EPRI

2024 ANNUAL REVIEW

Distribution Operations and Planning

PROGRAM 200

About Our Programs

Modernization of the distribution grid is at the forefront of industry activity. It involves the simultaneous optimization of existing assets while maximizing benefits of new technologies and resources to yield a more efficient, reliable, sustainable, and customer centric grid. EPRI's Distribution research programs are geared to provide members with research and application knowledge to support and inform the transition of the grid of today to a modern, integrated grid. These programs provide over 100 subject matter experts (SMEs) that act as an extension to utility staff.

Distribution Systems P180

- Asset health and management
- Failure analysis and diagnostics
- New technology and components
- Asset and reliability analytics
- Safety and work practices

Distribution Operations and Planning P200

- Planning and analytics
- Control center operations
- Grid modernization strategy
- Grid modeling capabilities
- System protection

DER Integration P174

- Interconnection practices
- DER management
- Grid impacts
- Integration economics
- Microgrid planning and design

Energy Storage and DG P94

- Safety, environment and community engagement
- Technology evaluation
- Planning and economics
- Deployment and operations
- Customer storage, microgrids & DG

Our labs routinely conduct research and testing for existing and future technologies from distribution crossarms and manhole covers to DMS/DERMS control and grid-forming inverters. Some of our capabilities include: Component aging, full-scale distribution testing, stray voltage testing, manhole, DER inverter testing, DERMS testbed, DMS/DA testing, protection testing, and HIL.

Industry Needs

- Decarbonization
- Electrification
- Flexibility
- Aging infrastructure
- Resilience
- Grid modernization

Recent Project Highlights

Climate READi – Developed a distribution planning assessment framework to support improved system resilience and investment decision-making.

DOE Distribution System Operator Roadmap – Developed an industry roadmap for future distribution operations requirements to support utilities in achieving their visions to enable DER to provide services.

Energy Storage Playbook – Created an energy storage deployment playbook with standardized and vetted processes that guide and coordinate new projects.

OpenDER Model – Open-source models developed with utility engineers, commercial software vendors, and hardware manufacturers to ensure accurate representation of DER according to latest standards.

Ground Level Distribution System Performance – Tested innovative undergrounding approach that could enable faster deployment of underground cable in difficult-to-bury areas.

Impact of Electrification on Distribution Assets – Assessed the impact of new loads, such as harmonics and reverse power flow, on distribution transformers and other assets.

Meet P200

EPRI's Distribution Operations and Planning Program (P200) assists distribution engineers with the transition to tomorrow's modern distribution grid using a balanced and no-regrets approach. DO&P is focused on enabling grid modernization by developing new planning processes, models, tools, reliability assessment analytics, and incorporating new automation, protection, and control technologies.

Program Value

Grid modernization strategy
Developing and adjusting plans

New resource integration
Integrating higher levels of DER, ES, EVs

Reliability and resilience
Maximizing improvements

Electrification and decarbonization
Proactively planning for future needs

Operational efficiency
Using data, tools, and technology effectively

Workforce skill development
Enabling new skills required

Leading practices
Gaining insights from utilities across the globe

> "P200 provides our engineers research and tools that we need to better prepare for the future of the distribution grid.
>
> — Dave Nestler, WEC Energy

How it Works

EPRI's DO&P research is delivered through five areas covering the breadth of needs across planning, operations, protection, analytics, and technology transfer. Task Forces provide EPRI project guidance and serve as a primary vehicle for R&D technology transfer to members.

Research Areas

- Planning
- Operations
- Protection
- Analytics
- Technology transfer

Featured Statistics

- **58** Peer-utilities sharing practices
- **50+** Leading research products
- **$7.2M** Annual R&D funding invested
- **50+** Task force engagement opportunities
- **34** SMEs
- **57:1** Member research ROI

Planning

About 200B

Advances the planning tools, methods, and practices needed to realize the modern distribution system. Methods and tools derived are cost-effective and lead to more informed system design and investment decisions.

Contact: Jouni Peppanen, jpeppanen@epri.com

Member Value

- Inform capital investment decision making
- Clear guidance on how planning can support increased reliability and resilience
- Cost-effective system designs that account for DER, electrification, and extreme weather scenarios
- Planning criteria that matches the needs of the modern decarbonized distribution system accounting for risk management
- Enhance ability to evaluate system expansion decisions under climate change and extreme weather events

Key Activities

System design practices

Guidance on design practices for enabling electrification and high penetration DER.

Analytics to support operational decisions

Tools to enable planners to assess system configurations and support operator decision making of a more flexible system.

Non-wires alternatives

Analytics, tools, and guidance to evaluate NWAs alongside traditional alternatives.

Electrification

Methods and models to assess the impact of changing system conditions and consideration in planning scenarios.

Strategic planning

Frameworks for evaluating strategies for cost-effective, reliable and resilient system expansion leveraging flexibilities in new end-use demands.

Forecasting

Guidance on refined forecasting methods and practices to account for extreme weather events and electrification.

> *EPRI's assessment of EV impacts on service transformers enables Ameren to make informed decisions on how to proactively address impacts and to update design standards accordingly.*
>
> — Jaime Sobotka, Ameren

Operations

About 200C

Develops and demonstrates new technologies, tools, techniques, and training methods to enable Distribution Control Center (DCC) managers and operators to meet the challenges of tomorrow. These capabilities will enhance operational processes, implement new analytics, and increase the resilience of the control center.

Contact: Brian Deaver, bdeaver@epri.com

Member Value

- Maximize the reliability improvements-per-dollar invested
- Improve situational awareness in the control center, resulting in improvements in reliability and safety
- Support utility plans to deploy DMS and evolve DCCs
- Enhance training of new and existing operators to meet evolving needs
- Develop operational techniques and processes necessary to ensure customer reliability in a decarbonized system

Key Activities

Advance DMS applications and automation

Algorithms to unlock value of DER and manage active system including improvements to existing applications and development of new capabilities.

Future DSO requirements

New processes and tools for a DSO including the new roles/responsibilities (operational planning) required.

Operational visibility

Guidance and analytics to achieve least-cost means for operational visibility.

Modernizing DCC

Guidance and leading practices to design and manage a modern DCC including guidance to improve situational awareness.

Reliability and resilience

Analytics and tools to evaluate reliability improvements and maximize their potential benefits as the system evolves.

Future operator training

Training, curriculum, and certification guidance to enable the operator of the future.

> *We have used the information gained from participation…to make meaningful improvements in the design of our new Control Center and in the development of our System Operator recruiting and training program.*
>
> — Scott Pifer, DTE Energy

Protection

About 200D

Develops new methods for protecting the modern distribution grid and take advantage of new grid modernization capabilities. Distribution protection engineers use the methods and protocols developed to evaluate protection schemes and philosophies, including the impacts of DER.

Contact: Aadityaa Padmanabhan, apadmanabhan@epri.com

Member Value

- Significantly reduced effort for protection analysis and monitoring
- Clear understanding of DER response and modeling for grid disturbances
- Secure and reliable protection of distribution grids with DA, DER and electrification
- Improve grid reliability through reduced protection mis-operation and use of new technologies
- Improve operator situational awareness of protection operation and fault location

Key Activities

Automated protection analysis

Tool to automatically perform protection studies, identify credible protection issues and propose mitigations.

Guidance for mitigation impacts of DER on system protection

Direction for modeling DER and load in protection studies as well as guidance to mitigate impacts.

Microgrid protection

Guidelines for safe and cost-effective microgrid protection design.

Evolve protection design practices and technologies

Guidance on evolving protection of distribution grids with high amounts of DER and electrification including leveraging new technologies.

Protection data management

Clear understanding of and guidance on deploying the methods and tools to store and manage protection configuration data.

Automated event analysis

Operator and protection decision support tools to automatically perform event visualization, root-cause analysis, fault location estimation, and event record analysis.

> *Testing of high impedance fault detection methods helped build confidence in ability to detect downed conductor events successfully across a range of different conditions.*
>
> — Xcel Energy

Analytics

About 200E

Provides engineers with the analytics necessary to modernize how existing assets and new resources are modeled and simulated for grid analysis. Distribution engineers use these capabilities to effectively and efficiently streamline complex analytics, consider emerging technologies, and leverage new data streams.

Contact: Matthew Rylander, mrylander@epri.com

Member Value

- Consistent, efficient, and effective analytics for strategic distribution planning decisions
- Enable and expand the use of both grid data and measurement data as a fundamental utility asset
- Reduced engineering time spent resolving modeling and data integration issues
- Increased confidence and consistency in operations and planning models

Key Activities

Enhanced grid modeling

Framework and automated methods for verification of grid model data availability, validation of grid models, and grid model correction and quality tracking.

Utilizing measurement data

Methods to leverage SCADA and AMI data to improve operations and planning decisions.

Hosting capacity

Advancement to and guidance on hosting capacity methods, tools, and application in planning and operations.

Wide-area distribution assessments

Tools to enable effective and efficient analysis of wide-area grid impacts from electrification, decarbonization, extreme events, etc.

> *Grid model data requirements provided significant value by identifying the critical and most common data elements needed for the majority of use cases as well as the level of detail required. It also supported the alignment of Distribution Planning and Operations Use Cases to understand where data requirements overlap and focus no regrets endeavors.*
>
> — Brian Hatt, AEP

Technology Transfer

We transfer the research value to members in a number of ways with a goal to enable application within the planning, operations, and protection.

- **Interest groups**
- **Workshops**
- **Task force meetings**
- **Newsletters**

Informing Grid Modernization Plans

Utilities continue to make significant investments in grid modernization, which require careful planning across many teams in the organization. DO&P provides research to inform these decisions as well as tools to help develop these plans.

The Grid Modernization Playbook provides a framework to help utilities develop company-specific strategies and identify capabilities needed to meet the evolving requirements. The DO&P team has worked with over a dozen utilities to apply this framework providing a consistent and efficient basis to develop grid modernization strategies.

Latest Grid Modernization Playbook 3002030340

> *The Playbook saved time in creating an initial roadmap and showing alignment between organizational goals and engineering projects.*
>
> — Uzma Siddiqi, Seattle City Light

Interest Groups

Operations and Planning Interest Groups provide control center managers, planners, and engineers the opportunity to discuss and share experiences, learn from other utilities, and identify gaps and opportunities.

Operations

- Distribution control center
- Staffing and training
- Operations practices
- DA & DMS
- DER

Planning

- Tools
- Methods
- Forecasting
- DER Interconnection, criteria, and practices

> *The Distribution Planning Interest Group provides an invaluable opportunity and platform for Avangrid distribution planners to discuss and collaborate directly with industry peers on key and common challenges they face as the distribution system is constantly evolving.*
>
> — Elder Romero, Avangrid

> *EPRI is an invaluable resource for the utility industry, offering a strategic partnership that provides insights into best practices and innovative solutions…it plays a crucial role in driving progress and supporting organizational excellence.*
>
> — Samantha Guenette, LG&E-KU

Your needs inform EPRI research.

Beyond information sharing these interest groups provide critical insights into the challenges utilities are facing and inform the research we do in the program throughout the year.

Software Tools

The DO&P team has an expanding toolset to help utilities assess complex problems while continuously improving our workforce impact. This allows members to utilize the methods and algorithms developed directly to support day-to-day functions. Tools are a vehicle for quick transfer of the R&D to application, with potential to save engineering time and reduce costs. Examples of our tools include:

DRIVE™

Used by 35 utilities worldwide. Enables an effective means for assessing location-based impacts of distribution resources.

Fleet EV Assessment Tool

Assesses the impacts of fleet electrification on the distribution system to improve grid utilization and identify mitigations.

Automated Distribution Assessment and Planning Tools (ADAPT)

Evaluates traditional and non-traditional planning alternatives in an automated fashion.

Optimal DA Switch Placement Tool

Evaluates the optimal placement of switches on the distribution system.

Measurement Data Cleaning Tool

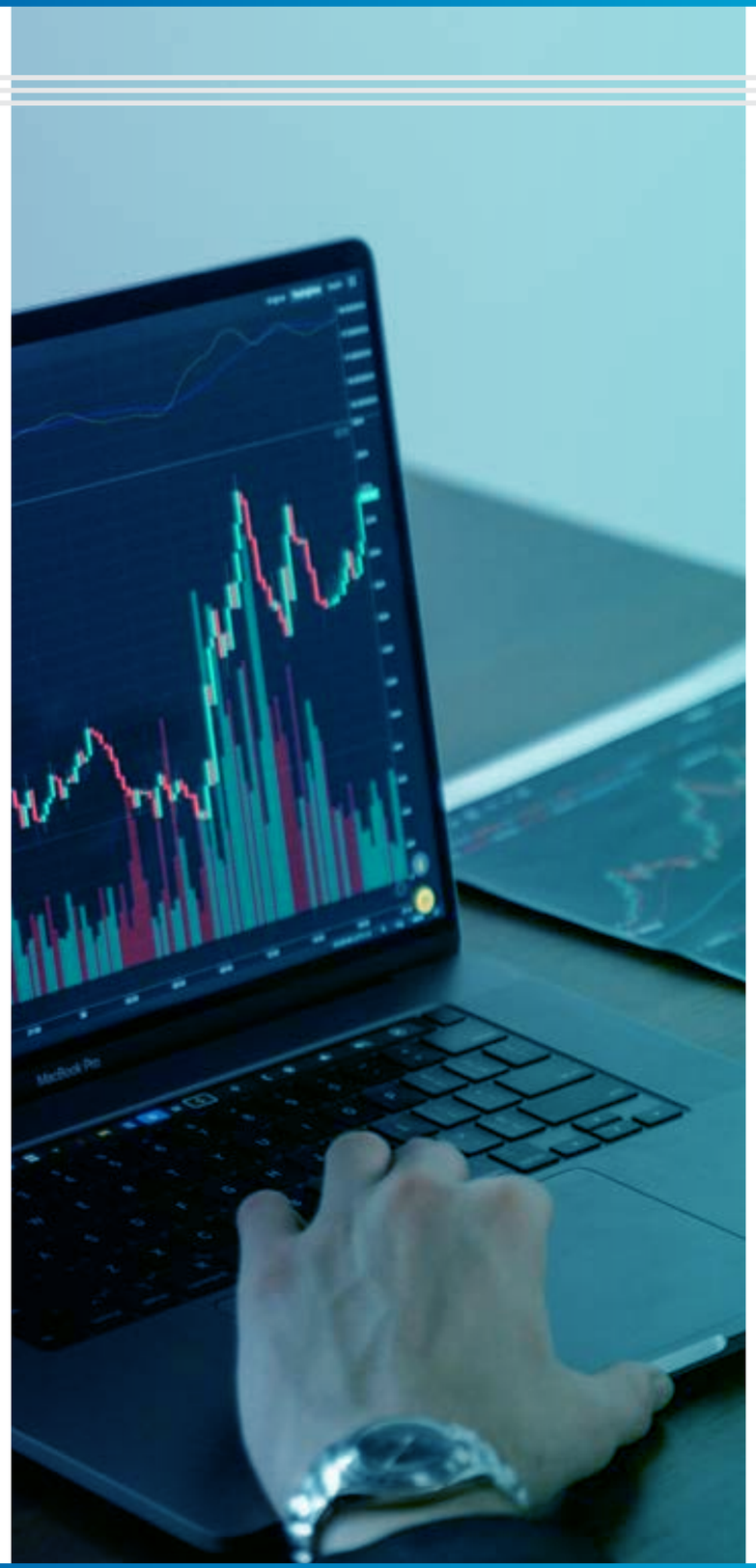
Automatic detection and processing of time-series measurement data issues based on intended applications.

Distribution Protection Analysis Toolkit (DPAT)

Enables protection engineers to perform wide-ranging protection coordination checks in an automated fashion.

OpenDSS

This open-source tool is a key resource for EPRI research and is used throughout the industry for simulating distribution systems.



> *DRIVE has helped fast track dozens of applications, reducing interconnection application processing time by ~10x.*
>
> — Andres Valdepena, Idaho Power

> *EPRI's ADAPT tool will allow APS to efficiently review multiple system upgrade options and technologies, efficiently and comprehensively providing results for various modern distribution system plans.*
>
> — Michelle Rodriguez, Arizona Public Service

> *Using the same criteria as our protection assessments, DPAT completes hundreds of assessments in the time it would take me to assess one device.*
>
> — Fortis Alberta

> *The Measurement Data Cleaning Tool simplifies the analysis of metering data for power systems engineers, ensuring reliable results without the hassle.*
>
> — Akheel Ambaram, Eskom

From research, to application, to commercial adoption.

EPRI has technology transfer plans in place for all software to ensure the methods developed in R&D can find its way into user hands and commercial applications.

OPS Lab

The goal of the OPS lab is to bridge the gap from planned deployments to field-ready applications. From the operator to the device, the OPS lab provides capabilities to emulate a complete distribution system and assess innovative solutions.

> *The capability to test the scheme in the lab provided the opportunity to observe scheme operation under various system conditions. The ability to simulate system conditions as well as modify logic on the fly allowed various scenarios to be tested cost-effectively.*
>
> — Richard Lavigne, Dominion

> *National Grid was able to rapidly iterate through different FLISR programming and test new ideas, improve designs, and validate stability of FLISR logic without the need for field work and lab/field tests.*
>
> — Christopher Lamothe, National Grid

About Our Lab

Our OPS Lab is about assessing and maximizing use of new technologies that can help transform distribution and is a key resource enabling P200 research.

DMS and DA testing

Utilities are very limited today in their ability to test complex DMS/DA algorithms prior to field implementation. The OPS Lab enables testing of all DMS functions (e.g. Volt/VAR, FLISR, DSSE) against a synthetic “real world”. The OPS lab enable a range of scenarios to be explored including the ability to manipulate loads, DER production, voltages, faults, etc. to evaluate DMS/DA algorithm response and performance.

Operator training

Present DMS Operator Training Simulators are more focused on the operator learning how to use the DMS software and basic activities. Using the OPS Lab utility, trainers and managers will be able construct realistic but complex scenarios, including multiple contingencies, control failures, device failures, communications failures, and variations in loading, DER production, and voltage during the training exercise.

Protection technologies

New technologies present opportunities for improving operations and protection of the grid, but there is also an increase of complexity. The OPS lab enables the evaluation of new protection technologies, logic and approaches to enable safe and reliable deployment.

Supplemental Projects

Supplemental projects are focused on implementing and demonstrating new methods/tools in a timely manner. They leverage collaboration to increase the pace and depth of research accomplished. From research to application, supplemental projects allow utilities to:

- Gain hands-on experience
- Implement new processes with utility SMEs
- Prove out technology and integration
- Get results specific to your system

What can we do?

Roadmaps and assessments

Operations and protection evaluations

Control center planning

Reliability, and resilience assessments

Wide-area distribution assessments

Strategic planning studies

Example Projects

- **Grid Readiness Assessments to Enable Electrification** Perform wide-area assessments to determine system constraints and potential mitigations to enable future electrification scenarios.
- **Secondary Design for Electrification** — Develop guidance on how to account for electrification loads in residential service design.
- **Measurement Data Cleaning** — Support utilities in planning and preparing the grid for fleet electrification using advanced analytics and tools.
- **Grid Model Validation and Verification** — Develop and apply tools to automate model validation and verification techniques and improve grid model accuracy.
- **Control Center of the Future Roadmap** — Develop a standard framework for future distribution control center capabilities including roadmap and decision support tools.
- **Alarm Management** — Apply alarm management philosophy to enable utilities to prioritize alarms and improve operators situational awareness in the DCC.

> *The framework and tool being developed by EPRI is a quick win for the Company in order to automatically detect, correct and validate system models and expedite the time Planning Engineers spend in the model clean-up process so that they can focus on other value added tasks.*
>
> — Elder Romero, Avangrid

> *The Distribution Operations team at EPRI have provided ESB Networks with invaluable insight and expertise on the interface design requirements for our ADMS implementation programme.*
>
> — Ronan Moore, ESB Networks

2024 Deliverables

Planning P200B

Guides	**Distribution Planning Guidebook** 3002030130	Guidebook focusing on traditional and modern distribution tactical planning procedures
	Medium- to Long-Term Forecasts Accounting for Decarbonization Goals and Climate Change 3002030194	Forecasting practices and guidance on methods to harmonize bottom-up and top-down forecasts for improved accuracy and efficiency
	Distribution Feeder Ratings and Planning Criteria 3002030132	Assessment of how planning criteria and ratings may need to evolve to effectively plan for changing ambient conditions and manage associated risks
	The Effect of Reverse Power Flows on Substation Transformer Banks 3002030664	Guidance on the thermal impacts of reverse power flow on substation transformers
	Planning for Passenger, Medium-, and Heavy-Duty Transportation Electrification 3002030887	Methods for serving transportation electrification loads with an emphasis on developing load shapes and diversity factors
	Distribution System Scenario Planning: Case Study and Guidance[P] 3002030781	Guide on scenario planning and how it can be used in the planning process including a case study demonstrating considerations like study horizon, data, planning criteria
Tools	**Automated Distribution Assessment and Planning Tools** Tool, 3002030135 Tutorial, 3002030808	Tool and tutorial on automating advanced analytical methods for integrating wires and non-wires alternatives into planning studies
Processes	**Scenario Planning for the Distribution System: An Overview** 3002030138	Guidance for developing, selecting, and applying scenarios in strategic and tactical planning assessments to capture uncertainty
	Strategic Capacity Planning Framework 3002030139	Framework to assess long-term, system-wide, substation- and feeder-level infrastructure needs and NWA opportunities
	Designing Distribution Systems to Enable Deep Decarbonization[P] 3002030782	A call to action on enabling decarbonization highlighting common opportunities and actions that can be taken to better prepare the distribution grid
	Implementation of IEEE Distribution Grid Resilience Metric[TI] 3002030297	Assessed resilience metric being proposed as part of the IEEE working groups leveraging utility data set
Workforces	**NWA Workshop** 3002030316	Case study insights and strategies employed in developing and operating real-world NWA programs
	Protection Tutorial for Non-Protection Staff 3002030902	Online tutorial on the concepts and methods of system protection, that are foundational for system reliability, safety, and DA

P = Public TI = Technology Innovation

2024 Deliverables

Operations P200C

Guides	**Distribution Operations Guidebook** 3002030140	Guidebook with foundational knowledge relevant to today's DCCs supporting implementation of DA and DMS applications
	SCADA/DMS Visibility of EV Charging 3002030142	Guidance on how to represent controllable resources in SCADA/DMS systems including what type of variables to monitor
Processes	**Selecting Tools for Short-Term PV Forecasting** 3002030141	Method and framework that can be used to evaluate the capabilities of operational forecasting tools
	Impacts of Energy Storage on Distribution Operations 3002030901	Practices for the use of storage as a resource in operations including the representation in control center displays
	Wide Area Distribution Assessment for Reliability 3002030143	Tool for wide-area predictive reliability analytics and critical operational data inputs
	Hot Line Tags 3002030783	Guide with common terminology and practices including lead times, peer checks, reaction to events, field crew involvement, recloser overreach and alternate configuration
Workforces	**Protection Tutorial for Non-Protection Staff** 3002030902	Online tutorial on the concepts and methods of system protection, that are foundational for system reliability, safety, and DA
	Informal Communications in DCC 3002030739	Example of a miscommunication during control center interactions that led to operational errors
	Distribution Systems Assets, Operations, and Planning Workshop Materials	Workshop with recent EPRI research results that can help improve distribution system reliability, resilience, safety, and cost management

2024 Deliverables

Protection P200D

Guides	**DER Impacts on Protection Performance** 3002030149	Guide on how DER can impact protection performance including how to identify impacts and mitigation solutions
	DER Impact on Protection Guidebook 3002031136	Application guide for a DER POI (PCC) recloser
	DER Models in Short Circuit Modeling Software 3002030151	Comparison of phasor domain DER short circuit models against lab test data
	Modeling DER for Protection Studies 3002031280	Reference guide on inverter-based and rotating DER short circuit characteristics, and modeling for short circuit studies
	Guide to Protection of Microgrids 3002030784	Reference guide to enable straight-forward design of microgrid protection and modeling short circuits and island to grid-connected transition
Tools	**Distribution Protection Analysis Toolkit for CYME** 3002030147	Tool to automatically perform protection studies across multiple scenarios, identify protection issues, propose changes to fusing or recloser settings to mitigate issues
	Distribution Protection Analysis Toolkit for Synergi Electric 3002030148	
Processes	**Hot Line Tags** 3002030783	Guide with common terminology and practices including lead times, peer checks, reaction to events, field crew involvement, recloser overreach and alternate configuration
	Adaptive Protection Schemes for Increasing DER Penetration 3002030152	Industry experience with adaptive protection and lessons learned from case studies to design and deploy solutions to enable higher DER capacity
	High Impedance Fault Detection Technologies 3002030685	Test results of high impedance fault detection techniques introduced by relay vendors to determine their efficacy
	Deploying Microgrids at Scale 3002031295	Protection strategies that can be adopted to enable successful rollout and deployment of utility microgrids at scale
	Protecting Your First Microgrid 3002031291	Protection guidelines for integrating a first microgrid project
Workforces	**Distribution Systems Assets, Operations, and Planning Workshop** Materials	Workshop with recent EPRI research results that can help improve distribution system reliability, resilience, safety, and cost management
	Protection Tutorial for Non-Protection Staff 3002030902	Online tutorial on the concepts and methods of system protection, that are foundational for system reliability, safety, and DA

2024 Deliverables

Analytics P200E

Guides	**Framework for Grid Model Verification and Validation** 3002030153	Guide to develop, implement, and demonstrate methods for grid model verification, validation, tracking grid data quality including remediation and automation methods
	Grid Modeling Guidebook 3002030154	Guidance to assess grid model readiness for various applications including required detail/resolution
	Hosting Capacity Guidebook 3002030158	Updated guidebook on hosting capacity methods and applications
Processes	**Measurement Data and Use Case Repository** 3002030155	Repository of uses cases for using measurement data and requirements to maximize its application in distribution operations and planning
	Measurement Data Cleaning 3002030156	Methods to clean, structure, and make measurement data easier to utilize with a focus on leveraging data maps to illustrate system observability and identify load transfers
	Measurement Data: Cold-Load Pickup and Load Shape Diversity 3002030157	Methods for use of AMI and SCADA data to characterize cold load pick up and load shape diversity applications
	Distribution Analysis Result Visualization 3002030159	Examines software options and tools to visualize a user defined set of data in a static, interactive, and dynamic interface
	Updates on IEC CIM Standards 3002030462	Updates on the latest in the IEC CIM standards related to distribution modeling use cases
	Grid Modeling in Distribution Planning: Importance of Good Grid Models[P] 3002031246	Summarized the criticality of efforts to improve grid modeling and the processes surrounding it for the future
	WADA Applications | Materials	Lessons learned applying wide-area assessment methods for reliability and investigated use of superposition for calculating hosting capacity
	Extending CIM Standard for Protection Settings[TI] 3002030337	Updates to CIM standard to incorporate protection settings data
Workforces	**Grid Modeling Workshop: Intro on CIM** Materials A, Materials B	CIM training on history of CIM and distribution feeder modeling including common questions and misconceptions
	Python Tutorial – Synergi Materials	Tutorials on the use of python with a focus on the basics of python use as well as Synergi specific applications
	Python Essentials Tutorial Materials	

P = Public TI = Technology Innovation

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600+ years of combined experience

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