaniel Washington Powerplant. Maintain and improve the current G24 cavitation monitoring and air injection systems.
- Refine cavitation data analysis, process existing data collected during G-24 operation, and bring new research team members up to speed.
- Update cavitation monitoring system signal processing circuit board design.
- Perform additional test data collection and evaluate unit operation to eventually expand permanent cavitation monitoring and air injection system implementation to additional units at the Grand Coulee Nathaniel Washington Powerplant. Units G-19 through G-21 in the third powerhouse are good candidates for monitoring system adoption as MCM system framework and base air injection system components are currently in place.

Why it Matters

Cavitation detection will offer reduced repair efforts and extended turbine runner service lives resulting in cost savings which indirectly benefit customers and allow Reclamation to better compete in an energy imbalance market and accommodate fluctuating load requirements.

BPA is committed to continually improving its asset management program. Working closely with BOR and GE will enhance risk-based decision-making to maximize asset value and preserve the reliability and resilience of the assets.

Goals and Objectives

This project will identify areas of improvement for the existing cavitation monitoring on the Grand Coulee Nathaniel Washington Powerplant G24 generator/turbine; provide additional data and analysis from units G-19 through G-21 at Washington Powerplant; and incorporate data and analysis into existing models to improve cavitation detection, machine condition monitoring systems, and air injection methods.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Generations Asset Management; Objective 13. Asset Management Data and Systems.

Deliverables

This project will provide: Project Management Plan, Quarterly Activity Reports, Presentation Summarizing Result and Findings at each Facility.

TIP 472: BOR Improved Techniques in Turbine Air Injection and the Detection, Monitoring, and Analysis of Cavitation and Hydraulic Phenomena in Operating Hydraulic Turbines

Project start date: March 2024

Project end date: September 2024

Links

Science and Technology | Research and Development Office (usbr.gov)

Partners:

General Electric (GE),
US Bureau of Reclamation (BOR)

BPA Sponsoring Orgs: PGA Generating Assets

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Technology Innovation Project Project Brief

TIP 473: USACE Reliability Centered Maintenance Pilot

Context

The mission of the **Federal Columbia River Power System (FCRPS)** is to provide low cost, reliable power to the Pacific Northwest through asset life-cycle maintenance practices. Current maintenance programs are based on recommendations from the original equipment manufacturers and are outdated and not cost effective.

The goal is to reach a state where appropriate maintenance techniques are applied to hydropower assets while balancing cost with reliability. To aid in this vision, the **US Army Corps of Engineers (USACE)** and BPA are partnering on a **Reliability Centered Maintenance (RCM)** and **Failure Mode Effects and Critical Analysis (FMECA)** pilot.

RCM is applicable in any industry and has been adopted by the DOD and the nuclear industry along with many others. It is used to determine what failure management strategies should be applied to ensure a system achieves the desired levels of safety, reliability, environmental soundness, and operational readiness in the most cost-effective manner. In the context of RCM, this can mean identifying various maintenance actions such as periodic, predictive, condition-based processes and run to failure. FMECA helps identify potential failures in your systems. It also factors in criticality analysis, which is a systematic approach to applying a criticality rating to equipment and assets based on potential risks.

Research Questions: What unnecessary maintenance tasks can be eliminated? What RCM principles can be adopted for cost savings and efficiency? What are the failure modes and corrective actions identified through the FMECA analysis, is implementation reasonable and cost effective?

Project description

BPA and the USACE seek to further their understanding of the RCM and FMECA principles and processes, and apply what they learn to hydro assets. The project includes training sessions that will provide an RCM overview, how the principles of RCM manage risk and improve performance; extend asset life and evaluation their effectiveness; how to utilize FMECA to optimize maintenance; and, how to structure audits, KPIs and improvement indicators. The facilitation session will lead BPA and the USACE through the process of applying the principles to USACE assets; define a maintenance approach and sparing strategy; recommend systems, processes, data to utilize in RCM program; and recommend key performance indicators, how to gather and track.

Why it Matters

RCM is a time-honored, proven process. When applied correctly and with qualified personnel, RCM produces overwhelmingly positive results. It has been shown to enhance safety, reduce costs, improve availability, increase maintenance efficiency, improve environmental integrity, and achieve longer useful life.

BPA is committed to continually improving its asset management program. Partnering with USACE on this training and pilot project will enhance risk-based decision-making to maximize asset value and preserve the reliability and resilience of the assets.

Goals and Objectives

The goal of this pilot is to gain knowledge and understanding of principles and processes needed to implement the RCM and FMECA for hydro assets, then tailor and apply the findings at the three FCRPS districts of the Northwest Division; Seattle, Walla Wall and Portland.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Mature Asset Management; Objective 13. Asset Management Data and Systems.

Application

The training, facilitation and tools supported in this program will result a report containing recommendation on how to implement an enterprise-wide RCM program. The technical team will gain the knowledge and real-world experience that enable them to effectively make programmatic recommendations to NWD and district leadership and Bonneville as an enhancement to the asset management program across the FCRPS.

Deliverables

The training, facilitation and tools supported in this program will result a report containing recommendation on how to implement an enterprise-wide RCM program. This project will provide: Training curriculum including agenda & materials; a Project management and implementation plan.

TIP 473: USACE Reliability Centered Maintenance Pilot

Project start date: March 2024

Project end date: September 2024

Links

Portland District, US Army Corps of Engineers

Partners:

US Army Corps of Engineers (USACE)

BPA Sponsoring ORGs:
PG-Power Generation Asset Management,
PGA-Generating Assets

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Technology Innovation Project

Project Brief

TIP 474: USACE Performance of Environmentally Acceptable Lubricants (EALs) in Hydropower Unit Thrust Bearings

Context

Hydropower units require large quantities of turbine oil and are necessarily located where spills have the potential to reach the environment. Oil releases to the river that have been traced to thrust bearings, and very slow leaks such as through piping pinholes can take time to become apparent. As concern for the environment is expected to continue to increase, it is desirable to expand the technical feasibility of using **Environmentally Acceptable Lubricants (EALs)** and water where possible, to have the option to transition away from traditional petroleum-based turbine oils.

The highest priority for transition are Kaplan runner hubs, but most **US Army Corps of Engineers (USACE)** turbines and powerhouses are designed to use a single lubricant, and to allow mixing of that lubricant between unit components, and even among all the units in the powerhouse. Without more data, it will not be technically feasible to use water or EALs in thrust bearings.

Research Questions: How can BPA responsibly support progress towards the potential future use of turbine EALs in hydropower units to enhance our environmental stewardship without compromising our hydropower operations?

Project description

To align with anticipated environmental standards, **USACE** will be required to begin transition from traditional petroleum-based turbine oils to EALs. There are numerous barriers to replace turbine oil with EALs; one of the more critical barriers is the thrust bearings. To address this concern, EALs will be tested using full-scale physical thrust bearings, which will require significant space and resources. Full-scale testing is necessary because wedge thickness and thrust bearing capacity depend strongly on lubricant viscosity. Testing will involve comparing the EAL to a traditional mineral oil in a thrust bearing by taking measurements, ideally with identical full-sized thrust bearings, side-by-side, with instrumentation that measures thrust bearing lift, load, and temperature. Experiments will include different types of lubricants at different levels of relative humidity, temperatures, and speeds. If possible, different types of thrust bearing designs will be tested as well.

Project Tasks include:

- Create simple versions of relevant **Computational Fluid Dynamics (CFD)** models, ready to add complexity in the future.
- Perform literature search and industry outreach for relevant efforts made by others to research performance of EALs in large thrust bearings and/or water in thrust bearings with alternate thermoplastic materials such as **Polytetrafluoroethylene (PTFE)** and **Poly-ether-ether ketone (PEEK).**
- Determine desired lubrication fluids, materials, and parameters for actual testing.
- Write a report summarizing FY24 work.

Why it Matters

The results of these experiments would provide important guidance in how to responsibly support progress towards the potential future use of turbine EALs in our hydropower units, and possibly even use of water in new designs, to enhance our environmental stewardship without compromising our hydropower mission. In conducting this research, BPA and USACE would be paving the way for the hydropower industry.

Goals and Objectives

The goal of this pilot is to gain knowledge regarding the technical feasibility of replacing the thrust bearing oil with EALs or with water.

Application

Comparative data showing how hydrodynamic lubrication performance and thrust bearing capacity are affected by use of EALs instead of mineral oils will inform potential paths towards future feasibility of using EALs in existing hydropower units. Data regarding performance of water in thrust bearings with alternative materials such as PTFE or PEEK will inform potential paths towards future feasibility of using water in new hydropower units.

Strategic Alignment

The project aligns with **BPA's Strategic Plan**: Mature Asset Management; Objective 17. Compliance to Changing Requirements

Deliverables

The results will be documented in a report, and if the tests are successful and the EALs plan is to be implemented, an HDC guidance document will be produced as well.

TIP 474: USACE Performance of Environmentally Acceptable Lubricants (EALs) in Hydropower Unit Thrust Bearings

Project start date: March 2024

Project end date: September 2024

Links

Hydroelectric Design Center

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Partners:

USACE Hydro Design Center (HDC)
U.S. Army Engineer Research and Development Center (ERDC)

BPA Sponsoring ORGs: PG-Power Generation Asset Management, PGA-Generating Assets

Technology Innovation Project Project Brief

TIP 475: EPRI P62 Heat Stress Monitoring and Management Tools for Worker Health and Safety

Context

The decade from 2011–2020 was the warmest recorded in the United States since instrument observations were initiated. One of the primary effects includes an increased frequency of extreme heat and greater incidence of occupational heat stress events.

EPRI's Occupational Health and Safety research program has shown that existing workplace heat stress management guidelines generally do not adequately protect workers. An employee's physiological strain response to a given level of heat stress is modified independently by inter-and intra-individual factors (e.g., age, acclimation state, hydration, sleep, consecutive work shifts), so it is challenging to prevent heat-related illness in all workers without directly assessing those physiological responses.

Research Question: How can we prevent heat related illness in BPA workers?

Project description

Implementing heat stress monitoring and management tools for worker health and safety includes understanding current technology, system safety and performance, and determining how biometric data should be used to manage risk. EPRI's approach is grounded in science, technical literature, and field testing to determine effective safety management strategies. This effort draws on EPRI's extensive expertise in heat stress management. For this supplemental project the following tasks are underway:

Task 1: Review current personal monitoring technology and performance specifications to determine those systems that would meet operational performance criteria for the electric utility sector.

Task 2: Review heat stress bio-metric approaches and develop a rationale for optimal data assessment and interpretation associated with wearable biometric monitoring devices.

Task 3: Evaluate technologies and data collection approaches through field trials.

Task 4: Determine how organizations can better understand the impact of heat acclimatization on electrical worker management and how this information can be used to minimize risk during heat events.

Task 5: Disseminate results via various deliverables to help ensure findings are accessible to participants' key stakeholders.

Why it Matters

Results from this project are anticipated to directly support electric utility workers and companies in reducing the incidence, severity, and cost of heat stress related injuries and illnesses in their workforces. Actionable information on monitoring technologies and risk mitigation approaches for heat stress should inform the development of sound safety management practices, supporting the health of the workforce and, by extension, the communities in which workers live.

Goals and objectives

The goals of this project are to: **define** operations processes to assist in providing improved safety management during extreme heat related events; **identify** monitoring technologies that meet safe operations and performance requirements within the electric utility industry and; **evaluate** relevant monitoring technologies and approaches that can be used to define worker risk more accurately.

Strategic Alignment

The project aligns with BPA's **2024-2028 Strategic Plan**: Invest in People – Objective 1 Become the safest utility in North America by continuously improving the physical and psychological safety of the BPA workforce.

Application

BPA will review current personal monitoring technology and performance specifications to determine those systems that would meet operational performance criteria for the electric utility sector. Review heat stress bio-metric approaches and develop a rationale for optimal data assessment and interpretation associated with wearable biometric monitoring devices. Evaluate technologies and data collection approaches through field trials. Determine the impact of heat acclimatization on electrical worker management and how this information can be used to minimize risk during heat events.

Deliverables

Deliverables for this supplemental project include the following:

- Quarterly webcasts providing an update on the project progression and deliverables;
- Webcast and brief-report outlining the personal monitoring devices most suitable for use in the electrical sector;
- Technical update and final webcast summarizing operational processes that could be employed to improve safety management during occupational heat stress exposure events.

TIP 475: EPRI P62 Heat Stress Monitoring and Management Tools for Worker Health and Safety

Project start: January 2024

Project end: December 2024

Links

Heat Stress Monitoring and Management Tools for Worker Health and Safety (epri.com)

Participants

Electric Power Research Institute (EPRI)

BPA Sponsoring Orgs: NF-Safety

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Technology Innovation Project Project Brief

TIP 476: EPRI P37 SF_6 Alternatives

Context

Sulfur hexafluoride (SF_6) has been used for decades in utility applications due to its excellent insulating and arc quenching capabilities. A drawback for SF_6 is that it has an extremely high **global warming potential (GWP)** and there is growing pressure to phase it out.

Several countries outside of the US, and a few states with-in the U.S., have implemented, or are considering, regulations to limit or fine utilities for loss of SF_6 above certain thresholds. These reasons have created a renewed interest in finding a suitable alternative to SF_6, whether by using other gases, vacuum technology, or some other approach.

Significant questions remain regarding effective handling, recycling, operation, maintenance, safety, and disposal of these new gas mixtures. Overlaid on the technical questions are the regulatory questions. This project aims to perform the studies and industry tracking to help inform utilities evaluating different SF_6 Alternative strategies.

Research Question*:* How can BPA find a suitable alternative to SF_6?

Project description

This project aims to help guide and inform optimal strategies for adopting SF_6 Alternatives, and to perform the studies and industry tracking to help inform utilities evaluating different SF_6 Alternative strategies.

EPRI's SF_6 Alternatives Research Laboratory has expanded to include more SF_6 Alternatives research activities. The full-scale laboratory environment allows for testing and experimentation in a safe yet flexible environment, allowing for wide experimentation and rapid learning.

EPRI's approach is to:

- Research regulatory and technology changes and share the critical insights in monthly calls.
- Acquire SF_6 Alternatives and use the EPRI laboratory to perform the practical tasks a utility would need to perform with these new alternatives (commissioning, analysis, leak detection, recycling, leak detection, disposal).
- Share the practical findings from the laboratory on the monthly update calls.
- The collaborative membership of the project will also allow for effective sharing of member experiences.

Why it Matters

BPA and other project participants will receive unbiased guidance on specification of emerging technologies for alternatives of SF_6. The guidance will be scientifically based and supported by the extensive laboratory testing.

Participants will stay ahead of changes in both the technologies and the regulations.

Overall, the industry will benefit from the real-world understanding of the wide range of new technical challenges (handing, analysis, recycling, leak detection, and disposal).

Goals and objectives

The research goal is to guide the industry on optimal adoption strategies for SF_6 Alternatives. EPRI has a full-scale SF_6 alternatives laboratory that is expanded to include SF_6 Alternatives. The industry will benefit from the real-world understanding of the wide range of new technical challenges (handing, analysis, recycling, leak detection, and disposal). The full-scale laboratory environment allows for testing and experimentation in a safe yet flexible environment, hence allowing for wide experimentation and rapid learning.

Strategic Alignment

The project aligns with **BPA's 2024-2028 Strategic Plan**: Enhance the Value of Products & Services– Objective 7. Transmission investments to integrate load & resources.

Application

BPA will acquire access to SF_6 Alternatives and use the EPRI laboratory to perform the practical tasks a utility would need to perform to evaluate these new alternatives (commissioning, analysis, leak detection, recycling, leak detection, disposal).

Deliverables

Deliverables for this project will derive from the following key activities:

- Monthly insights on industry trends, technology development and regulatory advances;
- Practical guidance on what to expect from the adoption of SF6 Alternatives. The guidance will result from the testing in the full-scale EPRI SF_6 Alternatives laboratory;
- Member insights from sharing of adoption experiences;
- Monthly webcast slides and published report.

TIP 476: EPRI P37 SF_6 Alternatives

Project start: January 2024

Project end: December 2024

Links

SF6 Alternatives Supplemental Project (EPRI)

Participants

Electric Power Research Institute (EPRI)

BPA Sponsoring Orgs: TEVA-Transmission Application Engineering & Analytics.

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