

124 Smart Distribution Applications and Technologies

Program Overview

Program Description

The Smart Distribution Applications and Technologies program focuses on the implementation of smart grid technologies at the distribution level. The program coordinates with EPRI's IntelliGrid program where the research focuses on the communications and information infrastructure to support the smart grid. This program specifies, develops, and applies the technologies and applications that take advantage of the communications and information infrastructure. The program provides industry coordination and technology assessments for smart distribution system technologies and applications while also working on an actual development and implementation of key technologies. Technology areas include power electronics applications like the intelligent universal transformer (IUT) and the modular solid-state switch. New research areas in the program will provide a focus on new sensor technologies for distribution system management and applications that can take advantage of investments in advanced metering. The program will also look at application issues for the advanced meters themselves. Finally, the program will help develop the next-generation distribution simulation platform that can support both planning and real-time applications—this work is being done in cooperation with the U.S. Department of Energy (DOE) and other industry participants.

Industry Needs and Issues Addressed

- Automating the power distribution system is a critical need to improve reliability, power quality, and management of distribution assets; reduce losses; and allow the integration of distributed resources.
- New technologies like the intelligent universal transformer and solid-state switchgear are needed to provide a foundation for advanced applications in the smart distribution system.
- Utilities need tools and information to evaluate new technologies and applications that can support the automation of the distribution system.
- There is a need to integrate and take advantage of investments in advanced metering infrastructure for the development of smart distribution systems.
- New simulation tools and system control approaches (distribution management systems) are needed to support advanced applications that will provide real-time optimization of voltage, losses, reliability, configuration, and equipment performance for distribution systems.

Impact

- Provides the foundation for collaborative research and technology assessments that assist members with the specification and deployment of smart distribution systems
- Coordination with DOE, IEEE, and other industry organizations to develop and maintain the Distribution Automation Application Guidebook
- Provides technology assessments and updates on new technologies that will become an integral part of smart distribution systems
- Provides the foundation for new power electronics technologies that will integrate with the smart distribution system
- Develops and evaluates new monitoring systems and sensors that will integrate with smart distribution systems, including technologies that will automatically identify equipment and system problems
- Develops and evaluates new software and control systems to improve the performance of smart distribution systems
- Develops and evaluates approaches for integrating advanced metering system infrastructure with smart distribution system applications

Key Accomplishments

- Roadmap for the implementation of the smart distribution system (updated each year based on international R&D collaboration)
- Design and Field Assessment for Advanced Monitoring Approaches for Smart Distribution Systems (e.g., Automated Fault Location)
- Distribution Fault Anticipator (DFA)
- Feeder designs to accommodate higher penetration of distributed resources
- Design and prototype for the IUT
- Design concept for a modular solid-state switchgear system
- Advanced simulation systems that can be a foundation for future planning and real-time tools for optimizing system performance (Distribution System Simulator and Guidelines for Distribution Fast Simulation and Modeling in Program 161)
- Power Quality Applications/Advanced Distribution Automation (PQA/ADA) Conference (2007 and 2008 – joint with Program 1)
- International Workshops for Coordination of Smart Distribution Research (annual event since 2003)

Current Year Objectives

- Initial version of the Distribution Automation Guidebook
- International Workshop on ADA and Distribution System of the Future
- PQA/ADA Conference and Exhibition
- Updated Smart Distribution System Roadmap
- Technology Watch for Distribution Smart Grid Technologies
- Final plan and design for IUT field prototype
- Field prototype of modular solid-state switchgear
- Advanced controls and simulation methods for implementing smart grid applications (e.g., loss reduction, equipment performance optimization, fault location)
- Recommended approaches and key applications for integrating advanced metering infrastructure with smart distribution systems
- Commercialization and integration of distribution fault anticipator technology

Industry Involvement

- Estimated 2009 funding: \$1.9M

Program Technical Lead

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Summary of Projects

PS124A Technology Transfer, Technology Watch, and Industry Coordination (058488)

Project Set Description: This project set will provide information and technology transfer products to the industry to help members understand the state-of-the-art in automating distribution systems. The project set sponsors the PQA/ADA conference, international workshops, technology watch, and development of the industry application guide for distribution automation in cooperation with the IEEE Distribution Automation Working Group.

Project Number	Project Title	Value
P124.001	Technology Transfer, Technology Watch, and Industry Coordination	<ul style="list-style-type: none">• Development of the Industry Distribution Automation Application Guide (with the IEEE Distribution Automation Working Group)• PQA/ADA Conference• International Coordination Workshop• Technology Watch and technology assessments• Industry standards participation

Project Descriptions

P124.001 Technology Transfer, Technology Watch, and Industry Coordination (067459)

Issue

The utility industry is rapidly moving to modernize distribution systems, including wider use of advanced distribution automation (ADA) systems. There is a need to coordinate research activities (both domestic and international) to achieve efficient development of technologies, software, standards, and other capabilities for the smart distribution system of the future. There is also a need to incorporate the best practices emerging from the utility and vendor communities into engineering tools to facilitate high-quality automation practices with uniform procedures and standardization wherever possible.

Utilities need to assess the relevant new technologies, software, and services emerging from the research and vendor communities to better understand the value of these products and the ways they can be most effectively used in advancing future system development and operations. There is also a need to evaluate performance through actual field application experience with emerging capabilities. This can be done by coordinating assessments and lessons learned across the many deployments and trial projects going on throughout the world.

Description

This project will develop and maintain a distribution automation application guidebook that can serve as a central tool to help utilities implement advanced distribution automation systems based on the latest technologies, research, and application experience. This industry guidebook will be a living document that will be available in both electronic form and periodic published versions. The online version will be delivered as a web-based product. Cooperation with the IEEE Distribution Automation Working Group is being organized for the guidebook's ongoing development and management.

This project supports annual activities to capture knowledge broadly from the industry and disseminate it. The information will be used to support strategic planning and coordinate the collaboration between domestic and international programs wherever possible. EPRI will continue to convene its Annual International Workshop on ADA and the Distribution System of the Future. The workshop provides a roundtable forum for reviewing the status of key international programs and developing plans for ongoing coordination and collaboration among the programs. Participation is limited to program participants and key industry leaders. The annual strategic plan for ADA and smart distribution systems will be updated to reflect workshop results, which will be posted on a website.

EPRI will also continue to conduct the annual joint PQA/ADA Conference with international participation. The large open conference is jointly sponsored by Programs 1 and 124. This conference includes papers and tutorials on a broad range of topics pertaining to power quality, ADA, and the distribution system of the future. The conference proceedings are documented on a compact disc.

EPRI will assess key technology and software products and advanced distribution automation system approaches. Technologies to be assessed will include automated reconfiguration systems, technologies for advanced voltage and var control, new power electronics, technologies for integration with automated distribution systems, advanced distribution sensors and monitoring technologies (including advanced metering systems integration with distribution automation), and advanced simulation technologies for distribution management including real-time state estimation. Monthly web-based technology updates will be issued on important industry developments. The monthly updates will be combined into an annual report on automation technologies.

Value

- Helps utilities apply new technologies more effectively by understanding important application issues, technology limitations, and functionality
- Provides an educational resource for utility personnel involved in automating distribution systems
- Helps provide coordination for industry developments in distribution automation to assure interoperability and successful integration with utility systems
- Helps utilities choose from among the technology, software, and system-level options for smart distribution systems
- Coordinates and disseminates information on worldwide activities in smart distribution systems

How to Apply Results

Electric distribution managers, engineers, information technology specialists, and planners will use the project results to help develop smart distribution systems that will feature improved reliability, improved power quality, better efficiency, and increased customer services. Implementation of project results will improve technology selection and application and will help assure interoperability of technologies with utility systems. Project results will be used as educational resources, technology guides to support specification development, and tools for assessment of technology options.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
First Edition of Guide for ADA and Smart Distribution Systems: Web-based guide on ADA and smart distribution systems	12/31/2009	Technical Resource
5th International Workshop on ADA and the Distribution System of the Future	12/31/2009	Workshop, Training, or Conference
Joint PQA/ADA Conference: Joint PQA/ADA conference conducted jointly with Program 1	12/31/2009	Workshop, Training, or Conference
Technology Watch Report on ADA and Smart Distribution Systems: A report on technical information and field application experience with emerging technologies, software, and distribution design approaches for ADA and smart distribution systems. The Technology Watch report will be a combination of monthly web-based technology watch documents issued throughout the year.	12/31/2009	Technical Update
Update to EPRI Strategic Plan for ADA and Smart Distribution Systems: The EPRI Strategic Plan for Smart Distribution Systems is updated each year based on technology assessments and the result of the international coordination workshop.	12/31/2009	Peer Literature

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Industry Guide for Smart Distribution Systems: Ongoing updates to the Industry Guide for Smart Distribution Systems will be developed in conjunction with the IEEE Distribution Automation Working Group.	2010	Technical Resource
6th International Workshop on Smart Distribution Systems: The 6th International Workshop on Smart Distribution Systems will continue the annual coordination of research activities around the world on distribution automation and related technologies.	2010	Workshop, Training, or Conference
PQA/ADA Conference: The PQA/ADA Conference provides a forum for new technology and application descriptions and presentations (including exhibits). The conference is sponsored jointly with the Power Quality Program, Program 1.	2010	Workshop, Training, or Conference
Technology Watch Updates and Report: The Smart Distribution Technology Watch updates will be published monthly as web-based reports and then combined into a Technical Update report at the end of the year.	2010	Technical Update
Smart Distribution System Strategic Plan Update: The Smart Distribution System Strategic Plan will be updated annually based on the coordination of workshop results, technology assessments, and application experience.	2010	Peer Literature

PS124B New Technologies for Smart Distribution System (058489)

Project Set Description: This project set develops new technologies for Smart Distribution Systems that could become an integral part of future distribution infrastructure. Two ongoing projects are developing power electronics technologies: the intelligent universal transformer (IUT) and the multifunction solid-state switchgear system (4-S). These two projects are complemented by two new projects in 2009—sensors for real-time distribution system monitoring and advanced meter application issues and testing. The combined projects support a cross-section of important technology developments in the industry.

Project Number	Project Title	Value
P124.002	Multifunction Solid-State Switchgear System (4-S)	<ul style="list-style-type: none"> • Development of a modular power-electronic switch system for applications in smart distribution systems • Characterizes important applications for solid-state switchgear (e.g., transientless switching, fast current interruption, fault current limiting) • Characterizes economics and other advantages of solid-state switchgear system (e.g., eliminating sulfur hexafluoride) • Incorporation of communication and monitoring to make the switchgear system a smart node in the distribution system
P124.003	Intelligent Universal Transformer	<ul style="list-style-type: none"> • Development of an advanced power-electronic system for voltage transformation in distribution systems • Provide a platform for convenient integration of

Project Number	Project Title	Value
		<p>distributed resources through a DC bus</p> <ul style="list-style-type: none"> • Characterize economics and advantages of a power electronics transformer system (e.g., eliminating liquid dielectrics, a modular system for reduced inventory, improved power quality, and voltage regulation) • Development of communications and monitoring functionality to make the distribution transformer a smart node in the distribution system • Develop application examples and test plan for a field prototype currently being designed and built
P124.004	Sensor Technologies for Real-Time Distribution System Monitoring	<p>This project builds on fundamental work in a Technology Innovation project to identify and evaluate important sensor technologies that can be part of the smart distribution system. It will focus on assessment of sensor technologies in actual smart distribution applications.</p> <ul style="list-style-type: none"> • Technology assessments of new transducers with communications for smart distribution applications • Technology assessment of communicating fault current indicators for overhead and underground applications • Technology assessments of equipment diagnostics sensors for asset management and maintenance
P124.005	Advanced Meter Application Issues and Testing	<p>This project focuses on physical application issues for advanced electronic meters.</p> <ul style="list-style-type: none"> • Lifetime assessments as a function of environment • Surge testing, overvoltages, ferroresonance, and more • Application guidelines for electronic meters

Project Descriptions

P124.002 Multifunction Solid-State Switchgear System (4-S) (060481)

Issue

Major issues that are addressed by the solid-state switchgear system (4-S) product include switching without the need for sulfur hexafluoride (SF₆) or another interrupting medium, faster switching to provide more options for fault clearing and system reconfiguration, switching transient control (e.g., capacitor banks), and fault current limiting. The 4-S also provides a monitoring node capability for integration with advanced distribution automation (ADA) monitoring systems. The 4-S can reduce costly inventory expenses associated with the variety of switchgear products currently needed for distribution systems. The 4-S is more parts-wise repairable than conventional switchgear, which will enable more instances of repair over total replacement of failed units, with attendant cost savings.

Description

The EPRI multifunction solid-state switchgear system (4-S) is a first-generation power-electronic replacement for conventional distribution switchgear. The goal of EPRI's multifunction solid-state switchgear system (4-S) project is to develop a first-generation modular power-electronic replacement for conventional distribution switchgear that can be widely used in distribution switchgear applications.

This project's 2009 work will continue the 2008 development of an S-GTO based 4.16 kV transfer switch. EPRI contracted Silicon Power Corp. (SPCO) to define the project plan for development, testing, and

supply of a prototype 15 kV class S-GTO based static transfer switch (SSTS). In 2008, SPCO was contracted to build and test the prototypical 4.16 kV SSTS and demonstrate key performance and benefits over the thyristor-based static transfer switch. In 2009, SPCO will work with EPRI to select a host utility for testing the field prototype. EPRI will develop a plan to test and evaluate the prototypical SSTS in pre-commercial field prototype form and to identify and resolve flaws or user problems prior to developing a specification for a first-generation commercial product. SPCO will test, evaluate, and debug the field prototype at the host site.

In 2008 and 2009, this project will develop and test two key 4-S functions:

1. The Fast Transfer Switch, which facilitates rapid load transfer in utility-scale applications
2. The Sensor and Communication System, which acts as a monitoring node in the smart distribution system

Value

- Modular design for a solid-state switch that can provide many functions for the smart distribution system
- Switchgear design that can be the basis of transient-free switching for automation applications like circuit reconfiguration, load transfers, capacitor switching, and fault current limiting
- Prototype design will illustrate the benefits of the technology and provide the foundation for a field demonstration to assess performance
- Design to include monitoring and communications that facilitate integration with smart distribution systems

How to Apply Results

Members will gain an understanding of new power electronics technology that may be the basis for many switchgear applications as part of smart distribution system.

Members will be able to use the results to develop designs for future smart distribution systems incorporating new switching functionality.

Members will evaluate the prototype design to help understand the economics and application issues for future system designs.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Status Report on Development, Testing, and Debugging of Field Prototypes for the Multifunction 4-S: This report will document design, prototype development, and application plans for the multifunction solid-state switch.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<p>Final Report on Multifunction 4-S Development, First-Generation Product Specification, and Commercialization Plan: This report will provide documentation of the prototype switch design, development, and testing. Conclusions and recommendations for applications and ongoing development needs will be included.</p>	2010	Technical Report

P124.003 Intelligent Universal Transformer (051716)

Issue

Conventional transformer costs and lead times are rising sharply. Conventional transformers suffer from poor energy conversion efficiency at partial loads, use liquid dielectrics that can result in costly spill cleanups, and provide only one function—stepping voltage. These transformers do not provide real-time voltage regulation, do not offer monitoring capabilities, and do not incorporate a communication link for use as distribution system monitoring nodes as part of the smart distribution system. At the same time, these transformers require costly spare inventories for multiple unit ratings, do not allow supply of three-phase power from a single-phase circuit, and are not parts-wise repairable. Future distribution transformers are also going to need to be an interface point for distributed resources (storage, PHEV, PV, other DG). A power-electronic system replacement for conventional transformers would resolve these issues.

Description

The intelligent universal transformer (IUT) is a first-generation power-electronic replacement for conventional distribution transformers. In 2007, a contractor was selected to develop the IUT and subsequently commercialize it. In the project, the team develops and tests field prototypes, working in conjunction with host utilities. Related business-case and utility-integration studies support the IUT development work. Knowledge gained from prototype testing and debugging is used to prepare a specification for a first-generation commercially releasable product. Specific optional functions chosen for inclusion in the first-generation product are based on sponsor priorities up to the limit of available funding. The project will also develop a commercialization plan and assess optional technologies for the intelligent universal transformer based on ongoing industry developments, market evaluations, and cost/benefit assessments.

Based on high-voltage semiconductor device availability, a 4.16 kV, 20 kVA IUT™ was identified as the first development target that would lead to a hardware bench model demonstration. In 2005, a laboratory bench model was designed and tested to establish proof of concept for a suitable HV power electronic circuit topology for the IUT™. The bench model was rated at 20 kVA with the input voltage rated at 2.4 kV_{RMS} phase-to-neutral, and output voltage rated at 120/240 V. It was concluded to pursue with the next phase of developing field prototypes from OEMs interested in the IUT™.

In 2007, a request for information (RFI) was issued to seek proposals to develop the 100 kVA 15 kV class IUT™ as a field prototype and test it in a wide range of climatic zones. EPRI and its advisors reviewed the proposals. Silicon Power Corporation (partner with SatCon Technology Corporation and Howard Industries) has been selected for developing the field prototype. The development started in 2008, and this will be continued in 2009 when the unit will be factory tested and then tested at a host utility site.

During the initial phase of this prototype development effort, it was decided that at a minimum, the prototype design will meet the basic functionality of a conventional distribution transformer in terms of its capability for voltage transformation and provide operational benefits in terms of standardization of the

distribution transformer with respect to input/output voltage and kVA rating. Additionally, the minimum design will include a communication interface in the IUT™ to allow remote monitoring and control of the IUT™ to detect component failures and to allow dispatch of IUT™ functions. It is also expected that the IUT™ be functionally capable of real-time voltage regulation at little additional cost relative to the basic voltage transformation function. Development of the smart transformer to interface with solar and other energy storage devices will not be covered through this initial effort.

Value

- Provides an alternative technology (an advanced power-electronic system) for voltage transformation in distribution systems at a time when conventional transformer costs and lead times are increasing rapidly
- Eliminates the liquid dielectrics of conventional transformers and the associated costly spill cleanups
- Provides a communication link and monitoring capability in the IUT to diagnose problems in the IUT
- Supports parts-wise repair, enables distribution system monitoring, and supports advanced automation and more efficient operations
- Can improve energy efficiency of distribution operations, because the IUT is more efficient than conventional transformers at partial loads and because the added functionality improves efficiency in distribution system operations
- Reduces spare inventory costs associated with warehousing many types of conventional distribution transformers, due to the IUT’s modularity
- Provides reduced unit weight and size compared to conventional transformers
- Offers added functionality, such as voltage regulation and distribution system monitoring capabilities, relative to conventional transformers

How to Apply Results

Electric distribution managers, engineers, and designers will use the IUT as a replacement for conventional distribution transformers, both in new installations and to replace aging units. They can apply the IUT in situations where avoidance of spill cleanups from conventional transformers is most crucial and expand to wider usage over time. Distribution system managers can inventory modules of IUT systems that can be configured for several rating levels and replace larger inventory requirements of many conventional transformers at different rating levels. Distribution system designers, information technology specialists, and operators can use IUTs as distribution system monitoring nodes to support system operations and advanced automation and use optional functions (to be prioritized for inclusion in the IUT product by sponsors) such as voltage regulation, configuring to supply three-phase power from a single-phase circuit, output ports for DC power and alternative AC frequencies, and interface with distributed generation.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
<p>Status Report on Development, Testing, and Debugging of Field Prototypes for the Intelligent Universal Transformer: This 2009 deliverable includes a technical status update on the IUT field prototype development work and any needed supporting studies on IUT business and system integration issues.</p>	12/31/2009	Technical update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Final Report on IUT Development, First-Generation Product Specification, and Commercialization Plan: This deliverable provides the final documentation on this project.	2010	Technical report

P124.004 Sensor Technologies for Real-Time Distribution System Monitoring (067460)

Issue

The smart distribution system is based on a variety of sensors for both real-time applications and equipment diagnostics. These sensors must have reduced costs to allow widespread deployment, and they must incorporate communications that will allow integration with the smart distribution system infrastructure.

Existing PTs and CTs are expensive and lack integrated communications.

Equipment diagnostics and asset management applications require a variety of new sensors to assess asset health continually and report on important characteristics.

Description

The project builds on preliminary work being conducted in a Technology Innovation initiative to characterize a variety of sensor technologies that could become part of the smart distribution system (both overhead and underground applications). The project focuses on actual field assessments of new sensor and transducer technologies with integrated communications. The project will demonstrate the technologies themselves, application issues, and integration with distribution management systems.

The project will demonstrate advanced current and voltage monitoring technologies with integrated communications. Issues to be evaluated include transducer accuracy, frequency response characteristics, interface issues, and communications functionality.

The project will also evaluate new sensor technologies for equipment diagnostics and asset management. This effort will include technologies such as temperature and other sensors for both overhead and underground applications.

Value

- Understanding and performance assessments for new sensor technologies that can be part of smart distribution systems
- Development of application guidelines for new sensor technologies
- Ability to integrate new sensor technologies with overall distribution management systems

How to Apply Results

Members will be able to gain an understanding of new sensor technologies so that they can be included in new smart distribution system designs.

Members will understand the benefits and limitations of important new sensor technologies and will get application guidelines from actual field experiences.

New sensor technologies must be integrated with overall distribution management systems and can provide the basis for new real-time system performance optimization. Members will get a head start on developing and implementing these advanced applications through documentation of sensor functionality, accuracy, and applications.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
<p>Report of Advanced Sensor Technologies for Smart Distribution Systems: This report will provide guidance on the application of new sensor technologies for smart distribution system applications based on actual field experience with the technologies, integration issues, and performance documentation.</p>	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<p>Report of Specific Advanced Sensor Technology Applications: The report will continue to document important sensor technologies and their application as part of smart distribution systems.</p>	2010	Technical Update

P124.005 Advanced Meter Application Issues and Testing (067461)

Issue

Many utilities are in the process of evaluating and deploying advanced metering technologies. These technologies will become part of the smart distribution system of the future. However, there is little experience with the actual performance of these new meter technologies in field applications. There is a need to understand important field application issues, environmental performance characteristics, and the ability to withstand voltage and current variations.

Description

The project focuses on evaluation of application issues for advanced meters that will become part of the smart distribution system. It will use a combination of laboratory testing and actual field performance assessments to develop conclusions about advanced meter application issues and lifetime characteristics.

There are a number of important parts to the research:

- Environmental testing in the laboratory. This project will use accelerated lifetime tests to understand the ability of advanced meters to withstand long-term environmental conditions.
- Voltage and current testing in the laboratory. This testing includes both the communications interfaces for the meters as well as the voltage and current monitoring performance under adverse conditions.
- Characterization of the effect of harmonics and power factor on meter accuracy. Future meters may need to characterize customer impacts on harmonic distortion and power factor. This feature will require the ability to characterize customer load (and generation) accurately, for both fundamental and harmonic conditions. Laboratory testing will characterize meter performance

for non-sinusoidal conditions and for characterizing load power factor.

- Evaluation of important field application issues and performance through experience of initial advanced metering deployments. The project will work with members that are deploying advanced meters to identify lessons learned and important application issues associated with the meters.
- Advanced meters will need to continue to operate during power outages, to provide functionality for smart distribution systems (e.g., integration with outage management systems). The project will evaluate battery performance and meter performance during and following outages.

Value

- Understand the application issues for advanced meters as they are integrated with smart distribution systems.
- Understand the expected lifetime for advanced meters for planning and budgeting of maintenance and replacement plans.
- Understand the performance of advanced meters during transients and for characterizing harmonics and power factor. These could be important functions in the smart distribution system.

How to Apply Results

Members will be able to develop more accurate budgets and plans for advanced meter deployments.

Members will be able to develop better plans for integrating advanced meters with smart distribution systems by understanding important application issues and meter limitations.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Testing and Performance Assessment for Field Applications of Advanced Meters: The project will provide test plans, test results, field application results, and application guidelines for the deployment of advanced meters as part of smart distribution systems.	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Testing and Performance Assessments for Advanced Meters: Continued updates to testing and field application assessments for advanced meters.	2010	Technical Update

PS124C New Applications for Smart Distribution System (062126)

Project Set Description: This project set develops and evaluates emerging circuit, control, protection, and monitoring system capabilities for Smart Distribution Systems. The Distribution Management System (DMS) of the future will need to integrate many functions to optimize system performance, reduce losses, optimize voltage and var control, and improve reliability through system reconfiguration and fast restoration. These applications will require new simulation functionality, as well as new monitoring and control systems. The advantages and disadvantages of various options will be described and actual field experience will be documented. Specifications will be provided for integrating new functions into smart

distribution systems. The project set will also evaluate specific distribution management applications that can take advantage of advanced metering systems. The resulting requirements for advanced metering systems will be documented, as will the integration requirements.

Project Number	Project Title	Value
P124.006	New Methods for Active Distribution System Management	<p>This project develops and evaluates new methods and applications for improving distribution system performance and reliability.</p> <ul style="list-style-type: none"> • Simulation methods and tools for both planning and real-time applications as a basis for optimizing performance • Volt/var control applications for optimizing voltage levels • Reliability improvement through disturbance response and reconfiguration approaches • Equipment diagnostic applications based on advanced monitoring and intelligent algorithms
P124.007	Distribution Applications Leveraging Existing Information and Communications Infrastructures such as AMI	<p>This project focuses on applications that build on a communication and advanced metering infrastructure.</p> <ul style="list-style-type: none"> • Advanced modeling approaches that incorporate load profiles, metering data, and more for system performance optimization • Integrating advanced metering with system applications such as outage management • Improved fault location using advanced metering infrastructure

Project Descriptions

P124.006 New Methods for Active Distribution System Management (067462)

Issue

Smart distribution systems will incorporate a variety of new control and system optimization functions. These functions will take advantage of advanced sensors, system communication infrastructure, new switchgear technologies, and new modeling and simulation capabilities. The applications with the most value for optimizing distribution performance need to be identified, to help prioritize development and implementation of these functions. Requirements for these functions (e.g., sensors, control technologies, modeling requirements, simulation tools, communication infrastructure, etc.) need to be defined. Finally, the performance limitations need to be identified as a function of the implementation (e.g., number of sensors, accuracy, modeling limitations, communication limitations, simulation capabilities)

Description

The project will characterize important functions and applications for the smart distribution systems and develop guidelines for their implementation. These functions will include the following:

- Voltage and var control functions to optimize distribution system voltage and var flows (minimize losses). These controls can take advantage of distributed sensors and advanced metering to control capacitors and regulators throughout the system.
- Fault characterization and location through improved monitoring, fault indicators, and integration with system models.

- Automatic system reconfiguration to optimize the response to system faults, including adaptive protection systems, load management, etc.
- Integration of demand response and distributed resources to optimize system performance.
- Applications to minimize risk of outages based on loading profiles, system characteristics, weather conditions, lightning, and other factors.
- Applications for equipment and system diagnostics through integration of technologies like the Distribution Fault Anticipator (DFA) and widespread sensors.

The project will continue to develop advanced modeling and simulation functionality that can be used to implement these advanced functions. The Distribution System Simulator (DSS) software is being released as an open source platform to facilitate development of advanced functionality around the world. This platform will be one of the platforms used to evaluate advanced applications.

In addition, many vendors are deploying distribution management systems with many advanced functions. Performance of these advanced applications will be documented and lessons learned will be developed for members.

These applications involve integration of advanced monitoring and new sensor technologies with advanced modeling, simulation, and control approaches.

Value

- Advanced applications for smart distribution systems are where the real value of the technology investment is realized. Members will understand the functionality of these advanced applications and the requirements to implement the functions.
- Guidelines for optimizing system steady-state performance will be developed – modeling, simulation, sensors, communications infrastructure, and integration.
- Guidelines for functions that improve the reliability of the distribution system—such as fault location, system reconfiguration, adaptive protection systems—will be developed.
- Guidelines for functions that improve equipment and system diagnostics for improved asset management will be developed – sensor requirements, modeling and simulation requirements, communications and data management, implementation issues, etc.
- Release of the Distribution System Simulator (DSS) for open source development will enhance development of advanced applications; the research program will coordinate these developments from around the world. The development will also be coordinated with industry developments such as GridLab-D (DOE development).

How to Apply Results

Members will be able to better plan investments in smart distribution applications through an understanding of application requirements and performance under different circumstances.

Members will be able to use the open source DSS software as a platform for evaluating advanced applications for their own distribution systems. Example applications will provide templates for these evaluations.

Members will be able to assess the economics and benefits of different applications as a function of the implementation costs.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
<p>Evaluation of Distribution Performance Optimization Functions Using Active Distribution Management: This technical update will document advanced distribution optimization functions that integrate advanced monitoring, communication infrastructures, advanced system models and real-time simulation functionality, and implementation of advanced controls based on the real-time simulations. The analysis will take advantage of advanced simulation tools such as the DSS, the DEW (Distribution Engineering Workstation), and GridLab-D (DOE distribution system simulation tool development).</p>	12/31/2009	Technical Update

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<p>Evaluation of distribution reconfiguration functions in Advanced Distribution Management Systems: The project report in 2010 will focus on advanced distribution reconfiguration functions that take advantage of real-time state estimation, adaptive protection functions, control of smart switches and reclosers throughout the distribution system, and management of system loading. The functions may also incorporate demand response and load control to maximize system reliability.</p>	2010	Technical Update

P124.007 Distribution Applications Leveraging Existing Information and Communications Infrastructures such as AMI (067463)

Issue

Utilities are deploying communication infrastructures and advanced metering systems. These systems are deployed for a variety of reasons (e.g., reducing manpower costs for meter reading, allowing remote disconnection and connection of customers). These infrastructures can provide very important operational benefits for the distribution system but there are integration requirements to achieve these benefits. This project focuses on the distribution management and operations applications that can leverage investments in advanced metering and the associated communication infrastructure.

Description

The project characterizes and evaluates important applications that can take advantage of advanced metering technologies, communications, and infrastructure. Important applications that will be evaluated and characterized in this project include:

- Improving the performance of outage management systems through integration of information from advanced meters
- Improving system voltage and var control using information from advanced meters
- Improved fault location functionality using advanced metering infrastructure
- Using advanced metering for improved load models and building better system simulation systems to take advantage of the advanced load models
- Developing more accurate planning models and tools that take advantage of advanced metering data

- Incorporating advanced metering as part of real-time state estimation systems for optimizing system performance

These applications will be characterized through detailed-use case development, and the requirements for the advanced metering and communication systems to implement these functions will be characterized.

As utilities deploy advanced metering systems, opportunities for deployment of these functions will be identified and actual performance will be characterized.

Value

- Members will understand the additional operational benefits that can be derived from advanced metering infrastructure investments through detailed characterization of important applications and the associated requirements.
- Business cases for advanced metering that rely on distribution operations benefits as part of the plan will be more accurate.
- Members can develop accurate implementation and deployment plans for distribution operations functions that are built on AMI investments.

How to Apply Results

Members will use the project results to develop more accurate AMI business plans and deployment plans.

Members will develop plans for future smart distribution systems that incorporate functions for improving performance that are built on investments in advanced metering and the associated communications infrastructure.

Members will understand the capabilities of advanced distribution performance optimization functions that take advantage of advanced metering.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Guidelines for Distribution Operations Applications using Advanced Metering Infrastructure Investments: The report will characterize distribution optimization functions that can be built on AMI investments. It will also characterize requirements for the advanced metering systems and communication infrastructure to implement these functions, as well as improved simulation and models that may be required.	12/31/2009	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Field Experience with Implementing Distribution Performance Optimization Functions that Integrate with Advanced Metering: This report will document actual field experience with deploying advanced distribution management functions that integrate with advanced metering systems. Application issues, performance, limitations, and needs for ongoing development will be identified.	2010	Technical Update
