

# IntelliGrid - Program 161

## Program Overview

### Program Description

The IntelliGrid(sm) program develops and evaluates technologies and methodologies for implementing a smart power grid infrastructure. The program focus is on the communications and information infrastructure that will become the foundation for many smart grid applications, as well as the implementation of security for this infrastructure. When this enabling infrastructure is matched with smart grid applications in transmission, distribution, or at a customer interface, then the resulting smart grid can reach significant gains in reliability, capacity, demand response, and offer value added customer services.

A major early accomplishment of the EPRI research is the IntelliGrid Architecture, an open-standards, requirements-based approach for integrating data networks and equipment that enable interoperability between devices and systems. The Intelligrid Architecture is supported by the Intelligrid Methodology that has since been adopted as an IEC Publicly Available Specification (PAS). This methodology describes the application of use cases for defining the requirements of a new technology in a way that provides traceability and allows the definition of standards based on the requirements. The Intelligrid research provides members with the methodologies, tools, recommendations for standards, and unbiased assessments of technologies when implementing new system-wide technology solutions for wide area monitoring and control, advanced equipment diagnostics, distribution automation, demand response, distributed resource integration, and advanced metering.

### Research Value

With the knowledge acquired through this research program, program members will have access to information that can help them in these ways:

- Development and support of standards-based approaches for achieving interoperability of technologies that make up a smart grid.
- Industry coordination and up-to-date technology information for members.
- Utility implementation approaches and results for smart grid technologies and systems.
- Roadmaps for implementing a smart grid.
- Coordination with smart grid applications and technology development to assure interoperability.
- Cost/benefit assessments for smart grid applications and technologies, especially with respect to implementing open, standards-based systems.
- Understanding communications and information system architecture requirements to support a smart grid.
- Assistance in how best to deploy monitoring, communications, computing, and information technology to address unique business and regulatory drivers, addressing questions as to which products and technologies to use, when to implement solutions, how to integrate new and existing systems, and how to manage and secure systems.
- Effective and consistent security and system management policies.

### Approach

EPRI research in the IntelliGrid program 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:

- IntelliGrid architecture providing methodology, tools, and recommendations for standards and technologies for utility use in planning, specifying, and procuring the communications and information systems to support smart grid applications such as wide area monitoring and control, advanced metering, distribution automation, and demand response.

- Support of roadmap development for individual utility smart grid implementation plans.
- Establishment of a living laboratory for assessing devices, systems, and technologies.
- Development of a relay laboratory for evaluating advanced data integration and control approaches.
- Coordination with member smart grid implementations and laboratory assessments.

### Accomplishments

In the past, the IntelliGrid program has delivered valuable information that has helped its members and the industry in numerous ways. Some examples include:

- The IntelliGrid Profiling & Mapping report provides an analysis of research and development (R&D) programs whose goal is to improve the intelligence of the electric power infrastructure. The study updates the information of the previous assessment of ten selected grid R&D programs, characterizing their vision, mission, governance, budget, promotion activities, and technical program portfolio, including main objectives, completed or ongoing projects, deliverables, and accomplishments. It also adds three international organizations to the scope of the previous assessment scope.
- The IntelliGrid Architecture provides the technical foundation for federal government's efforts to identify, develop and harmonize smart grid interoperability standards
- The AMI Security supplemental project has developed the cyber security requirements and policies for advanced metering systems
- The IntelliGrid methodology has been used by several utilities to develop Smart Grid roadmaps.

### Current Year Activities

- Industry coordination and tech transfer to provide industry guidance on smart grid implementations
- Migration path for IEC 61850 implementation and coordination with CIM standards
- Guidebook for using the common information model (CIM) for distribution applications
- Common Information Model (CIM) Interoperability tests for transmission, distribution, and advanced metering
- Guidelines for deploying communications infrastructure for transmission operations, advanced distribution automation, demand response, and energy efficiency
- Regular reports on laboratory testing of technologies and products
- Security requirements and recommendations for advanced metering infrastructure (AMI)
- Coordination of security requirements and recommendations for compliance - transmission, distribution, and customer interface infrastructure

### Estimated 2010 Program Funding

\$4.0M

### Program Manager

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## Summary of Projects

### PS161A IntelliGrid Technology Transfer and Industry Coordination (063528)

#### Project Set Description

This project set provides the overall industry coordination and high-level tech transfer activities related to continued development of the utility infrastructure to support smart grids. It supports users of the IntelliGrid architecture methods and introduces potential users to the benefits of migrating towards an intelligent grid. Every activity is designed to enhance access to research results—so continuing and new funders of the IntelliGrid program alike will find value. The IntelliGrid program includes membership of utilities, vendors, public organizations, and other research organizations. One of the important objectives through this project set is to enhance coordination across all the different research organizations and industry organizations (for example, the Department of Energy [DOE], the Institute of Electrical and Electronics Engineers [IEEE] Intelligent Systems Coordinating Committee, and European smart grids efforts) working on the development and definition of future system architectures and integration needs.

Project Number	Project Title	Description
P161.001	Intelligrid Technology Transfer and Industry Coordination	<p>The project provides coordination across the industry. Important efforts include:</p> <ul style="list-style-type: none"> <li>• Maintaining information about smart grid deployment activities across the industry and sharing this information in the form of case studies so that members can learn from the lessons of previous deployments.</li> <li>• Coordination of industry-wide use-case repository (in conjunction with the smart grid demonstration initiative).</li> <li>• Smart grid roadmap workshop for sharing of information related to roadmaps for a smart grid implementation.</li> <li>• Coordination of standards activities and reports to members about important standards development activities (IEEE, IEC, etc.)</li> <li>• Report on industry wide smart grid activities - this is an update from previous reports.</li> <li>• Coordination with international smart grid initiatives - report to members for lessons learned.</li> </ul>

### P161.001 Intelligrid Technology Transfer and Industry Coordination (065585)

#### Key Research Question

Utilities increasingly deploy advanced technologies (monitoring, communications, computing, and information technologies) to enhance system operation and maintenance and to enable demand response and energy efficiency applications. The challenge utilities face is how to deploy these technologies efficiently and cost-effectively to meet today's needs as well as future needs. Some of their questions include which applications to deploy and when to do so; what are the requirements for these technologies; what technologies are available that meet these requirements; what are the costs and benefits of different alternatives; how new systems should be integrated with existing systems; how these systems should be managed and secured.

#### Approach

This project provides coordination across the industry for smart grid technology implementation and deployment. Numerous smart grid efforts are under way at individual utilities, at the Department of Energy, in various standards organizations, and internationally. This project provides coordination across all these efforts

so that members can take advantage of important developments and lessons learned across the entire industry. Coordination is achieved through sharing of use cases, member forums, webcasts, newsletters, and workshops.

### Impact

- Promotes the cost-effective integration of communications and information infrastructure for support of advanced applications and diverse vendor products in transmission, distribution, and end-use systems
- Promotes interoperability among vendor products, lowering capital costs for members
- Provides the most current information on technical, policy and implementation issues related to smart grids
- Provides coordination with a wide variety of research and industry initiatives related to development and definition of a smart grid

### How to Apply Results

Utility executives responsible for “grid of the future” planning, information technology (IT) architects designing the infrastructure to support the future grid, and project engineers deploying systems can use the project results as information resources. These resources are intended to familiarize members with the latest in technology advancements, as well as highlight vendor activities on smart grid efforts.

### 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Repository of Smart Grid Demonstrations, Deployments and Use Cases:</b> Web-based repository will compile information on Smart Grid demonstrations, pilots and deployments. The repository will also compile publicly available smart grid business cases.	12/31/10	Technical Resource
<b>Smart Grid Cases Studies:</b> The Smart Grid case studies will profile a utility's specific Smart Grid deployment. The report will describe how the company approached the deployment, the technology choices made, architectural decision made, anticipated benefits, regulatory drivers, etc.	12/31/10	Technical Update
<b>Tracking and Coordination of Industry Smart Grid Activities:</b> Regular reports will be provided to funders that describe industry Smart Grid activities. Activities will include policy, legislative, standards, demonstrations and research and development. Reports will provide up-to-date information that will be valuable to utilities and non-utilities alike.	12/31/10	Technical Resource
<b>Smart Grid Roadmap Workshop:</b> This workshop will provide will bring together utilities that have developed or are currently developed a smart grid roadmap to share plans, experiences and lessons learned. 2010 will mark the third annual Smart Grid Roadmap workshop.	12/31/10	Workshop, Training, or Conference

## PS161B Infrastructure for Intelligent Transmission Systems (063437)

### Project Set Description

The Infrastructure for Intelligent Transmission Systems project set is focusing on the communications and IT infrastructure, technology gaps to achieve an open and interoperable system and migration strategies. The transmission system is using already extensive and sophisticated instrumentation and applications. This project set will assess additional possible communications needs for real-time applications and identify strategies to migrate from the existing communications and data models to interoperable, common database models and communications standards by developing enterprise wide use cases for advanced transmission applications.

Project Number	Project Title	Description
P161.003	Common Information Model and Information Integration for Transmission Applications	This project develops requirements and use cases for advanced transmission operations. These requirements serve as the basis for data and device models for emerging standards as well as for contributions to standards activities within key industry organizations such as IEC, IEEE, NIST and others.
P161.015	Smart Transmission System Implementation Strategies	This project will create strategies for utilities migrating existing transmission communications technology to a system wide communications and IT infrastructure. Lessons learned will be documented in case studies.

## **P161.003 Common Information Model and Information Integration for Transmission Applications (063286)**

### Key Research Question

Federal and state regulators and legislators are increasingly driving utilities towards the concept of a smart grid. Several utilities have embraced this concept and are aggressively installing the infrastructure to make the concept a reality. For transmission systems, a smart grid may provide a wide-area view of system performance and health. It may anticipate events and take action to avoid them or minimize their impact. Robust and highly integrated communications and distributed computing infrastructures will be needed to create a smart grid. These infrastructures need to be interoperable across vendor equipment and across the enterprise. Achieving the necessary level of interoperability requires the development and industry adoption of a tightly coupled suite of standards. The Common Information Model (CIM) provides a common language for integrating applications across the enterprise and is a foundation standard for smart grids. IEC 61850, Distributed Network Protocol (DNP), and the Internet Protocol (IP) also are key standards. Significant work has been done on these standards, but a substantial amount of work is needed.

### Approach

This project develops requirements and use cases for advanced transmission operations. These requirements, in turn, serve as the basis for data and device models for emerging standards and as the basis for advanced applications that can be developed using equipment from different vendors. This project tracks and makes contributions to activities within key standards organizations such as IEC, IEEE and industry organizations such as DOE, National Institute of Standards and Technology (NIST), Federal Energy Regulatory Commission (FERC), National Association of Regulatory Utility Commissioners (NARUC), and National Electrical Manufacturer's Association (NEMA) relating to transmission smart grid applications. CIM interoperability tests will be conducted with vendor products.

### Impact

This project could have the following impacts:

- Promote true interoperability and enable integration of applications across the enterprise via systems built to open standards
- Promote standards that enable competitive equipment procurement and result in 20-25% capital cost reductions for advanced automation equipment
- Enable improved life-cycle savings through equipment that is common and well known to systems administrators

## How to Apply Results

Utility control center information technology project managers, automation project engineers, operators, and transmission planners will use the tools and knowledge produced in this project to apply the CIM standard within their organization. The results from this project will help the utility to plan for future requirements for upgrades to its energy management systems and when procuring next-generation transmission operations equipment such as relays and protection equipment.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Transmission Common Information Model (CIM) Workshop:</b> This will be a two day industry workshop for status of 2010 and 2011 CIM design allowing transmission system applications to integrate with distribution systems (applications). The CIM facilitates integration between applications and systems and provides maximum value as more systems share data . Recent work that has been completed or is in final stages now that can be part of a lower costing utility solution.	12/31/10	Workshop, Training, or Conference
<b>Common Information Model (CIM) Tools Workshop:</b> This project is a two day industry workshop to teach and demonstrate various CIM Tools that have been developed to facilitate CIM implementations. Modern tools have been designed over recent years to support the multiple interoperability tests (IOP's) and are applicable for individual utility CIM implementations.	12/31/10	Workshop, Training, or Conference
<b>Conduct industry CIM/GID interoperability tests in conjunction with current IEC revisions:</b> EPRI will work with several vendors to test the interoperability of their products in conformance with the CIM / Generic Interface Definition (GID) standard.	12/31/10	Technical Update

## P161.015 Smart Transmission System Implementation Strategies (069294)

### Key Research Question

Recent focus on accelerating the implementation of smart transmission systems technologies within the confines of the existing infrastructure has significant challenges. Since the transition will take a number of years, operating in the mixed state of partial smart grid and partial legacy will be challenging. Research is needed to determine how a utility transitions to a smart grid while maintaining continuity of service during the transition and to determine what options are available to have smart equipment co-mingled with legacy devices. Also, are there benefits to different implementation strategies. Should a company implement by voltage class or by geographic region or some other approach. What are the pros and cons to the various approaches?

### Approach

This project will document the proposed and actual transition approaches to implementing a smart grid by various utilities and assess the issues associated with the implementation strategy. We will also look at the various approaches proposed or being implemented by various utilities in implementing smart grid and assess the pros and cons. Actual lessons learned will be documented and communicated.

### Impact

This project could have these impacts:

- Utility members will be able to better understand the pros and cons of various implementation methods and the challenges associated with each.

- Utility members will be able to plan, design, develop, and implement a better smart grid implementation strategy for their company and better understand the benefits achieved using different approaches.

### How to Apply Results

Utility members will be able to apply the knowledge gained from the project products for designing and implementing smart grid technologies effectively through the transition from legacy environments to smart grid.

### 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Implementation Strategy Assessment:</b> This project will perform an assessment of a selection of smart grid implementations at utilities for best practices, lessons learned and other insights beneficial to utilities considering adoption of smart grids.	12/31/10	Technical Update
<b>Information Sharing across T&amp;D operations:</b> This project will focus on value of smart grid enabled information sharing across the T&D enterprise. This will be a joint project with PS161C.	12/31/10	Technical Update

## PS161C Infrastructure for Intelligent Distribution Systems (063438)

### Project Set Description

The Infrastructure for Intelligent Distribution Systems project set focuses on the communications and IT infrastructure necessary to achieve fully integrated distribution operations. It will address design issues when integrating diverse communications at scale, attempting to isolate communications complexity from the distribution operations applications. Data management is another focus. Distribution operations deal with a large number of data points and parameters. Integrating all the data using a common interface model may improve data quality, efficiency and reduce redundancy.

Project Number	Project Title	Description
P161.004	Communication Technologies for Smart Distribution Applications	The project develops requirements and initial designs for communications infrastructure for advanced distribution automation applications. These designs are based on emerging next generation open standards and will also assist in the development of the infrastructure necessary to meet next generation application needs.
P161.005	Enterprise Information Sharing for Smart Distribution Applications	This project will produce a guidebook to Enterprise Application Integration (EAI) suites.

## P161.004 Communication Technologies for Smart Distribution Applications (063428)

### Key Research Question

Federal and state regulators and legislators are increasingly driving utilities towards more advanced functions and applications on the distribution system. The distribution system communication infrastructure must be robust enough to meet future needs for reliability as well as have the capacity for implementing advanced distribution automation applications. In addition, systems maintenance will require a careful integration between field equipment and back office information systems. Robust and highly integrated communications and distributed computing infrastructures will be needed to support foreseen applications. In addition the key

standards targeted for distribution systems operations need to be integrated and harmonized to integrate field equipment with back office systems as appropriate.

## Approach

The project will build upon and further industry requirements for advanced distribution operations. The requirements will use the use case formats from the IntelliGrid program and will provide a systems architecture perspective on advanced distribution operations. These requirements provide the basis for developing initial designs for next generation distribution communications. Details for basic understanding of functional and technical capabilities of the key applications supported will be included in the requirements write ups. The applications include, but are not limited to system protection, integrated volt var management, fault location, isolation and restoration, integration of customer metering, demand response and distributed resource integration. The report also will provide a detailed and systematic analysis of issues directly related to the integration, interoperability, and performance of the communication networks for distribution applications. The focus will be to better understand the design issues associated with integrating key communications infrastructures as well as the behavior of individual networks especially when integrated on large scales. Emphasis will be to identify the integration and implementation methods and techniques to isolate the riding applications from the complexities of underlying individual networks to assure seamless and secure integration and access with consistent and predictable performance.

## Impact

- Utility members will be able to make use of both the requirements as well as advanced designs for application to their own systems.
- The architecture perspective will also provide critical input for the development of the industry standards necessary to support the next generation of distribution operations
- Key standards development provides a robust communications infrastructure for supporting next generation equipment
- Utility members will be able to plan, design, develop, and implement a reliable and functional network with consistent performance and predictable results. They will be able to mitigate the risks associated with the integration and performance issues in a typical large network of heterogeneous technologies and systems.

## How to Apply Results

Utility members will be able to apply the knowledge gained from the project for designing and implementing communication networks for their distribution operations. In addition the results can be contributed to the key standards organizations developing advanced distribution automation communications. These include efforts underway within the IEC, IEEE and related standards communities and consortia. In this way the results become part of the standards based equipment that utility members can procure. Members will be able to make informed and sound decisions on how to design and implement a functional, secure, efficient, and predictable communication network.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<p><b>Managing the Communications Infrastructure for Distribution Operations:</b> Managing the Distribution Communications Infrastructure (what's installed where, controlling what equipment, running what firmware, communicating how, configured how?) Challenge: managing the security, including keeping up with compliance issues (NERC CIP) -- must keep in mind the myriad technologies, processes, and regulations.</p>	12/31/10	Technical Update

## P161.005 Enterprise Information Sharing for Smart Distribution Applications (065546)

### Key Research Question

A smart distribution infrastructure can be realized by smart applications to synthesize information from a host of data repositories and other applications. The interfaces for these applications are often custom, one-off interfaces, which require development work that does not increase the functionality of the application itself. A set of common interfaces could help reduce development effort for new applications as well as ensuring that the information can be shared across a utility's enterprise. The Common Information Model (CIM) can serve as the common language for these interfaces at a utility's back office environment. In addition, communication with devices in the field as well as device-to-device communication can benefit from standard object models for distribution equipment used for smart automation.

### Approach

A guidebook to Enterprise Application Integration (EAI) suites will be developed. Enterprise Application Integration (EAI) suites are software products that provide the capability to share data between applications within the enterprise. This includes solutions for dealing with applications that run on different operating systems, database architectures, programming languages, and the broad category of legacy applications. This project also tracks and makes contributions to activities within key standards organizations such as IEC, IEEE, and industry organizations such as DOE, NIST, and NERC.

### Impact

- Promote true interoperability and enable integration of applications across the enterprise via systems built to open standards.
- Enable improved life-cycle savings through equipment that is common and well-known to system administrators.

### How to Apply Results

Distribution system operators and information technology managers can use the knowledge produced in this project as guidance in procuring, installing, and maintaining an EAI suite appropriate for their utility's goals and objectives for system integration for distribution operations.

### 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Distribution Operations Guide to Enterprise Application Integration (EAI) Suites:</b> Application and system integration best practices; the judicious use of the Common Information Model (CIM) for information exchange; overview, benefits, and cautions for Enterprise Application Integration (EAI) suites.	12/31/10	Technical Report
<b>Distribution CIM Interoperability Testing:</b> Annual interoperability testing of the Distribution CIM standards to vet the standards and to identify where they need to be improved.	12/31/10	Technical Update

## PS161D Infrastructure and Technology for Advanced Metering, Integrating Demand Response and Energy Efficiency (063439)

### Project Set Description

This project set focuses on development and demonstration of low-cost, standards-based, two-way communications between energy service providers and their customers and demonstration of technologies that integrate with this communications infrastructure through the EPRI Living Laboratory. The project also addresses the information integration approaches for making customer information such as AMI part of the overall information system available for advanced applications. The resulting interactive exchange of information provides enhanced reliability and security, lower energy bills, and new, value-added services—ultimately fostering greater satisfaction among electricity consumers. The living laboratory provides an independent, unbiased assessment of technologies and products. Finally, the project set offers strategic and societal benefits by supporting greater power system reliability, functionality and consumer value; enhanced system security; improved energy efficiency; accelerated rate of reduction of carbon emissions; lower costs for infrastructure upgrades and expansion; and greater economic productivity.

Project Number	Project Title	Description
P161.006	Communication Technology Assessment & Testing for AMI, HAN & Distributed Energy Resources	The project will test leading AMI, HAN, and DER communication power line, radio, and broadband technologies in laboratories test and field demonstrations as well as identify the gaps in the standards.
P161.007	Communications Architecture Development for Integrating, AMI, HAN, & DER into the Smart Grid	The project develops requirements and initial designs for communications infrastructure for advanced customer systems applications. These designs are based on emerging next generation open standards and will also assist in the further development of the infrastructure necessary to meet next generation application needs.
P161.008	Life Cycle Management of AMI, HAN, and DER Communication Technologies	This project designs a process for utilities to deal with AMI, HAN and DER technologies from selection, through testing, implementation, configuration, operations, upgrades, and eventual technology retirement. This may lead to a comprehensive life cycle management methodology for utilities to select, integrated and manage the technology cost effectively, reliably and securely.

### P161.006 Communication Technology Assessment & Testing for AMI, HAN & Distributed Energy Resources (063432)

#### Key Research Question

Utilities are deploying Advanced Metering Infrastructure (AMI) & Home Area Network (HAN) technologies in their service territories to create a 2-way communication network between the grid and end use devices at the customer premises. This communication infrastructure will enable the utility to send dynamic pricing signals to the customer premises during peak demand periods to reduce electricity consumption and create operational savings. Additionally, utilities are looking to integrate other Distributed Energy Resources (DER) such as thermal and electric storage, Photovoltaics (PV), and Wind Power with the grid at various levels to offset the growing demand for electricity with a low carbon alternative. The diversity and complexity of the communication technologies being considered for these applications requires objective lab and field testing of products and systems to validate their specifications and identify the technology gaps that need to be filled for commercial viability of these solutions.

## Approach

The project will test leading AMI, HAN, and DER communication technologies based on power line, RF, and broadband networks in lab and field tests and document the findings in EPRI technical reports. The project will also identify the gaps in the standards for the communication interfaces of AMI, HAN, and DER technologies that need to be filled to offer vendor agnostic integration of these technologies to the grid.

## Impact

- Utility members will be able to develop their own assessment of various communication networks in a timely manner by referencing the technical reports as a single consolidated resource.
- Utility members will be able to plan, design, develop, and implement a reliable and functional communication network with consistent performance and predictable results. They may be able to mitigate the risks associated with the integration and performance issues in a typical large network of AMI, HAN, and DER systems across their service territories.
- Utility members will have empirical data to accelerate the development and adoption of the missing standards for communication in AMI, HAN, and DER

## How to Apply Results

The operational side of distribution companies will use the EPRI technical reports to help them implement the research results.

Information technology (IT), information security staff (within a distribution company), and the chief information officer's organization (CIO of the distribution company) also can use the results of this project. Knowledgeable IT staff will use results to calibrate their own implementations of AMI, HAN and DER within their own service territories. The CIOs will use the results to design data integration architecture.

The IT experts within the electric utility trade organizations and state and federal agencies focused on grid security are also good audiences for the research results. These organizations will find the research is valuable in helping to understand the current status of AMI, HAN, and DER and determining the technology gaps for future innovation.

Standards organizations (for example, IEC, International Organization for Standardization [ISO], American National Standards Institute [ANSI], and National Institute of Standards and Technology [NIST]) can use these results guidelines for future interoperability standards work.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Test Plans for RF and Power Line Base AMI Systems:</b> The Technical Update will provide a detailed test plan for leading AMI Vendor Technologies with HAN interface on the Smart Meters that will provide the Member Utility AMI implementation teams a comprehensive guide for testing and verifying the features and characteristics of the products. The Test plan will include Characterization, Functional, Installation, and Manufacturing tests.	12/31/10	Technical Update

## **P161.007 Communications Architecture Development for Integrating, AMI, HAN, & DER into the Smart Grid (067466)**

### Key Research Question

The customer communications infrastructure needs to be effectively integrated on at least two fronts. The primary category of system integration has to include revenue cycle services and customer internetworking systems for advanced rate structures, demand response and energy efficiency. The second category should include homes and businesses that are installing renewable and other forms of generation which have to be prepared for more dynamic integration with transmission and distribution operations. The industry must strive for consistency in how large numbers of customers integrate with real-time power grid operations. Multiple standards are developing in these areas but the industry needs some key convergence on communications infrastructure and open standards to achieve the levels of interoperability, equipment management and security now envisioned for the smart grid. One of the key needs of the industry is to achieve convergence on application level communications. Another emerging issue is to achieve closure on some critical core networking functions such as naming and addressing and establishing a robust communications management infrastructure. One of the big challenges facing the industry is achieving the necessary level of cooperation, harmonization and integration to achieve interoperable systems development. In addition to integrating customer operations with T&D operations, the infrastructure must also assist in the integration of other key industry standards. Critical industries include industrial, commercial building automation, plug-in electric vehicles as well as residential in-building communications.

### Approach

The project will evaluate industry requirements developed to this point and, as appropriate, build upon them to provide an initial foundation for a complete customer communications architecture. In particular, the requirements should address the key areas where customer operations will interact with utility operations including both revenue cycle services and T&D operations. Industry requirements for advanced customer communications will, in turn, be used to develop designs for an architecture that effectively integrates with key interfaces to T&D operations. The requirements will utilize the use case formats from the IntelliGrid program and will provide a systems architecture perspective necessary for integrating key applications across the operating domains. The proposed designs will draw upon the requirements and make use of leading industry standards across industries and domains. Standards for this architecture include but are not limited to the following organizations: IEC, IEEE, ASHRAE, ANSI, and SAE. Initial designs will build from prior industry work for integrating across the standards. The analysis will also identify key areas where development work is still needed to be able to converge on important elements of the infrastructure, including application level communications and fundamental networking functions.

### Impact

- Utility members will be able to make use of both the requirements as well as advanced designs for application to their own systems and procurement plans.
- The architecture perspective will also provide critical input for the development of the industry standards necessary to support the next generation of customer communications operations for emerging applications.
- Key standards development provides a robust communications infrastructure for supporting next generation equipment.
- Utility members will be able to plan, design, develop, and implement a reliable and functional network with consistent performance and predictable results. They may be able to mitigate the risks associated with the integration and performance issues in a typical large network of heterogeneous technologies and systems.

## How to Apply Results

Utility members will be able to apply the knowledge gained from the project for designing and implementing communication networks for their next generation revenue cycle and demand response operations as well as T&D integration. In addition the results from this work can be contributed to the key standards organizations developing advanced distribution automation communications. These include efforts within the key industry standards communities and consortia. In this way the results become part of the standards based equipment that utility members can procure. Members will be able to make informed and technically sound decisions on how to design and implement a functional, secure, efficient, and predictable communication network.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<p><b>Analysis of Architecturally Significant Use Cases for Demand Response &amp; Load Management Programs:</b> This report will identify and analyze use cases from Intelligrid, SCE, and other sources that impact the architecture of the network used for Demand Response Programs in Customer Premises. The report will define the environments within the Customer Premises that are impacted by the use cases and provide detailed description of the interfaces between these environments from the top down on the GWAC Stack. This mapping will be used in the future to identify the key standards that are applicable at those interfaces.</p>	12/31/10	Technical Update

## P161.008 Life Cycle Management of AMI, HAN, and DER Communication Technologies (067467)

### Key Research Question

Utilities that are investing in Smart Grid technologies will require a "no regrets" path from technology selection, through testing, implementation, configuration, operations, upgrades, and eventual product retirement. Each phase of this Smart Grid life cycle needs extensive analysis, planning, and management which can stretch the human and financial resources of a utility. A comprehensive Life Cycle Management methodology needs to be developed for the utility industry to adopt so that Smart Grid technologies such as AMI, HAN, and DER can be integrated cost effectively, reliably and securely.

### Approach

This multi-year project will produce a series of deliverables that focus on each phase of a Smart Grid technology life cycle. The first phase deliverable will be a use-case based approach to identify the AMI, HAN, and DER technology requirements for utilities. The second phase deliverable will be a set of test procedures for the variety of AMI, HAN, and DER technologies that utilities are considering for their Smart Grid projects. The third phase deliverable will be a detailed set of implementation procedures for each type of technology which will provide the sequence of steps necessary for successful implementation that avoids costly redesigns or technical inconsistencies. The fourth phase deliverable will provide a "best practices" guide to configuring the AMI, HAN, and DER technologies for optimal performance. The fifth phase deliverable will provide recommendations for day-to-day operations and management of the AMI, HAN, and DER technologies with particular focus on data processing, transmission, and storage. The fifth phase deliverable will provide guidelines for hardware and software upgrades, firmware version control, asset management, and techniques for upgrading that minimize the downtime of Smart Grid technologies. The sixth phase deliverable will provide the metrics for determining when a particular AMI, HAN, or DER technology has reached "end of life" and detailed steps to replace the technology with new solutions in a way that causes the least disruption to grid availability and reliability.

## Impact

The availability of such a comprehensive "Life Cycle Management" tool for AMI, HAN, and DER technologies will accelerate the utility adoption of these technologies by reducing the technical and economic uncertainty associated with these technologies. Utilities can plan their human, capital, and infrastructure resources around such investments in a better way and optimize their long term operational costs. By standardizing the life cycle management of AMI, HAN, and DER technologies, utilities can cost effectively integrate such resources from other utilities and independent power producers through mergers, acquisitions, and partnerships. AMI, HAN, and DER product vendors can use the "Life Cycle Management" methodology as a guide to design new products or modify existing products to better conform to the utilities' requirements.

## How to Apply Results

Utility operations personnel can use this tool as a guide for each phase of the AMI, HAN, and DER technology life cycle. Utility IT staff can use this tool to identify the areas where they need to collaborate with the operations side to develop seamless IT processes for the successful implementation of these technologies. Public utilities commissioners can use this tool as a guide to determine the financial incentives to be given to the utilities during each phase to cover costs and keep Smart Grid technologies economically viable. AMI, HAN, and DER vendors can use the recommendations and requirements from this tool to develop future technology roadmaps that adhere to certain standards for communications, certification, reliability, and durability for long term competitive advantage.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Use Case Analysis for AMI &amp; DER Requirements Definition:</b> This report will analyze the various use cases for AMI and DER available in the industry and identify a set of requirements that utilities can use as templates for their RFPs to vendors. The use cases will be broken down into architecturally significant, process focused, and regulatory/policy oriented to provide a comprehensive set of requirements.	12/31/10	Technical Update

## PS161E Security Issues for the Power System Communication, Information, and Control Infrastructure (065456)

### Project Set Description

The Security for the Power Systems Communications, Information and Control Infrastructure project set focuses on improving cyber security for members. A key value is best practice sharing among members which is facilitated by EPRI in periodic workshops. These workshops provide a forum where members can discuss lessons learned and share experiences. This research will also conduct interoperability testing of secure implementations of wide area communications and inter and intra substation communications technologies. Communications reaching beyond substations and feeder devices reaching meters and home automation networks will require extending the overall security and device management architecture.

Project Number	Project Title	Description
P161.011	Wide Area Communication Security (EMS, SCADA, PMUs, Smart Grid Components – including secure ICCP)	This project facilitates best practice sharing among members in periodic workshops. These workshops provide a forum where members can discuss lessons learned and share experiences. This project will also conduct interoperability testing of secure implementations of wide area communications and develop security architectures for advanced wide area applications.

P161.012	Security Issues for the Intelligent Distribution Infrastructure	This project will focus on facilitate the Security Interoperability testing for DNP and define functional requirements for managing the security features of substations and feeder devices.
P161.013	Security & Management of AMI, HAN, & DER	This project will assess security of AMI, HAN and DER technologies and develop a database of use cases of security and management requirements as well as survey the security policies and guidelines of relevant national agencies.

## **P161.011 Wide Area Communication Security (EMS, SCADA, PMUs, Smart Grid Components – including secure ICCP) (065590)**

### Key Research Question

SCADA/EMS, substation control systems and plant process control systems are the central nervous systems for a utility as they provide the means for trouble free, reliable operation of the bulk power transmission system. The Smart Grid initiative has created the need for seamless integration. These systems have become more vulnerable to internal and external intruders as open architecture and wide area communications have become more prevalent. Since electric power infrastructures are increasingly being stretched to their operational limits, they are becoming more fragile and vulnerable to attack. Increased linking, operating the transmission system at close to operational limits, and new national security requirements all point to a need for an increased focus on the security of the power system.

### Approach

This project will have 3 deliverables in 2010.

#### **Information Sharing and Lessons Learned in securing EMS/SCADA systems**

This deliverable will focus on information sharing to facilitate the industry's technical and operational response to infrastructure threats. Member-directed, collaborative sharing of technical information via three annual workshops, occasional webcasts and other communications as required has been a key component of this information security program since its inception.

Facilitated workshops provide an opportunity for members to discuss security practices, concerns, solutions, and other topics of mutual interest with EPRI, other industry experts, and peers. Representatives from regulatory and research agencies (such as the Department of Homeland Security [DHS], Department of Energy [DOE], National Laboratories, North American Electric Reliability Corporation [NERC], and Federal Energy Regulatory Commission [FERC]), vendors, and other subject matter experts are regularly invited to participate in these workshops, which provide first-hand interaction with security professionals directly related to the electric power industry sector.

Information sharing also consists of timely information e-mailed directly to members and provided through periodic web casts on pertinent issues. Topical application documents (such as policies and procedures, guidelines, primers, frameworks, and methodologies) also are delivered to contributors of this project.

#### **Secure ICCP (TASE.2) Interoperability testing**

Secure ICCP is an extension of the existing standard ICCP (IEC 60870-6), with security recommendations that adopt transport layer security (TLS/SSL) into the appropriate layer of the TASE.2 profile. TLS/SSL is a transport layer certificate-based security approach providing encryption and authentication. Utilities exchange critical real-time data from ICCP connections and thus require a more effective mechanism to manage and administer digital certificates for authenticating secure ICCP links. A product was developed in 2008 (Product ID.1018285) to meet this need. A prototype of this solution will be tested in 2009 and promoted to vendors. This deliverable will focus on the interoperability testing of the Secure ICCP products from multiple vendors. This enables utilities to easily implement secure ICCP communications.

### Develop Security Architecture for PMU network

Use the EPRI PMU/Relay lab setup to develop Security Architecture for PMU network.

#### Impact

- Maintain awareness of emerging security technologies and the appropriate and cost-effective applications of those technologies to secure communications within EMS networks
- Maintain knowledge of common industry security practices
- Maintain awareness of national research efforts, provide input on their applicability, and contribute to directing future research in beneficial directions
- Maintain current knowledge of NERC cyber security standards as they evolve and understand the commonly accepted methods to become and remain compliant with them
- Update to IEC standards on secure SCADA protocols DNP3 and IEC.
- Provide Security architecture for PMU network

#### How to Apply Results

The workshops are aimed at attracting utility personnel who have the responsibility or want to gain more knowledge on utility security infrastructure. When these people attend any of the project workshops, they discuss security issues with colleagues in a trusted environment (workshops), learn what has worked and failed for other utilities and, hence, are able to avoid false starts and wasted efforts. They contribute to the improvement of security for the North American electric power industry, and provide direction to national research efforts to ensure that they provide products and technologies that are beneficial to the industry. Additional deliverables will enable Secure IEC implementation in a timely manner. Security Architecture for PMU network will provide timely frame work for design and implementation of PMUs.

#### 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Secure IEC interoperability Test Results</b>	12/31/10	Technical Report
<b>Secure DNP3 Interoperability Test Results</b>	12/31/10	Technical Report
<b>Security Architecture for PMU network</b>	12/31/10	Technical Report
<b>Three Workshops:</b> Same as for 2009 with modifications to address issues of (then) current security concern	12/31/10	Workshop, Training, or Conference

### P161.012 Security Issues for the Intelligent Distribution Infrastructure (067470)

#### Key Research Question

DNP3.0 Security Interoperability Testing: DNP3.0 protocol is being adopted worldwide as the standard protocol for inter- and intra-substations communication and communication between substations and control centers. IEC TC57 WG15 (International Electro technical Commission, Technical Committee 57, Working Group 15) has developed standards to ensure security of these communications under IEC 62351-5 for both serial DNP3.0 and DNP3.0 over Transmission Control Protocol / Internet Protocol (TCP/IP) communications. Correctly implementing these standards requires significant expertise and an in-depth knowledge of the standards.

IEC 61850 has been widely used in Europe, and North American utilities are slowly migrating to obtain high bandwidth and more secure communications for advanced substation and substation-to-control-center communications. It is important to obtain in-depth knowledge of security advantages with the migration or implementation to IEC-61850 for substation communications. Developing Security and network management

tool for IEC-61850: IEC-61850 is advanced SCADA communication protocol based on the object oriented model. It is and will be widely used in Advanced Distribution Control Systems to enable the Smart Distribution applications. IEC-61850 provides detailed object definitions for security and device management. It is required to create guides to assist in the development of this type of tool.

### Approach

DNP3.0 Security Interoperability Testing:

In 2009 Secure DNP Specifications will be completed and tested so that the vendor community will start implementing the standards in to their products. In 2010 this work will be continued to perform Interoperability Testing of multiple vendor implementations to ensure the protocol can be deployed in timely manner while securing control system infrastructure. The Project Team will promote the standards specifications to be implemented in vendor products in 2009. Interested vendors can bring their products for this interoperability testing to ensure that utilities who deployed various vendor product can benefit from the results while implementing secure DNP is SCADA control systems involving both serial and TCP/IP implementations. Deliverables of this project will involve developing techniques and procedures, tailored to the contributor's needs, to effectively secure DNP3.0 at substations and DNP3.0 communications from substations to control centers.

Developing Security and network management tool for IEC-61850: This project deliverable will be a technical report evaluating the IEC-61850 objects related to security management. The goal is develop guidelines for developing a tool to monitor and manage IEC-61850 devices from a security perspective.

### Impact

- Obtain the techniques to securely implement DNP3.0 based on IEC-62351-5 standards of data modeling features to capture and communicate the complete functionality within substations
- Be able to securely utilize DNP3.0 from current serial implementation to address NERC Critical Infrastructure Protection (CIP)
- Be able to migrate from Serial DNP3.0 communication to DNP.3 over TCP/IP in a secure way
- Be able to group substation control blocks to allow secure switching between groups as the operational situation may dictate
- Be able to securely monitor substation activity
- Ability to securely send commands to the substation
- Ability to securely store configured substation data
- Provide guidance on security management tool development for managing IEC-61850 devices

### How to Apply Results

SCADA engineers will implement Secure DNP3 products while applying security measures to their control system. This will also enable utilities comply to NERC CIP requirements.

### 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Security and Device management tool guide book for IEC-61850</b>	12/31/10	Technical Report
<b>Secure DNP3 Interoperability Test Results</b>	12/31/10	Technical Report

## P161.013 Security & Management of AMI, HAN, & DER (067471)

### Key Research Question

Advanced Metering Infrastructure (AMI) and Home Area Networks (HAN) are two enabling technologies that will allow electric utilities to establish a two-way communication network to offer Demand Response (DR) programs to their residential and light commercial customers to reduce peak load. Additionally, integration of Distributed Energy Resources (DER) such as electric/thermal storage, photovoltaics, and wind power into the utility grid will reduce the growth of expensive and polluting central generation capacity. The extension of the utility communication network into the customer systems to harness the benefits of AMI, HAN, and DER will expose the informational assets of both the utility and the customers unless security policies are enforced to block unauthorized access and limit information dissemination to a “need-to-know” basis. The utilities, the AMI, HAN, and DER technology vendors, and the customers all have to abide by a consistent set of security standards and methodologies to maintain a safe, reliable, and consistently available smart grid in the 21<sup>st</sup> century. To enforce the security policies on hundreds of thousands or even low millions of AMI, HAN, and DER nodes in a utility grid requires remote management tools that can provide fault, configuration, accounting, performance, and security management in a scalable manner. Comprehensive security and management of AMI, HAN, and DER is critical for the economic viability of utilities that deploy these technologies in a Smart Grid of the future.

### Approach

This project will focus on the security and management features of leading AMI, HAN, and DER technologies and how they will fit into the overall security architecture of an electric utility’s smart grid. The project combines a theoretical and empirical approach to security and management to offer advice and tangible results to the planners, designers, and implementers of AMI, HAN, and DER at the sponsoring utilities. The project will provide a database of use cases to distill a set of security and management requirements from member utilities AMI, HAN, and DER projects often benchmarked against EPRI’s own lab tests on similar technologies. The project will track the information security and management related policies and guidelines for the utility industry from U.S. national agencies such as FERC, NERC, Federal Bureau of Investigation (FBI), and National Security Agency (NSA) and provide security briefs to the project sponsors on a regular basis. This project will be carried out in close coordination with the Utilities Communications Architecture (UCA) Open Smart Grid Working Group.

### Impact

- Create a benchmark of information security and management standards and methodologies for utility AMI, HAN and DER rollout programs
- Create a repository of information on AMI, HAN, and DER security and management relevant national policies and guidelines
- Create working relationship with the UCA Open Smart Grid Working Group to develop new security and management standards and methodologies and address technology gaps in the market
- Conduct empirical testing of commercially available security and management tools in EPRI Living Lab and member utility labs to identify technology and standards gaps

### How to Apply Results

The member utilities that sponsor this project will receive periodic EPRI Technical Reports, Technical Updates, and Technical Briefs on AMI, HAN, and DER security/management documenting the findings from literature search, surveys, and lab tests. The project technical team will be available to the sponsoring member utilities to discuss the project products and advice on the specifics.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>System Security Requirements for Home Area Networks:</b> This report will sift through the security related use cases to identify the known threats to Home Area Networks and determine a list of cyber security requirements to mitigate the risks posed by these threats. The report will provide overviews of any recommended security practices from ISO, ITU, IEEE, and IEC to protect Home Area Networks from various sources of intrusion.	12/31/10	Technical Update