

# Smart Distribution Applications and Technologies - Program 124

## Program Overview

### Program Description

New technologies will be critical to future smart grid operation. These technologies will include advanced sensors for understanding conditions in real time, power electronics technologies to improve performance and provide fast response to system changes, and new protection and switching technologies that facilitate automation. The future smart grid must integrate widespread distributed resources as part of the normal operation of the system. The distribution management system, automation systems, protection systems, planning tools, and more must all be designed to accommodate this new paradigm.

Automating the distribution system provides one of the most cost-effective ways to improve distribution reliability. It is critical to understand the benefits that can be achieved compared to alternatives, the technology required to achieve those benefits, and the overall economics. The distribution management system (DMS) will be the centerpiece of the smart distribution system in the future. Research is required to provide not only technology development and assessments in these areas, but also standards to ensure interoperability and industry deployment opportunities for smart grid technologies.

The Smart Distribution Applications and Technologies program focuses on implementing smart grid technologies at the distribution level. The program coordinates with EPRI's Intelligrid program, in which research focuses on the communications and information infrastructure to support the smart grid. This program specifies, develops, and applies distribution technologies and applications that take advantage of the communications and information infrastructure developed in the Intelligrid program. The program provides industry coordination and technology assessments for smart distribution system technologies and applications, while also working on actual development and implementation of key technologies.

### Research Value

With the knowledge acquired through this research program, members will have access to resources that:

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

### Approach

EPRI research in smart distribution applications will yield a variety of data and knowledge that will be beneficial to members of the program. This information will come in a number of forms and is expected to include:

- Initial version of the *Distribution Automation Application Guidebook*

- International workshop on Advanced Distribution Automation™ (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.

### Accomplishments

The Distribution Applications and Technologies program has delivered valuable information that has helped its members and the industry in numerous ways. Some examples include:

- An interim report titled *Advanced Distribution Automation Guide Development*, which describes the first stages of developing a guide intended to serve as a central tool to help members implement ADA/smart distribution systems. As the utility industry is rapidly moving to modernize its distribution systems, the smart distribution system of the future will be based on ADA, which will enable new capabilities to increase flexibility, improve reliability, and expand customer services. Smart distribution systems will use new intelligent electronic devices and will integrate advanced metering infrastructure (AMI) data into real-time monitoring systems needed to enable ADA operations.
- EPRI has proposed the concept of a solid-state transformer that has the potential and feasibility to meet the above-mentioned needs of the utility power delivery system. The ability to provide a wide range of services and improved operational benefits has put solid-state transformer technology—the Intelligent Universal Transformer™ (IUT™)—in the forefront of this endeavor. The *100-kVA Intelligent Universal Transformer Development* report documents the design and development of this technology.

### Current Year Activities

In the coming year, this research program expects to accomplish these 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.

### Estimated 2010 Program Funding

\$2.0M

### Program Manager

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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	Description
P124.001	Technology Transfer, Technology Watch, and Industry Coordination	This project is the main technology transfer effort for the Smart Distribution Applications and Technologies program. Products include conferences, workshops, technology assessments, and ongoing guidebook development. This project also maintains the Smart Distribution R&D Roadmap that provides guidance for the entire program.

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

#### Key Research Question

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 both domestic and international research activities to efficiently develop 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 relevant new technologies, software, and services emerging from the research and vendor communities to better understand the value of these products and how 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.

#### Approach

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 periodically published versions. The online version will be delivered as a web-based product. Cooperation with the IEEE Distribution Automation Working Group will facilitate industry-wide participation in the guidebook's development.

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 an 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. This workshop also provides the basis for an annual update to the roadmap for smart distribution system development. EPRI will also continue to conduct the annual joint PQA/ADA Conference with international participation. The large open conference, which is jointly sponsored by Programs 1 and 124,

includes papers and tutorials on a broad range of topics pertaining to power quality, ADA, and the distribution system of the future. Conference proceedings are documented on a compact disc.

EPRI will assess key technology and software products as well as 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 integrating advanced metering systems 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.

### Impact

- Coordinates the development and maintenance of an industry guidebook on smart distribution applications and technologies
- 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 coordinate industry developments in distribution automation to ensure interoperability and successful integration with utility systems
- Helps members 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 with improved reliability, improved power quality, better efficiency, and increased customer services. Implementation of project results will improve technology selection and application, and will help ensure interoperability of technologies with utility systems. Project results will be used as educational resources, technology guides to support specification development, and tools for assessing technology options.

### 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Update to Smart Distribution Application Guide :</b> The <i>Smart Distribution Application Guide</i> is developed as a web-based guidebook in cooperation with the IEEE Distribution Automation Working Group. Important new additions to the guidebook will be summarized as an EPRI update report.	12/31/10	Technical Update
<b>PQA/ADA Conference:</b> 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).	12/31/10	Workshop, Training, or Conference
<b>International Workshop on Smart Distribution Systems:</b> The International Workshop on Smart Distribution Systems will continue the annual coordination of research activities around the world on distribution automation and related technologies. The workshop provides the basis for updating the Smart Distribution Development Roadmap.	12/31/10	Workshop, Training, or Conference
<b>Technology Watch Updates:</b> Smart Distribution Technology Watch updates will be developed monthly as web-based reports and then combined into an EPRI technical update report at the end of the year.	12/31/10	Technical Update

## PS124B New Technologies for Smart Distribution Systems (058489)

### Project Set Description

This Project Set develops and evaluates new technologies for smart distribution systems that could become an integral part of the future distribution infrastructure. There are two ongoing projects in the power electronics area: the Intelligent Universal Transformer (IUT) and the Multifunction Solid-state Switchgear System (4-S). These two projects are complemented by two others related to improving monitoring technologies for integration with distribution automation and control: sensors for real-time distribution system monitoring, and advanced meter application issues and testing. Together, these projects support a cross-section of important technology developments in the industry.

Project Number	Project Title	Description
P124.002	Multifunction Solid-State Switchgear System (4-S)	This project develops a first-generation modular power-electronic replacement for conventional distribution switchgear that can be widely used in distribution switchgear applications.
P124.003	Intelligent Universal Transformer	The project develops the first-generation power-electronic replacement for conventional distribution transformers.
P124.004	Sensors and Technologies for Distribution Asset Management and Equipment Diagnostics	This project will evaluate sensor technologies for current and voltage monitoring as well as equipment diagnostics and asset management.
P124.005	Advanced Meter Application Issues and Testing	This project will use a combination of laboratory and field testing to develop lifetime characteristics of advanced metering applications and equipment.

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

#### Key Research Question

Major issues addressed by the 4-S product include switching without the need for sulfur hexafluoride (SF<sub>6</sub>) 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 ADA monitoring systems. The 4-S can reduce costly inventory expenses associated with the variety of switchgear products currently needed for distribution systems. In addition, it 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.

#### Approach

The EPRI Multifunction Solid-state Switchgear System is a first-generation power-electronic replacement for conventional distribution switchgear. The goal of EPRI's 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.

Project work in 2009 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 prototype 4.16-kV SSTS and demonstrate key performance and benefits over a 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 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:

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

### Impact

- Advanced modular designs for a solid-state switch can provide many functions for the smart distribution system.
- Advanced switchgear designs can be the basis of transient-free switching for automation applications like circuit reconfiguration, load transfers, capacitor switching, and fault current limiting.
- Prototype designs will illustrate the benefits of the technology and provide the foundation for a field demonstration to assess performance.
- Designs will also incorporate 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 a 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.

### 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Final Report on Multifunction 4-S Development, First-Generation Product Specification, and Commercialization Plan:</b> This report will document the prototype switch design, development, and testing. Conclusions and recommendations for applications and ongoing development needs will be included.	12/31/10	Technical Report

## P124.003 Intelligent Universal Transformer (051716)

### Key Research Question

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 a 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, plug-in hybrid electric vehicles, photovoltaics, and other distributed generation). A power-electronic system replacement for conventional transformers would resolve these issues.

## Approach

The Intelligent Universal Transformer 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 this project, the team develops and tests field prototypes, working in conjunction with host utilities. Related business-case and utility-integration studies support 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 member priorities up to the limit of available funding. The project will also develop a commercialization plan and assess optional technologies for the IUT 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 high-voltage power electronic circuit topology for the IUT. The bench model was rated at 20 kVA with the input voltage rated at 2.4 kV<sub>RMS</sub> phase-to-neutral and output voltage rated at 120/240 V. The project team then decided to proceed 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, and Silicon Power Corporation (partnered with SatCon Technology Corp. and Howard Industries) was selected to develop the field prototype. Development started in 2008 and 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 should meet the basic functionality of a conventional distribution transformer in terms of its capability for voltage transformation, and provide operational benefits in terms of standardizing the distribution transformer with respect to input/output voltage and kVA rating. Additionally, the minimum design will include a communication interface to allow remote monitoring and control of the IUT to detect component failures and allow dispatch of IUT functions. It is also expected that the IUT will 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 energy storage devices will not be covered through this initial effort.

## Impact

- 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
- Reduces unit weight and size compared to conventional transformers
- Offers added functionality, such as voltage regulation and distribution system monitoring capabilities, compared to conventional transformers

## How to Apply Results

Electric distribution managers, engineers, and designers could use the IUT as a replacement for conventional distribution transformers, both in new installations and to replace aging units. Members can apply the IUT in situations where avoidance of spill cleanups from conventional transformers is most crucial, and then 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 members) such as voltage regulation, configurations to supply three-phase power from a single-phase circuit, output ports for dc power and alternative ac frequencies, and interfaces with distributed generation.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Final Report on IUT Development, First-Generation Product Specification, and Commercialization Plan:</b> This product provides the final documentation for this project.	12/31/10	Technical Report

## P124.004 Sensors and Technologies for Distribution Asset Management and Equipment Diagnostics (067460)

### Key Research Question

The smart distribution system is built around 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.

### Approach

This project builds on preliminary work being conducted through a Technology Innovation initiative to characterize a variety of sensor technologies that could become part of the smart distribution system in 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, application issues, and integration with distribution management systems.

In addition, 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.

### Impact

- Understanding of, 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 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 receive 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.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Report of Advanced Sensor Technology Applications for Smart Distribution Systems:</b> The report will continue to document important sensor technologies and their application as part of smart distribution systems.	12/31/10	Technical Update

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

### Key Research Question

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 technology's ability to withstand voltage and current variations.

### Approach

This project focuses on evaluating 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. This research has a number of important parts:

- 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 includes testing both the communications interfaces for the meters as well as 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 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.

### Impact

- Understand 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.
- Understand the impact of integrated communications with advanced meters on application issues (such as lifetime, maintenance requirements, and installation issues)

### 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.

### 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Testing and Performance Assessments for Advanced Meters:</b> Continued updates to testing and field application assessments for advanced meters.	12/31/10	Technical Update

## PS124C New Applications for Smart Distribution Systems (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. The DMS of the future must also enable integration of distributed resources with the normal operation of the distribution system. These applications will require new simulation functionality, as well as new monitoring and control systems.

The advantages and disadvantages of various options are evaluated in this Project Set, and actual field experience is documented. Specifications will be provided for integrating new functions into smart distribution systems. Projects 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	Description
P124.006	New Methods for Active Distribution System Management	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.
P124.007	Distribution Applications Using Existing Information and Communications Infrastructures such as AMI	This project will involve working with members to characterize distribution communication infrastructure and advanced metering deployment opportunities, and how these systems can be integrated with distribution operations. Previous use cases will be reviewed and refined to characterize important applications, and requirements for the AMI and communication infrastructure will be derived. This work is expected to produce improved application guidelines for AMI and distribution communications to help obtain maximum functionality for distribution systems.

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

### Key Research Question

Smart distribution systems will incorporate a variety of new control and system optimization functions, as well as the ability to integrate a wide variety of distributed resources. These functions will take advantage of advanced sensors, system communication infrastructure, new switchgear technologies, and new modeling and simulation capabilities. Such functions need to be characterized and evaluated to determine the requirements for the DMSs of the future, which will include sensors, control technologies, modeling requirements, simulation tools, and communication infrastructure. Performance issues also need to be evaluated as these functions move to real-time applications.

### Approach

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

- Voltage and VAR control functions to optimize distribution system voltage and VAR flows (minimize losses). 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 and load management.
- 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 tools that can be used to implement these advanced functions. The Distribution System Simulator (OpenDSS) software has been released as an open source platform to facilitate development of advanced functionality around the world. This platform is being developed through this research project in combination with efforts in the Green Circuits initiative and Smart Grid Demonstration projects. Functions demonstrated using the OpenDSS can then easily be implemented in commercial DMS platforms.

### Impact

- 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 how to implement them.
- Guidelines for optimizing system steady-state performance will be developed, including modeling, simulation, sensors, communications infrastructure, and integration.
- Guidelines for functions that improve the reliability of the distribution system—such as fault location, system reconfiguration, and adaptive protection systems—will be developed.
- Guidelines for functions that improve equipment and system diagnostics for improved asset management will be developed, including sensor requirements, modeling and simulation requirements, communications and data management, and implementation issues.
- Release of the Distribution System Simulator (OpenDSS) for open source development is enhancing development of advanced applications; this research program will coordinate those developments from around the world. Efforts will also be coordinated with industry developments such as DOE's GridLab-D.

## 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 OpenDSS 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 their implementation costs.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<p><b>Evaluation of distribution reconfiguration functions in Advanced Distribution Management Systems:</b> 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>	12/31/10	Technical Update

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

### Key Research Question

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

### Approach

This 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 by integrating information from advanced meters
- Improving system voltage and VAR control using information from advanced meters
- Improving fault location functionality using advanced metering infrastructure
- Using advanced metering to improve load models and build better system simulation systems to take advantage of 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 examined through detailed-use case development, and the requirements for advanced metering and communication systems to implement these functions will be characterized. As utilities deploy advanced metering systems, opportunities for deploying these functions will be identified and actual performance will also be characterized.

## Impact

- Members will understand the additional operational benefits that can be derived from advanced metering infrastructure investments through detailed characterization of important applications and their 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 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.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Field Experience with Implementing Distribution Performance Optimization Functions that Integrate with Advanced Metering:</b> 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.	12/31/10	Technical Update