EPRI | ELECTRIC POWER RESEARCH INSTITUTE

IntelliGrid Program

2012 Annual Review

Enabling a Smart Grid by Applying Information and Communication Technologies

IntelliGrid

Enabling Smart Grid Applications for Transmission, Distribution, and End-Use

Dear IntelliGrid Advisors and Industry Stakeholders,

Welcome to the 2012 IntelliGrid Program Annual Review. This report summarizes the results of research conducted by the program in 2012 and presents our research plans for 2013.

2012 has seen utilities aggressively deploying smart grid technologies such as advanced monitoring, communications, analytics and enterprise systems to support applications such as wide area monitoring and control, integration of bulk or distributed renewable generation, distribution automation, and demand response. Companies are facing significant challenges when deploying these technologies, including:

- Selecting technologies that best meet current and future business needs and regulatory requirements, while minimizing the risk of early obsolescence and vendor lock-in
- Creating an overall architecture that integrates the many intelligent devices, communications networks, and enterprise systems to utilize resources and provide information to all users
- Managing the tremendous amount of data that is generated by the smart grid, converting data into actionable information and effectively presenting the information to the people who need to take action
- Managing a growing network of intelligent devices that have different capabilities and that use different protocols and data formats in a way that optimizes performance
- Ensuring that the workforce has the skills necessary to design, operate, and maintain equipment and systems that use new technologies.

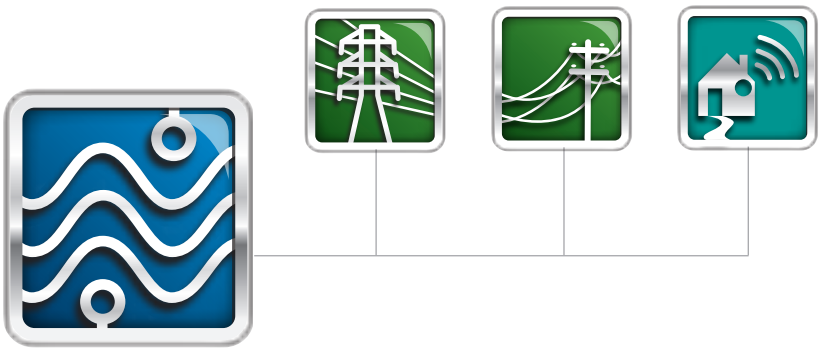
The IntelliGrid Program continues its work to address these challenges by conducting research that delivers tangible results that can provide immediate value to members as well as longer term results that help to lead the industry towards an interoperable smart grid.

Ongoing program activities include:

- Tracking federal government and regulatory activities relating to standards and communications and interpreting the impact that these actions will have on the utility industry
- Promoting interoperable systems by contributing to the development of key smart grid standards, assessing emerging standards, conducting interoperability tests of products that implement key standards, and providing information to utilities on how to implement standards
- Performing basic research into the nature and structure of utility data, where data is required and how data is turned in to actionable information—as well as understanding the cost of poor data quality to the utility
- Working with utilities to integrate data from multiple sources to support applications such as equipment health monitoring and storm recovery.

In 2013, the program will launch new projects in the areas of cost benefit analysis, enterprise architecture, and interoperable AMI systems.

Sincerely,
Don Von Dollen



"Smart Grid" is a high level concept that infuses information and communications technologies with the electricity grid to increase performance and provide new capabilities. The smart grid vision includes the idea that the utility's meters, sensors, control devices, and software applications will be able to exchange information, and to do this with sufficient timing and data volume to enable a wide range of applications.

Key technical foundations of the smart grid are the communications networks that provide connectivity to the intelligent electric devices, the interoperability standards that enable devices and systems from multiple vendors to exchange information, and data management and analysis to convert the tremendous amount of data generated into actionable information. To achieve this vision, utilities will also need the methods, tools and information for effective smart grid planning and implementation.

These four research themes run through each of the four project sets in the IntelliGrid program:

- **Project Set A** – IntelliGrid Coordination, Analysis and Technology Transfer
- **Project Set B** – Information and Communications Technology for Smart Transmission Systems
- **Project Set C** – Information and Communications Technology for Smart Distribution Systems
- **Project Set D** – Information and Communications Technology for Customer Integration Including Metering and Demand Response

The 2012 results and 2013 plans for each project set are described on the following pages.

Interoperability

The electric utility industry needs to migrate towards interoperable devices and systems. IntelliGrid will support this migration by providing technical and organizational leadership within key industry organizations, making technical contributions, providing training to utilities, organizing interoperability tests and conducting demonstration projects.

Communications

Communications technologies and utility communications requirements are evolving rapidly. IntelliGrid will provide leadership in communications standards development, provide tracking and analysis of emerging communications technologies, conduct research on emerging technologies such as TV White Space and other lightly-licensed spectrum—and conduct field demonstrations of 4G technology for utility operations.

Data Management and Analysis

As the amount of data increases dramatically, utilities need tools to effectively manage and process data. IntelliGrid will perform basic research into the nature and structure of utility data; apply techniques such as complex event analysis, data fusion, pattern recognition and neural networks to utility data; and develop models to understand the cost of poor data quality to the utility.

Smart Grid Planning and Implementation

Utilities need the strategies and tools to effectively implement their smart grids. IntelliGrid will capture lessons learned from demonstrations and deployments, work with utilities on company specific smart grid roadmap development and conduct cost/benefit analysis for smart grid applications.

IntelliGrid Coordination, Analysis, and Technology Transfer (161A)

This project set provides utilities with tools and information to help them plan, design, and implement smart grid infrastructure and applications. Projects include tracking and analysis of the rapid advances in smart grid standards and communications technologies so that utilities can minimize risk when specifying and procuring equipment. Webcasts and an annual report summarize smart grid standards development activities and provide guidance on where and how utilities should get involved. The project set also documents lessons learned from industry smart grid deployments, including cost/benefit assessment information and best practices, and provides members a forum to share experiences with roadmap development and maintenance through the Smart Grid Roadmap Interest Group.

A feature of this project set is overall industry coordination and high-level technology transfer activity related to the information and communications technologies needed to support Smart Grid applications. In order to be relevant and timely with results, project set deliverables are primarily white papers, webcasts, and workshops.

Project 161A lead is Don Von Dollen, Senior Program Manager.

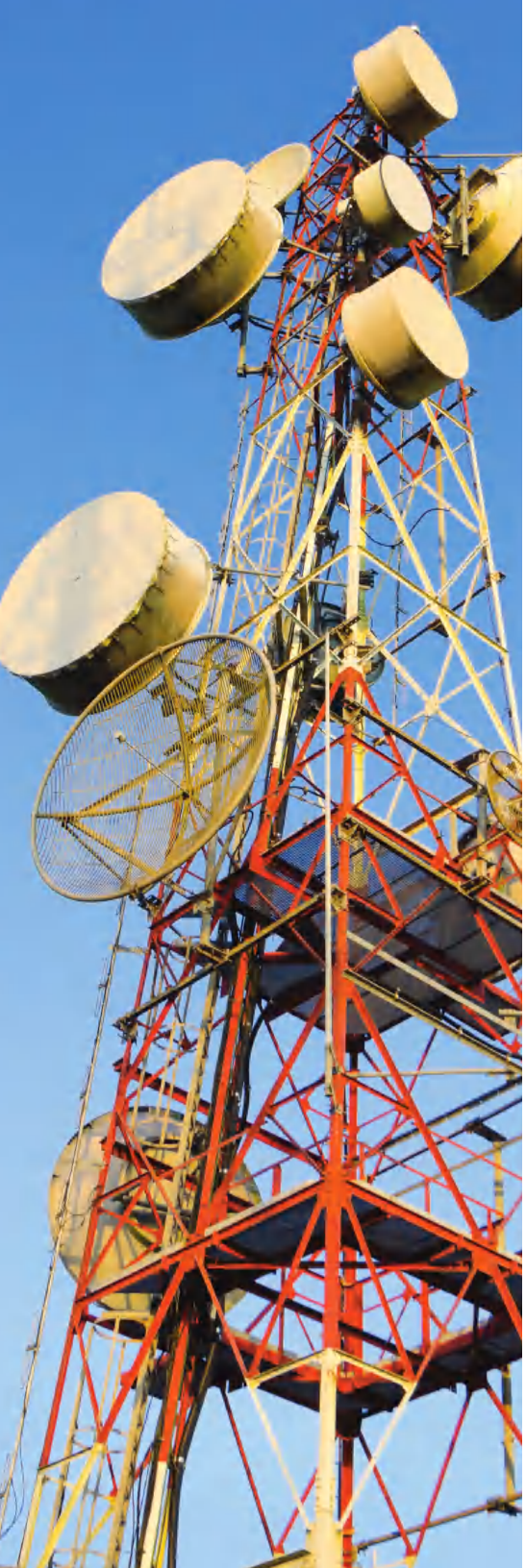
Success Story: Duke Energy and California ISO Benefit from EPRI's Smart Grid Roadmap Methodology

Given the day to day demands placed on utility management and staff, it can be difficult to find the time to develop a sound technology implementation strategy for both the immediate and longer term. In addition, getting engagement, consensus and organizational support for a plan across different departments and from executive to operational levels can be extremely difficult. However, such commitments are essential for the success of a plan of this nature. An effective technology plan with strong cross-functional support enables the best possible economic business case because the benefits from technology investment are captured across the whole company.

In 2007, EPRI began working with utility members to develop company-specific "smart grid roadmaps." These roadmaps define or build upon the company's vision for its smart grid and recommend actions for the company to take to achieve its vision. EPRI has developed smart grid roadmaps for FirstEnergy (initial and update versions), Salt River Project, Duke Energy, Southern Company, the California ISO, the Tennessee Valley Authority (TVA) and TVPPA (for the distribution companies served by TVA). EPRI also worked with Pacific Gas & Electric, Southern California Edison and San Diego Gas & Electric to develop the Smart Grid Vision and Roadmap for California in 2020. Southern California Edison has used similar guidance from IntelliGrid in developing its own smart grid roadmap. Senior SCE staff members have indicated that the EPRI methodology helped them to zero in and understand what they wanted to accomplish and then build a timeline for the plan.

The California ISO completed its roadmap in late 2010 and then published a public version a few months later. "As a result of the Roadmap development we can now articulate both internally and externally, what the smart grid is for the ISO" said Heather Sanders, Director of Smart Grid Technologies and Strategy at the California ISO. "Our people have gained a better understanding of applicable smart grid technologies and how they can benefit the ISO and our stakeholders. This has positioned our staff to participate effectively in policy, regulatory and environmental discussions and address topics such as customer response, customer data and net metering."

Duke Energy has been successful with its technology deployments. The timing of the roadmap development was fortuitous for Duke as it helped to establish a plan for the serial-to-IP program prior to funds being available from the DOE



The smart grid vision that these roadmaps embrace links electric operations, communications, and automated control systems to create a resilient power delivery system.

ARRA grants. The roadmap work was followed by a business case for the serial-to-IP program. "A key take away from the roadmap for us was the recommended approach for governance. We now have an executive-level leadership team and a director-level technology team for our roadmap programs" said Tim Bradberry, Manager, EMS/DMS Engineering Manager, Central Carolinas. "These leadership teams include people from all related departments and have made a real difference for us. Leadership topics frequently include the other core technology recommendations in the roadmap. We now have projects underway for most of the recommendations."

EPRI's goal for the roadmap development projects is to help companies transition from a generic understanding of smart grid technology to achieving a highly effective adoption and deployment timing of smart grid technology. To be truly effective, this requires a unique plan that maximizes the benefits and minimizes risks for the company. The roadmap is essentially a technology portfolio optimization plan.

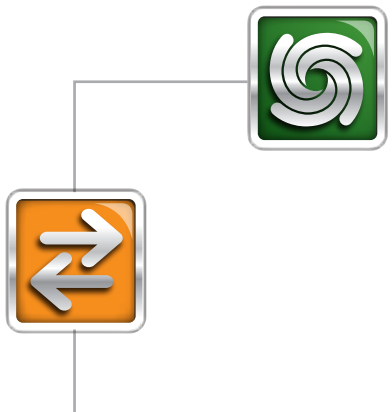
In August 2012, EPRI published the Smart Grid Roadmap Guidebook (1025470), which describes the methodology that EPRI has created to develop roadmaps. The Guidebook addresses the lessons learned, the best practices followed and the benefits identified from the eight different roadmap development projects. The EPRI Smart Grid Roadmap Methodology has five steps: Vision, Requirements, Assessment, Planning, and Roadmap Implementation. Within each step there are three or four recommended tasks.

As part of the preparation of the Smart Grid Roadmap Guidebook, EPRI was able to capture follow-up feedback from most of the utility managers who were involved in the roadmap development projects. Benefits that were reported include:

- "Future-proofs" technology investments by identifying guiding principles and interoperability standards that help protect the value of investments made
- Provides approaches for mitigating risks associated with technology investments
- Enables the utility to discover the potential future impacts from technologies such as distributed energy resources and electric vehicles
- Supports the long term planning needed to achieve overall systems and data integration
- Is useful as a source of input for regulatory applications and general rate case documents.

The EPRI Smart Grid Roadmap Methodology has been found to be an effective tool in assisting utilities to move forward in their grid modernization efforts. The smart grid vision that these roadmaps embrace links electric operations, communications, and automated control systems to create a highly-automated, responsive, and resilient power delivery system that should both improve service and empower customers to make informed energy decisions.

Although each company-specific roadmap is confidential and available only to the company that it is developed for, EPRI's IntelliGrid program publishes lessons learned and best practices from the roadmaps for the benefit of its members. The IntelliGrid program also facilitates a Smart Grid Roadmap Interest Group and hosts an annual workshop. These activities are designed to bring together the people who are responsible for developing and maintaining smart grid roadmaps for their companies to share experiences, issues, and concerns.



Intelligrid Coordination, Analysis, and Technology Transfer (161A)

Product ID: 1025470

Smart Grid Roadmap Guidebook

EPRI began working with utility members to develop company-specific "Smart Roadmaps" in 2007. These roadmaps define the company's vision for its smart grid and recommend actions for the company to achieve its vision. To date, EPRI has completed roadmaps for eight companies. *The Smart Grid Roadmap Guidebook* describes the methodology that EPRI has created to develop roadmaps and documents lessons learned and best practices collected from the roadmap development projects. The report summarizes each of the company-specific roadmaps and consolidates the technology recommendations from them.

This report describes the methodology that EPRI has created to develop company-specific smart grid roadmaps and documents best practices and lessons learned.

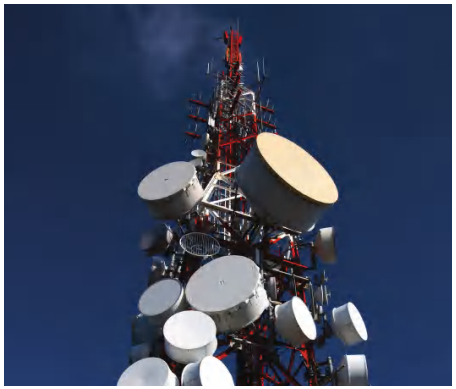
Product ID: 1025471

Smart Grid Interoperability Standards Tracking and Analysis

The vision of the smart grid is that millions of devices in different domains and with different owners will be able to freely exchange information. Interoperability is critical for realizing this vision; however, achieving interoperability is a huge undertaking. Most utilities do not have the resources to participate in or even track all of the activities related to smart grid interoperability standards. EPRI's technical staff does this on behalf of member utilities, and conducts monthly webcasts that track standards activities and analyze their potential impact. A key result of this tracking activity is an annual report summarizing the most significant accomplishment relating to interoperability standards in the calendar year.

Through webcasts and an annual report, IntelliGrid provides utilities with concise information on key smart grid standards developments and provides guidance on where they should get involved.

Product ID: 1024295, 1025757, and 1025756



Communications Intelligencer Newsletter

The *Communications Intelligencer*, published three times a year, provides relevant and timely information on developments and activities related to utility communications technologies. The newsletter features technical updates, overviews, and progress reports from standards organizations that are developing standards with application in utility communications. Standards that were tracked and profiled in 2012 include IEEE 802.11, 802.15.4e/g, 802.16, 802.21, 802.22, 802.24 and the IETF RPL and 6LowPan standards. Industry activities in alliances and forums that support communications standards were also followed including the WiMAX Forum and the WiSUN Alliance. The Intelligencer included articles on emerging technologies and updates on EPRI research in the area of utility communications.

The Communications Intelligencer provides utilities with concise information on the developments in communications technology that will have an impact on their business.

Product ID: 1026826

Identifying Stakeholders, Applications, and Impacts of AMI Systems

Utilities are eager to understand what the benefits are from advanced metering infrastructure (AMI). There have been many cost benefit studies done on AMI but very little information is available on realized benefits. This white paper provides a concise framework for conducting cost benefit analysis for advanced metering Infrastructure (AMI). It defines the cost and benefit categories (both quantifiable and non-quantifiable), provides quantifiable benefit formulas, identifies stakeholders and maps benefits to stakeholders. This framework will provide the basis for a 2013 IntelliGrid project to capture actual costs and realized benefits from AMI implementations.

This report provides a concise framework for conducting AMI cost benefit analysis.

Product ID: 1024294

Standards and Technology Adoption Case Study: Inter-Control Center Protocol (ICCP/TASE.2)

This white paper is the second in a series examining the implementation of standards within the electric utility industry. Specifically, the papers study the factors that a utility takes into consideration when selecting which standards to implement. This document describes the development and deployment of the Inter-Control Center Protocol (ICCP), later to be known as IEC 60870-6, the Telecontrol Application Service Element 2 (TASE.2). The factors that made ICCP successful—when many of its contemporary technologies were not—are examined. As the industry wrestles with the concept of the "smart grid," the story of ICCP provides many lessons on what it takes to achieve interoperability.

This white paper provides insight into why some standards are readily adopted by utilities while others are not.

Technology Transfer Activities

A key function of this project set is to transfer technology to members. This is accomplished in a few different ways. The IntelliGrid newsletter is published three times a year. The newsletter includes articles on recent results of IntelliGrid research projects, recently published research reports, and provides a calendar of events. The project set also sponsors monthly webcasts in which EPRI technical staff present on recent research results. Another area of activity is support of a public advisory group comprised of regulators, an representatives of federal agencies and other organizations. This group provides advice on R&D needs and issues related to smart grid adoption.

The IntelliGrid program provides a variety of approaches for engaging and transferring technology to its members.

Looking Ahead to 2013

Tracking standards and technology—and documenting AMI benefits—is on the agenda.

Smart Grid Standards and Communications Technology Tracking and Analysis

In 2013, the IntelliGrid program will continue to track developments in interoperability standards and communications technology, and will provide an analysis of the impact of these developments to utilities. This information is valuable to utilities that are planning on deploying smart grid systems because it provides insight on trends in these rapidly evolving technologies. Information will be provided to program members through newsletters, webcasts and reports.

Smart Grid Cost/Benefit Analysis

Understanding the true costs and the realized benefits from smart grid applications such as advanced metering, demand response and voltage management is a strong need within the utility industry. EPRI, through the Smart Grid Demonstration Initiative, has developed a cost/benefit analysis methodology for smart grid applications and has worked with utilities to implement the methodology. In 2013, the IntelliGrid program will work closely with utilities that have deployed AMI to document how AMI systems and AMI data are currently being used, capture realized impacts and resulting value chains and, where possible, the monetized benefits.

Information and Communications Technology for Smart Transmission Systems (161B)

Truly intelligent transmission is challenged by the variety of existing systems and devices already in place at many utilities. The primary challenge is in the integration of these legacy stand-alone systems and the synchronization of data and events across them.

Transitioning to truly intelligent systems will be complex, as the evolution will entail the co-mingling of modern streaming data from devices like synchrophasors with legacy data such as oscillography and external sources into cohesive visualizations of grid conditions. As customer expectations continue to rise the need to enable new business processes that capitalize on technology and the strength of standards to benefit them is critical. The Information and Communications Technology for Smart Transmission Systems Project Set is focused on the core issues needed for success.

The Project 161B lead is Paul Myrda, Technical Executive.

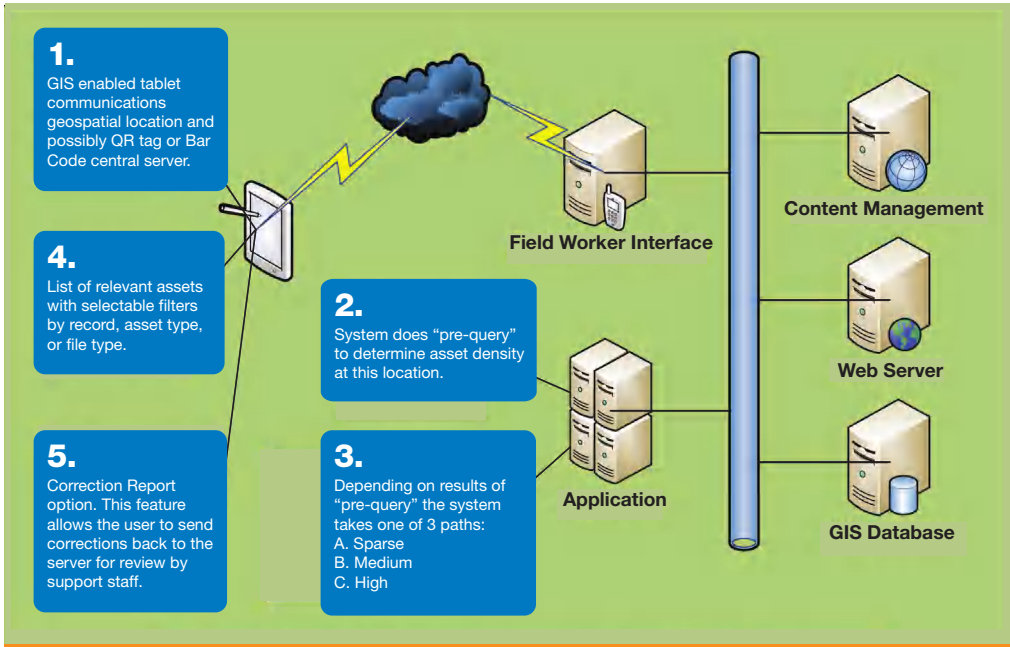
Success Story: Development and Demonstration of a Field-Enabled Geospatial Information System-Based Retrieval of Documentation

Southern Company Services, Inc.

Electric-utility field work forces are routinely trained in a wide variety of activities; however there may be an extensive amount of time between receiving training and the actual execution of the related field work. This results in a need for quick and easy on-location access to training materials and procedures to refresh their understanding of the process. These materials exist in a variety of electronic formats, but most of the documentation is on utility corporate networks and company internal websites.

Tablet computing, smart phones, wide area wireless communications and geospatial information systems have set the stage to enable field forces to gain rapid access to the relevant material for the task at hand. The objective of this project was to demonstrate the feasibility of linking these technologies together to create a seamless connection between the field forces, their field locations and the relevant information for the locations.

Southern Company Services and EPRI partnered to develop a pilot demonstration. The purpose was to investigate how well the geospatial coordinates measured by a smart device, such as a smart phone or tablet computer, could be used to develop geospatial query. A geospatial query is a distance from a specific location. These queries are common with mobile mapping applications that can show a user everything from the closest gas station to the best BBQ within 25 miles.



A. Sparse – Single circuit transmission line or rural distribution feeder
B. Medium – Substation Yard Asset or suburban distribution feeder
C. High – Substation Control House or urban distribution feeder

In this case, the user is looking for utility assets with a specified distance from the worker's location.

There were three primary objectives of the project: 1) to design and specify the core infrastructure required to link the necessary systems to provide the specific documentation to field forces based on a geospatial information system approach, 2) develop a demonstration system suitable for prototyping a small portion of a utility service territory within the EPRI Smart Grid Substation Lab, and 3) evaluate with utility staff the prototype example of document retrieval.

Based on the geospatial coordinates of the user, the system identifies a listing of relevant documents for equipment at that location with appropriate filter options to insure rapid and accurate retrieval is achieved. Some filter options could be training records, user manuals,

> **We see this tool as one of the first of many to intelligently utilize new and existing data for more efficient field practices.**

photographs, test reports, etc., so that the desired document can be selected and displayed.

Also, depending on the document retrieved, provide secondary links or selections to documents related to the primary selection. For example, the primary selection may be for a circuit breaker user manual. A subsequent selection may be required for another manual for an auxiliary device associated with the circuit breaker such as an air compressor. Development of forms as a secondary selection for maintenance problem reporting is also required.

Depending on the user's role, the number of assets within an area may vary widely. For example, if the role is a distribution worker the assets within a 300' radius would most likely be fairly limited; however, for a substation worker the same radius would return a large number of assets due to the high density—especially within the control house. By providing a variety of filters to the user the number of assets listed can be managed to be a suitable number.

The illustration on page 8 provides a conceptual overview of the proposed system. The numbered boxes describe a possible process flow for consideration.

Use Cases

The project considered the following use cases in establishing overall requirements.

- Training refresher capability through on-line document review
- User manual retrieval for field worker reference during maintenance activity
- Safety video review prior to executing infrequent tasks
- Providing operators a similar platform to assist field workers remotely
- Drawing retrieval during trouble shooting of equipment problems

The use cases were used to derive a set of requirements for the technical architecture necessary to support these activities. This includes requirements for the information interface for field workers and the authentication procedure of the person or device including the required layers/levels of authentication required by the utility.

Lessons Learned

A prototype application was developed to demonstrate the feasibility of the project and some early lessons learned are:

- Different performance from different mobile vendors
- Different performance from different web browsers
- Different behavior between Wifi location based on IP address and GPS-enabled devices
- Extension of search radius from 300', 600', to 2,000' will require that intelligence added into search function
- For the search, one should assume that the Earth is a true sphere. ***Note:*** *the earth is slightly ellipsoidal; using a spherical model gives errors typically only up to 0.3%*
- The Spherical Law of Cosines needs to be used to calculate the radial distance from the user's location.

Benefits for the Industry

Through the interactive nature of this process one can ensure that only the current authorized versions of documents are provided to the end user. Even if documents are allowed to be stored locally on the tablet computer, the process can verify that the version is current or suggest that the latest version be downloaded. Actions such as this can help to mitigate procedural errors and work towards improved reliability. According to Dexter Lewis, Research Engineer, Southern Company Services:

"We see this tool as the first of many to intelligently utilize new and existing data for more efficient field practices."

The architecture development identified where the Common Information Model or other relevant standards can be used to support data exchanges and information representations. This aspect is fundamental to future proofing applications and broadens the reach and reusability of software lowering overall costs.

Next Steps

This project is still underway at the end of 2012, and the following areas are under consideration:

- Further refinement of the user interface
- Need to add Southern Company-specific security
- Develop additional forms and include additional assets
- Expand to include other operating company data
- Need to develop and refine a substation demo (high density data)
- Conversion to an actual application rather than a web-based application.

Information and Communications Technology for Smart Transmission Systems (161B)

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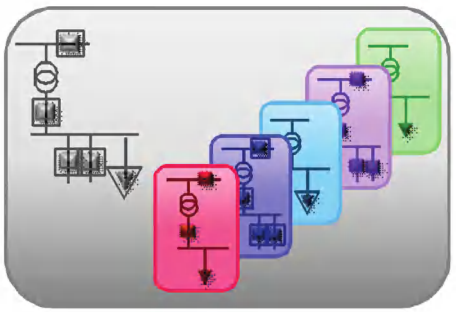

Network Model Manager and Repository

There is one physical transmission network, but there are hundreds of redundant models of the network resident in applications maintained by multiple entities across the electric utility industry, a situation which leads to data inconsistency, divergent power system simulation results and wasted labor. This project explores the feasibility of an integrated approach to network model management from the perspective of a Transmission System Operator. The Common Information Model (CIM) forms the basis of a straw man solution used to develop an accurate understanding of required functionality, to identify challenges likely to be faced and to gauge the distance between current and required readiness of standards and products.

Enter it once, use it everywhere. Single point maintenance of transmission network models leads to reduced costs and improved reliability.

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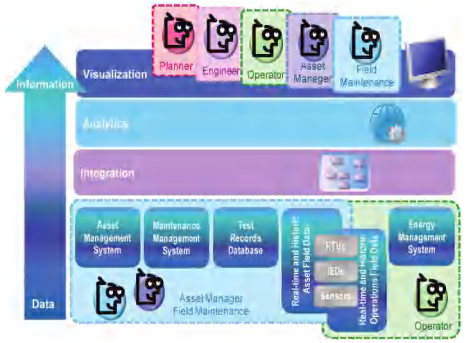

Standards Based Integration Specification

The efficient, safe and reliable operation of an electrical system is dependent on the utility's knowledge of the condition of its field assets. The organization and integration of disparate data from disparate sources is of key importance in providing the understanding required to accurately assess asset condition. Building on transformer modeling work done in 2011, this project explores the use of the Common Information Model (CIM) standard data model for the representation of information related to breaker asset health. In the work, the CIM is utilized to organize breaker-related nameplate information, field data, tank DGA test results, power factor test results and inspection records for use by asset health analytics and visualization tools.

Representing asset-related data from across the enterprise using CIM models provides the basis for analytics and visualization that can improve operational decision making.

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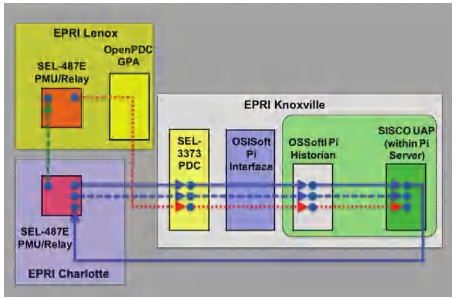

Synchrophasor Communication Infrastructure

Expected changes in the future generation mix and other advances in grid control are leading to new concepts for grid control using synchrophasors. This project began investigating the architectures in use and their suitability for grid control. It is expected that this control would most likely be over an IP network infrastructure. In 2012 the focus has been primarily on the design of the network architecture to be tested and determining the expected applications to be run on the architecture that will have an impact on the performance of various closed-loop control use cases.

Architectures suitable for future grid control using IP network infrastructures with acceptable latencies should be achievable.

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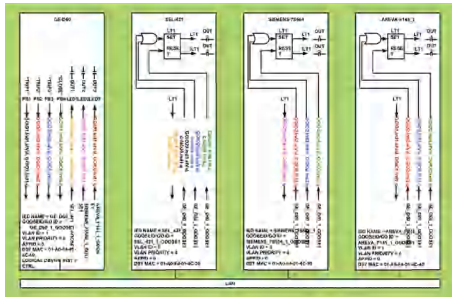
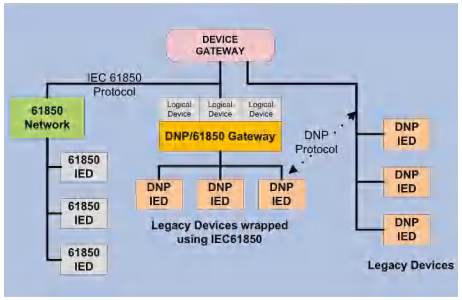


IEC 61850 Implementation

The IEC 61850 standard has been broadly identified as one of the key smart grid standards for the industry; however, adoption has been limited, at best, in North America. One of the primary issues is the need for tools to support the utility design process. Essentially utilities or even system integrators need to develop the general design for the substation and its associated protection system. Historically these have been documented in utility standard practices and then translated into drawings (wiring and schematics). What is lacking is the equivalent to these practices within the IEC 61850 domain, where messages and software-based logic replaces wiring. New methods need to be documented for commissioning, testing and maintenance.

Tools to support the general engineering design process are inadequate and need to be developed before this technology can flourish.

Product ID: 1024300

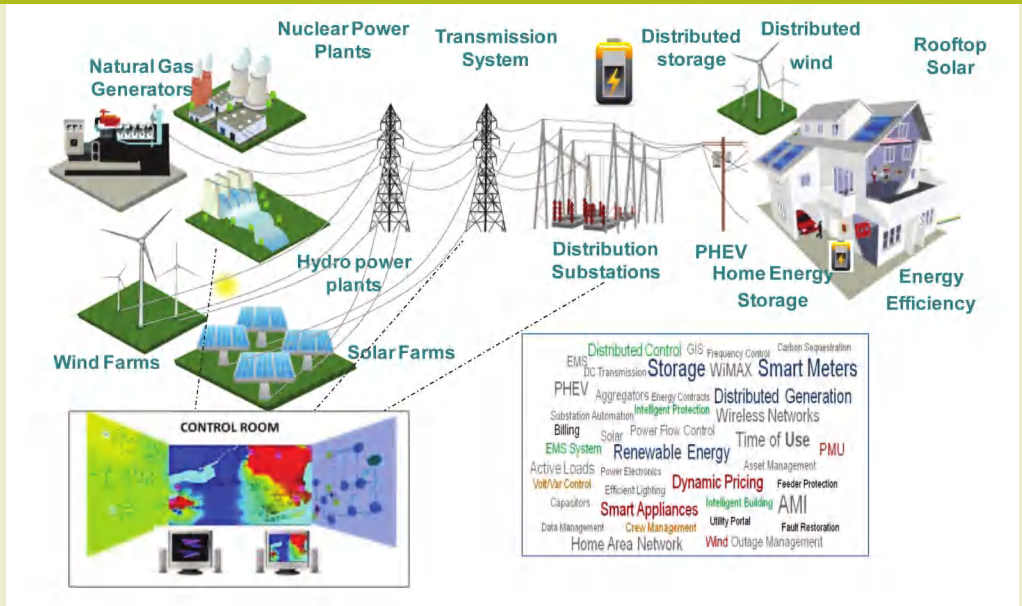


Transition from Legacy Protocols to IEC 61850

From an IEC 61850 perspective, "legacy" devices will continue to be around for 20-30 years, if not more. Adding IEC 61850 devices to an existing substation is not necessarily easy or straightforward and in most cases it will be necessary to operate with both older and newer devices and protocols. Use of a substation gateway to act as a translation component will be a key component in that architecture.

This project looked at the implications of this multi-protocol mode and developed guidance as to the approaches that are available to utilities for a successful transition to the new IEC environment from a planning and engineering point of view. Both short-term and long-term planning perspectives are provided. The EPRI Smart Grid Substation Lab was used to validate portions of the test plan outlined in the report.

Strategies to effectively maintain both legacy and IEC 61850 systems in parallel are needed to provide a clear migration path.



Develop an Enabling Infrastructure that Supports Deriving Business Intelligence from Diverse Data

Common Information Model (CIM) for Transmission – Development and Implementation

This project develops requirements for integrating smarter transmission applications within industry-defined areas of interest. These requirements serve as the basis for the development of data and device models for demonstration solutions such as The Standards-Based Integration Specification and Network Model Manager and Repository. This, in turn, validates the readiness of the CIM and IEC 61850 standards and contributes to standards activities within key industry organizations such as IEC, IEEE,NIST and others. Additionally, this project provides educational resources to utilities interested in applying the CIM.

IEC 61850 Implementation and Transition

IEC 61850 implementation has its challenges, and this project will effectively break down the implementation phases into clear concise parts, with the benefits of each described. The transition that is most beneficial is utility specific, depending on their specific needs and capabilities. The benefits need to be carefully considered within the context of the substation, control center, and enterprise. The project will also look at existing tools that can be used to help manage the infrastructure. There will be two major thrusts including IEC 61850 Implementation Phases, IEC 61850 Data Management.

Synchrophasor Communications Infrastructure and Data Management

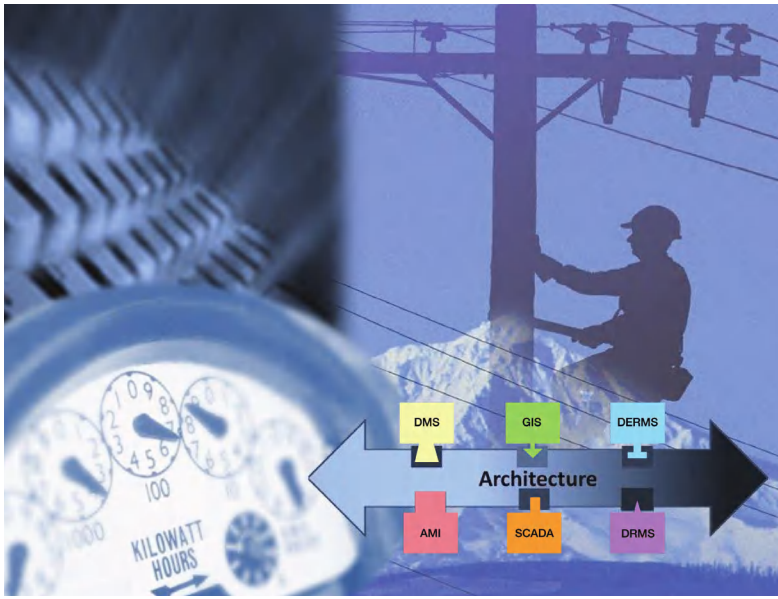
This research area investigates synchro-phasor communications and data management methods implemented by utilities and other regional entities. EPRI will assess the various approaches implemented and provide the pros and cons of each method. Actual lessons learned will be documented. Two keys areas are of interest. First is Synchrophasor Communication Infrastructure, the other is Data Management. Both of these topic areas are still in their infancy while future expectations are high for both application development and potentially future control methods. Association with other available data sources such as power system models, fault records, generation dispatch, and other operating information will further enhance the value of this data stream.

Information and Communications Technology for Smart Distribution Systems (161C)

Success Story: Harmonization of MultiSpeak with the Common Information Model (CIM)

The Information and Communications Technology for Smart Distribution Systems project set focuses on the IT infrastructure and architecture necessary to achieve fully integrated distribution operations. It addresses design issues related to integrating diverse device and applications at scale and attempts to isolate integration complexity while still supporting distribution operations applications. Data quality, validation, visualization, and management are another focus. Distribution operations deal with a large number of data points from multiple data streams. Diverse and sometimes conflicting data streams require attention due to human factors, and necessitate developing common semantics, algorithms, and business processes to achieve the full benefit from integration. The use of standard practices, such as enterprise architecture, insures that technology implementation adequately supports the business and operations needs. Central to achieving the level of required support is the reliance on the IntelliGrid℠ methodology for translating business requirements into technical specifications, test cases, and training manuals.

Project 161C lead is Dr. John Simmins, Senior Project Manager.



Electric utilities are increasingly choosing and implementing semantic standards as the integration mechanism for the enterprise. Utilities are interested in ensuring that the significant investment in these standards achieves the maximum result. In order to accomplish that, standards that cover the same domain—or standards that interface—must be harmonized to facilitate interoperation with other traditional systems in the utility such as customer information, outage management, meter data management, load management, work management and connect/disconnect systems as well as emerging "smart grid" systems such as home area networks and flexible demand response systems. In addition to facilitating interoperation and reducing the cost of system interfaces, the use of industry standards gives utility management confidence that their investment will not be stranded as systems change over time.

At present there are two leading standards for software interoperability in the electric utility industry: MultiSpeak[1] and the Common Information Model (CIM), which is maintained by Technical Committee 57 (TC57) of the International Electrotechnical Commission (IEC). The two standards have been developed by different committees that have some overlap in membership. As a result, the two standards cover much of the same material, but in a different manner. The existence of two somewhat dissimilar standards creates a dilemma for both utilities and vendors. Utilities must decide which of the two standards to support and, in some cases, must interface between two products, each designed for compatibility with different standards. This raises the cost of interoperable software and sometimes means that expensive custom development is necessary to achieve the utility's business goals. Vendors must decide which of the standards to support. In some cases vendors must support both standards; this raises their development costs—which must in turn be passed on to the utility customers. Similarly, support for both standards lengthens product development times, thus delaying the availability of systems for utility implementation.

Parts of each standard have been adopted by some utilities; MultiSpeak more commonly by smaller utilities and CIM more commonly by large utilities. Utilities wishing to gain the value of standardization currently have to choose one or the other standard or invest significant resources in a custom harmonization effort. There is confusion in the marketplace about which standard to support, how to support both standards, and how to integrate systems based on the different standards, when the standards can take different approaches to solving a problem.

The CIM–MultiSpeak harmonization effort sought to identify the degree of correlation that exists between the International Electrotechnical Commission (IEC) Common Information Model (CIM), which is based on IEC standards 61968, 61970, and 62325, and the MultiSpeak v4.1.5 standard for electric system interoperability. A proof-of-concept

[1] MultiSpeak is a registered trademark of the National Rural Electric Cooperative Association.

The harmonization effort showed where the respective standards are closely aligned—and where significant effort may be required to bring them in closer alignment.

interoperability test example using the on-demand market case was created that leveraged MultiSpeak web services to a CIM-based web service. The initial effort focused on mapping attributes from the IEC 61968-9 profiles to equivalent profiles that were created for MultiSpeak v4.1.5. A proof-of-concept interoperability test example using the on-demand market case was created that leveraged MultiSpeak web services to a CIM-based web service.

New Opportunities

Technologies for grid modernization are evolving and interoperability, the capability for various devices and technologies to work together and share data seamlessly, is important for developing a highly efficient system that benefits utilities from an operations standpoint and consumers from a performance standpoint. In the past if a utility wanted to create a system where a variety of products and technologies could work together to offer greater operating and performance efficiencies, they were hampered in their integration efforts by the overlap of standards, in this case CIM and MultiSpeak. Harmonization of standards offers a path forward for integration regardless of the vendor.

Benefits for the Industry

A process was created whereby MultiSpeak profiles could be created. (MultiSpeak was one large model, and no CIM-like equivalent profiles existed.) A process was developed for mapping from CIM to MultiSpeak. UML for the MultiSpeak equivalents were developed such that XSDs could be directly generated from the model.

Correlations, transformations, and gaps between the profiles were documented, with a set of suggested changes for IEC Working Group 14 and the MultiSpeak Technical Committee to consider in future editions of their respective standards. The documentation also includes suggested mappings. While the mappings for any given implementation may vary somewhat based on the business requirements of a customer; e.g., some attributes may be optional and hence the customer may choose not to implement them, the transformations are suggested solutions to common systems integration problems such as concatenating multiple attributes into a single attribute or performing logical functions on an attribute prior to mapping. This mapping would (i) assist utilities to specify either standard with confidence, knowing that MultiSpeak systems could interoperate with other systems with minimal customization, (ii) permit vendors to develop interfaces that work with systems compatible with either of the standards, and (iii) enable both standards groups to improve their standards and possibly to move closer to full harmonization over time.

The harmonization effort demonstrated where the respective standards are closely aligned and where significant effort may be required in future additions to bring them to closer alignment.

Suggestions for changes based on the identified gaps have been contributed to the respective technical teams that support each standard. These suggestions will need to be vetted by the respective teams for consideration for updates in forthcoming editions of each standard.

As the standards become better aligned it means lowered cost for systems integrations that are based on these standards, eventually lowering costs for ratepayers.

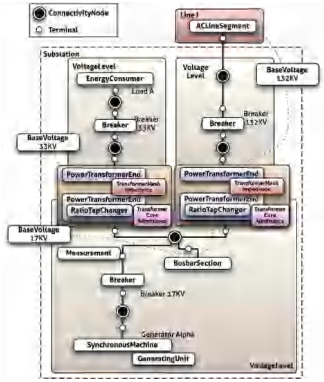
The proof-of-concept integration of a well-known use case (on-demand meter reading) demonstrates the practical applicability of integration using an enterprise service bus with mapping not only to the respective meter read payloads but also to those message elements required for reliable systems integration.

According to Bob Saint, NRECA's MultiSpeak Program Manager, "Harmonization of MultiSpeak with the CIM and other standards helps a great deal to improve the credibility and exposure of MultiSpeak and demonstrates the richness that MultiSpeak has achieved. We appreciate the effort of EPRI on the harmonization project and their continuing support of the MultiSpeak Software Integration Initiative."

David Haynes, Staff Systems Scientist, said, "At Aclara, we find that small utilities tend to be interested in plug-and-play interoperability, and large utilities tend to be interested in customizations that will optimize their processes. As a result, utilities such as COOPs express considerable interest in MultiSpeak, while utilities such as IOUs favor the CIM. I think the harmonization effort and resulting cross-pollination can lead to the best of both worlds. MultiSpeak is famous for its testability—the CIM for its flexibility and its model driven dictionary. Not only should the harmonization effort improve both standards, it will make it easier to support both standards."

Information and Communications Technology for Smart Distribution Systems (161C)

Product ID: 1024302



Application of CIM in Distribution Enterprise Applications

In 2011, EPRI developed the CIM Primer (1024449) to introduce utilities to the CIM. In 2012, EPRI prepared a training DVD that takes the viewer from no understanding of the CIM to a level of comfort with the concepts and particulars of IEC 61970 and IEC 61968. The last half hour of the DVD is an introduction to a common tool to model the CIM, Enterprise Architect.

EPRI developed a universal semantic standard test harness (1023648) that is an open source conformity test for any semantic standard, such as IEC 61968, MultiSpeak, OpenADR, and SEP 2.0. This test harness can be used by developers for unit testing or by any test lab to implement conformity tests.

The Common Information Model seems mysterious and complex but if the information is presented using terms and concepts that the typical utility engineer uses, the learning curve is greatly reduced. Tools such as the universal semantic standard test harness will make it easier for test labs to develop conformity tests.

Product ID: 1024303

GIS Data Improvement

Utilities continuously struggle with the quality of geospatial information system (GIS) data. With the advent of the smart grid and advanced metering infrastructure, utilities are facing increased pressure to resolve data quality issues.

In many cases, utilities are finding that their capital intensive smart grid investments are not yielding anticipated benefits simply because the utility does not have an adequately accurate representation of the distribution system.

This report provides utilities with an adaptable template and set of tools that can be used to assess, improve, and ensure ongoing data quality. Following the recommendations of the report and using the associated tools will provide utilities with a strong foundation to ensure data quality on an ongoing basis.

Many utility personnel have this vague feeling that their GIS data is not as accurate as it needs to be. This deliverable explains the major issues with GIS data and offers a way to assign value to GIS data and justify a GIS data improvement project.

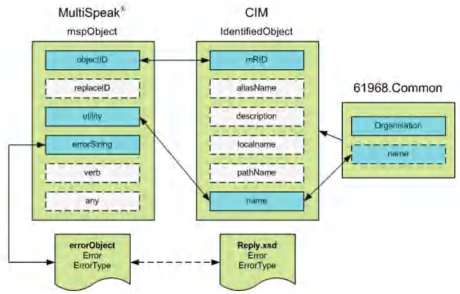
Product ID: 1024304

Field Force Data Visualization: A Mobile Integrated Data Access Platform Report and Software

To show the power of data integration and modern human-computer interfaces, EPRI has drawn from emerging technologies in the mobile computing domain, such as augmented reality and context aware GIS, to create a prototype mobile integrated data access platform for operational data in the field using tablet technology. This software prototype leverages the Common Information Model (CIM) so it can be deployed on a smart phone or a tablet. By integrating back-end systems in the field, better field decisions can be made which speeds up work, particularly storm damage assessment and restoration. The associated report (1024304) describes the underlying technology for this generic data viewer that can seamlessly utilize any utility's operational data for visualization via a single user interface.

This software can help provide field crews with powerful yet inexpensive technology that integrates all the data they need with one, multiplatform technology.

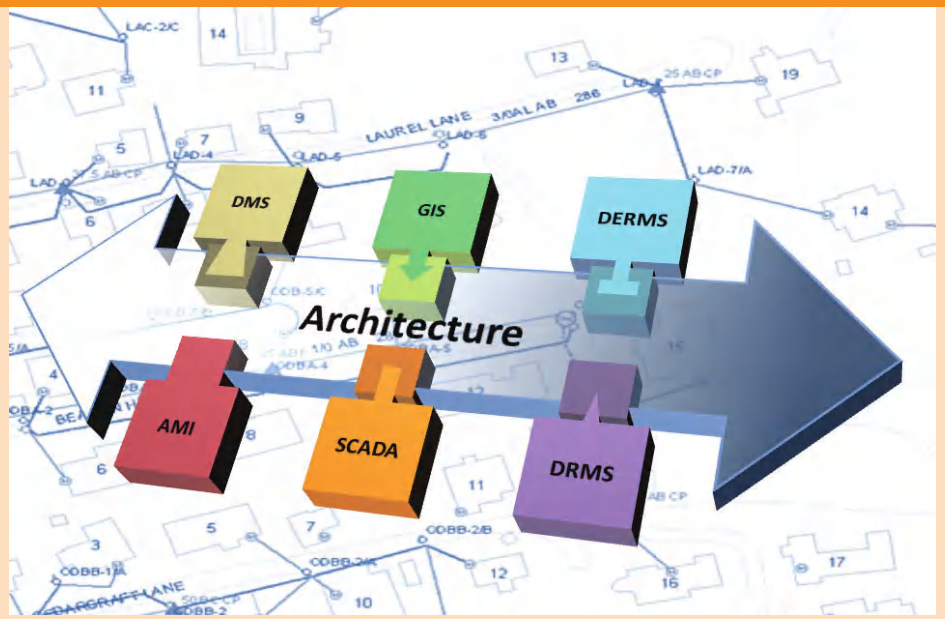
Product ID: 1026585



CIM MultiSpeak Harmonization

This report reflects the effort to harmonize the International Electroctechnical Committee's (IEC) Common Information Model (CIM) for utilities, which incorporates IEC standards 61968, 61970, and 62325, 1st Edition, with MultiSpeak v4.1.5. Specifically, the harmonization is with the IEC 61968-9 Meter Reading & Control profiles. The objective of the harmonization effort was to determine the degree of correlation that already exists between these complementary models of utility application integration. MultiSpeak-based profiles were created and mapped to existing 1st edition CIM profiles with the correlations, data transformations that may be needed, and any gaps in the models respective to the other.

CIM-MultiSpeak harmonization was completed for the IEC 61968-9 (meter reading and control) profiles. A proof-of-concept integration of on-demand meter reading demonstrates the practical applicability of integration using an enterprise service bus with mapping not only to the respective meter-read payloads but to those message elements required for reliable system integration.



Clean GIS data is a critical component of mission-critical applications.

Geospatial Information System (GIS) Data Management

GIS acts as the "hub" around which the engineering and operations application revolve. In an ideal world, the GIS feeds critical information to the other applications in the distribution environment. By cleaning up the data in GIS, improvements to mission-critical applications such as the outage management systems (OMS), power systems modeling, and distribution management systems (DMS) could be expected.

The 2013 development effort will focus on collaboration with EPRI Program 180 (Distribution Systems) to develop tools for GIS data clean-up using AMI and other resources. A follow-up technical update to the 2012 report (1024303) on monetization of GIS data quality will be produced that will be a step-by-step guide to the process of developing a business case for GIS data improvement. Identifying data requirements for systems that depend on GIS and working toward CIM messages to integrate GIS will be the remainder of the effort.

Utility Enterprise Architecture Development

Enterprise architecture as a practice has evolved over the course of the last couple decades. The scope of this effort will be limited to smart grid related systems. This project will collect and organize existing utility artifacts, and develop new artifacts into a comprehensive enterprise architecture repository. The repository will follow TOGAF (The Open Group Architecture Framework) with a focus on the first four phases, A) Architecture Vision, B) Business Architecture, C) Information Systems Architecture, and D) Technology Architecture. This effort will also use the Carnegie Mellon University/ Software Engineering Institute Smart Grid Maturity Model (SGMM) as a complement to the IntelliGrid methodology to benchmark utility maturity and in partnership with program members, develop enterprise architecture roadmaps, and a cost/benefit analysis of enterprise architecture.

This project will closely coordinate with others within EPRI, member participants, and utility forums such as the Smart Grid Interoperability Panel (SGIP) Architecture Committee (SGAC), UCAIUG Open Smart Grid (OpenSG) task force, and various standards working groups, i.e. IEC Working Groups 13, 14, and 19.

Common Information Model (CIM) for Distribution Development and Implementation

Basic messaging utilizing the Common Information Structure is necessary to develop a smarter, more efficient grid. Gaps in the CIM standards still exist and the standards that make up the CIM have yet to reach their full potential. This project will collaborate closely with EPRI Program 174 (Integration of Distributed Renewables) by holding a series of workshops to bring together utilities, vendors and standards development organizations to accelerate the writing of new CIM messages for back office integration of distributed energy resources (DER).

EPRI will continue to expand and improve training material to facilitate the use of CIM by utilities. A second edition of the popular CIM Primer will be produced to expand the scope to cover the latest CIM standards and add more examples and exercises at the end of each chapter. The CIM training DVD will be improved upon and developed in close coordination with the CIM Primer to provide a complete training package. Finally, EPRI will continue to provide CIM development news and analysis.

Development of Distribution Integration Laboratory

EPRI is deploying an entire suite of distribution back office applications to perform end-to-end interoperability tests, benchmark best practices, study the impact of using an enterprise service bus, test tools to translate from MultiSpeak to CIM and back, test the effects of bad GIS data on operations, and perform table top demonstrations of technology.

EPRI will use the universal semantic test harness developed this year, to test interoperability of products in the lab for IEC 61968, MultiSpeak, OpenADR, Green Button (NAESB Req 21), and SEP 2.0. The test harness can also be used as an application simulator, being able to send and receive messages as if it were an application. CIM for DER will be tested as the messages are being developed.

Information and Communications Technology for Customer Integration including Metering and Demand Response (161D)

The future of customer integration bears little resemblance to the monthly meter read of the past. Both residential and business customers are increasingly likely to have solar photovoltaic systems, electric vehicles, backup generators, battery storage, and intelligent load devices. Optimally integrating these resources with the grid will require new program designs, advanced metering, and a range of communication technologies. This project set is focused on the systems and methods that utilities use to accomplish this task, including advanced metering infrastructure (AMI), demand response, and distributed energy resources (DER). The scope encompasses all customer classes (industrial, commercial, and residential) and the range of communication technologies and protocols involved in each domain. This research seeks to coordinate with industry and standards groups in efforts to drive openness and interoperability, to improve utility options in the marketplace, and reduce the total cost of system ownership. Studies will include technology performance evaluations, field demonstrations, system and software upgradeability, and the identification of best-practices for life-cycle management.

Project 161D lead is Brian Seal, Technical Executive.

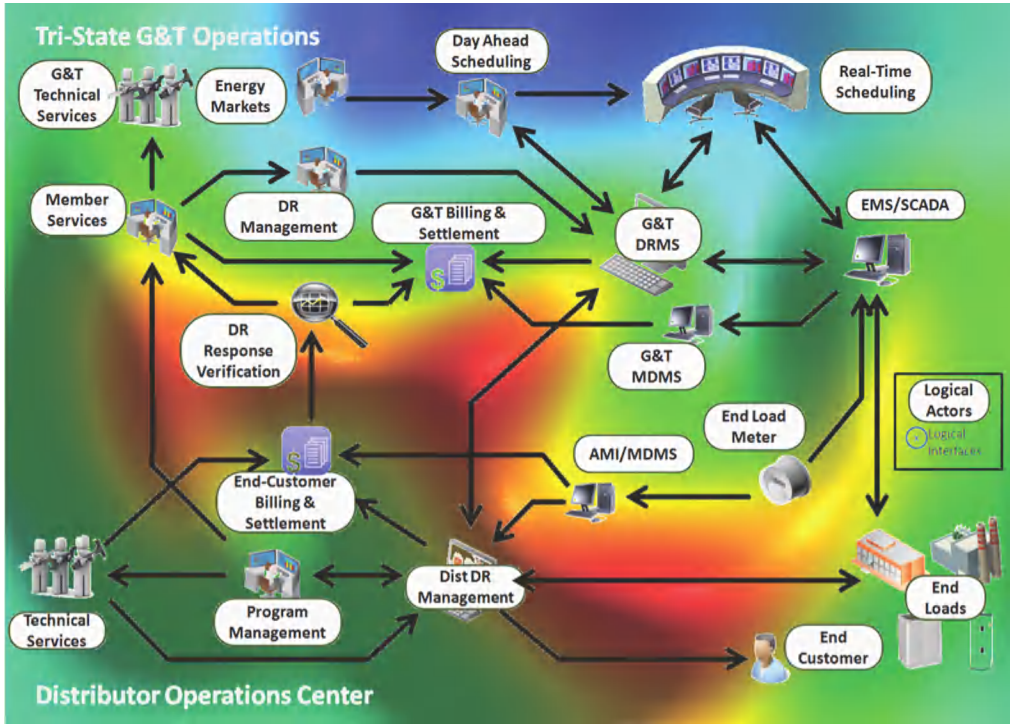
Success Story: Tri-State Generation and Transmission Demand Response Framework Development

Tri-State Generation and Transmission Association (Tri-State) is a wholesale electric power supplier to 44 electric distribution cooperatives in the Rocky Mountain west. Tri-State generates and transmits electricity to its member systems throughout a 200,000 square-mile service area reaching from Mexico to Montana. Tri-State serves approximately 1.5 million consumers in Colorado, Nebraska, New Mexico and Wyoming.

Tri-State's power is currently generated through a combination of owned base-load, intermediate and peaking power plants that use coal and natural gas as their primary fuels, supplemented by purchased power, federal hydroelectricity allocations and renewable resource technologies.

Tri-State has maintained an array of successful efficiency programs historically, and in the context of advancing technology is looking to augment and compliment these programs with demand response and energy shaping opportunities.

Tri-State has developed an assortment of demand response and energy shaping products and services designed to both shave peak and shift consumption to off-peak hours. In this respect, and in combination with rates, Tri-State's intent is to improve the shape of its annual load duration curve. This will help Tri-State optimize its asset base by mitigating system exposure to periods of high demand while at the same time augmenting service off-peak.



Through the use of products and services offered across the residential, agricultural and commercial and industrial classes, Tri-State is looking to create a DR resource that can be used to shape the coincident, system-wide load profile comprised by all 44 Tri-State Member Systems and their member owners. In this context, Tri-State looks to an enhanced ability to use demand-side resources for controlling costs at both the wholesale and retail levels.

The development a comprehensive system to support present and planned demand response needs is particularly challenging for Tri-State, because end-use loads and end-customer relationships belong to the 44 distribution cooperatives that make up the system. Each of these cooperatives is an independent business entity, each with different systems and capabilities, each serving their own unique loads across a variety of extreme climate zones, which vary from agricultural plains to high altitude alpine environments. Low

Through the use of open standards, Tri-State aims to reduce the risk of vendor lock-in and free member distributors to utilize their preferred vendors and to evolve according to their own timelines.

population density and a large geographic territory also pose challenges for Tri-State, whose largely rural membership serves areas with sparse communications coverage and small customer populations over which to amortize the costs of fixed investments.

Tri-State's goal has been to design an overall system framework that ties together these systems into a functional whole that respects jurisdictional boundaries yet operates in a 'virtually vertically integrated' fashion.

Framework Development Process

Tri-State engaged EPRI in the framework development process in order to benefit from the cumulative learning of other utilities and to contribute the findings of the project back to this knowledge base.

EPRI introduced and applied the IntelliGrid Methodology to the project. The IntelliGrid Methodology is a use-case based process for the development of system architectures and the determination of requirements for the elements and interfaces that make up large and complex systems. In the Tri-State project, this methodology was applied to the demand response and energy shaping applications that inform Tri-State's use cases.

Tri-State engaged representatives in the process from several member systems with experience with direct load control, as well as those from all affected internal departments. EPRI facilitated a use-case workshop of this cross-functional group, which resulted in the development of 17 key use cases and a conceptual system architecture that spanned from the Tri-State operations, through distributor systems, and to end-use meters and loads. The architecture identified 19 primary actors, interacting through 30 distinct interfaces.

One goal of the project was to understand how, and where, open standards might be applied to make the demand response system easier to implement, maintain, and evolve over time. Because the system will span multiple business entities (i.e. Tri-State G&T and 44 distributors), it was important to start with an architectural foundation that allowed these business entities to make decisions independently in terms of technologies, software platforms, and timelines.

With this goal in mind, the interfaces identified through the use-case process were assessed in terms of criticality with respect to the objective of designing an interoperable system that relies on open standards. For each of those interfaces of greatest architectural significance, EPRI compared the information to be exchanged to the capabilities of candidate communication standards to diagnose if, and to what extent, the interface may be based on open standards. EPRI drew on insights gained through direct participation in standards groups and ongoing NIST Interoperability Standards Tracking and Coordination (NISTAC) to perform this assessment; which looked at the intended domain, maturity, and data coverage of each standard. The EPRI project helped Tri-State to identify key interfaces and standards suitable for use at these interfaces. Through the use of open standards, Tri-State aims to reduce the risk of vendor lock-in and free member distributors to utilize their preferred vendors and to evolve according to their own timelines.

Another goal of the project was to better understand the status of Demand Response Management Systems (DRMS). An increasing number of companies are offering these software applications, with broadly varying functionalities and standards utilization. Both at the Tri-State and distributor levels, DRMS are central elements of the system.

To aid in this process, EPRI conducted interviews and surveys of representative DRMS companies. These surveys were designed to understand the manufacturer's use of open standards on both upstream (enterprise) and downstream (load-facing) interfaces and their perspective on the sufficiency of present and emerging standards.

Insights Gained Thus Far

Tri-State's benefits of participation in this project thus far include distributor engagement and cooperation with Tri-State in the DR provisioning process, improved product design as a result of the level of detail required by the IntelliGrid Methodology, and insights gained into how to better align internal business processes to both facilitate the offering of DR programs and to optimize their value.

Tri-State looks forward to EPRI's closing winter workshop for this engagement, which will be attended by technical staff from its distributors system-wide. Anticipated content includes a wider orientation to the IntelliGrid Methodology highlighting the importance of open architecture, and an open forum for Tri-State's distributors to get EPRI's perspective on their provisioning options.

Information and Communications Technology for Customer Integration including Metering and Demand Response (161D)

Product ID: 1024305

Secure and Cost Effective Sub-Metering

Emerging technologies such as solar photovoltaic systems and electric vehicles have increased interest in sub-metering of residential loads for many utilities. Available products and standards offer few options other than installation of additional meter bases and socket-type meters. This project conducted a series of workshops, engaging stakeholders from the AMI/metering, solar, and electric transportation industries, to scope-out the range of options that exist, and to identify the pros and cons of each. This scoping study was a first step toward understanding whether new metering, processing and/or communication standards may be needed to enable better options.

There is strong alignment in the fundamental sub-metering needs of the solar and electric vehicle industries, as well as with traditional sub-metering uses such as water heating. The utility industry would be well served by a common solution. A few of the identified sub-metering approaches stand out and merit further investigation.

Product ID: 1024306

Future Role of Retail Broadband for Grid Integration

Retail broadband networks have experienced rapid growth in performance and availability. What role can retail broadband networks play in a range of smart grid applications, particularly those related to residential customer integration, as a primary or alternate means of providing connectivity? The report categorizes applications and use cases involving communications at the customer premises, and maps key requirements to the capabilities of communication networks: private utility AMI networks and residential broadband (with and without special provisioning by the service provider). The report includes contributed perspectives on fixed and wireless broadband from cable operators and a wireless operator. A case study from a utility that is also a broadband service provider highlights the unique aspects of this business model. Approaches for incremental migration from existing private AMI networks to hybrid networks that leverage customer broadband are addressed.

The use of retail broadband appears to be possible and practical for some, but possibly not all, utility applications at the customer premises.

Product ID: 1024307

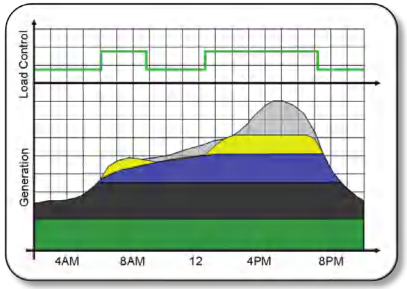
Standards for Residential DER Integration

The Smart Energy Profile (SEP) is a specification set forth by the ZigBee Alliance for application layer messaging in Home Area Network (HAN) environments. Many changes and additions have been made in the 2.0 version of this specification, including a range of capabilities intended to support distributed energy resources, such as small-scale solar photovoltaic and battery storage systems that may be integrated in the residential domain.

This report presents the results of a detailed study of the role SEP2 is intended to play to support distributed energy resources, and is an application guide for using these features. The report explains what capabilities are and are not supported, and provides recommended usage (down to the message level for implementing a range of common functions.

The 2.0 version of SEP has added capabilities to support distributed energy resources in a way that is consistent with new IEC standards for smart inverter functions. A core set of functions, representing those most likely to be useful in a residential environment, are supported.

Product ID: 1025415



Using AMI Data to Verify DR Participation

Residential products are becoming available that are "demand-response (DR) ready" off the shelf. Several factors are making this possible, including continued reduction in the cost of microprocessors and communication electronics, new communication standards, and incentives such as those created by the EPA's "connected" criteria for ENERGY STAR products. DR-ready products that can receive utility signals and act on them intelligently offer many benefits compared to traditional products that could only be turned on and off using a switch. But they also bring many challenges, as consumer adjustability and event-override make fixed incentive programs impractical. This project studied the possibility of processing interval consumption data (e.g. 15 minute, hourly) to validate or even to quantify consumer participation in demand response programs.

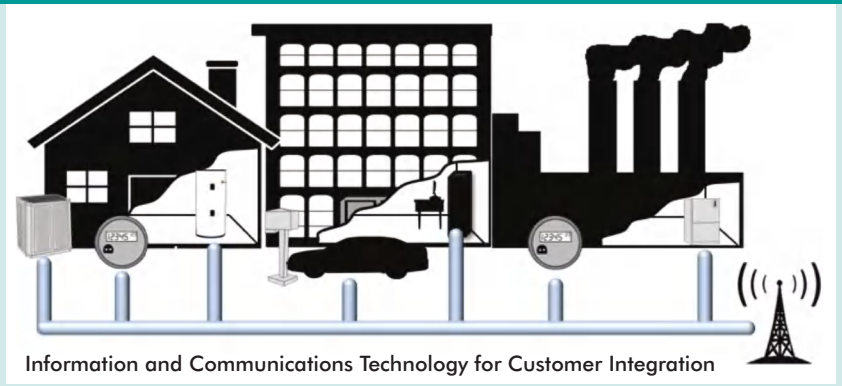
Averaged over several events, it appears that interval AMI data can effectively be processed to verify participation of large loads such as HVAC and water heaters. Smaller loads, and non-recurring events, may require other means of verification.

Product ID: 1026509

Interfacing with Smart Buildings

Commercial buildings are increasingly likely to include specific loads or whole-building systems that are capable of responding to grid signals. This capability, provided by advances in control and communication technologies, can be implemented through open communication interfaces. One of the most popular demand response open interfaces is OpenADR, which is designed to make commercial buildings price responsive or aware of DR event notifications. Other specifications like IEC 61850 and DNP3 are designed to integrate distributed energy resources with the grid. This effort was designed to research the current state of open interfaces used in grid-connected commercial buildings.

Without open communication interfaces, the potential contribution of commercial buildings to the grid could not be realized. If OpenADR could be deployed and tested in more DR programs, it could prove to be one of the most impactful interfaces.



Information and Communications Technology for Customer Integration

Advanced Metering Infrastructure – Advancing Performance, Openness, and Interoperability

The IntelliGrid program is conducting research aimed at providing utilities with more options and more flexibility in future AMI system selection, deployment, and use. Many gaps exist in this area and a sustained and collaborative effort is required to address the needs. In 2013, program members will work together with utilities worldwide to develop a comprehensive strategic plan for achieving more open, interoperable AMI systems. This plan will include an assessment of the present situation, the establishment of a vision for the desired future state, and identification of key steps needed to achieve industry goals. This plan will serve as a guide to future year's research in the AMI area so that projects both inside and outside EPRI may be aligned. Achieving industry goals in this area will require a high degree of collaboration and coordination. EPRI envisions that all of its research will be coordinated will be coordinated with the actions of many standards and other stakeholder groups.

An important part of this process is capturing and sharing of lessons learned, best practices, and beneficial system uses that have been identified by utilities through the present round of AMI deployments. The IntelliGrid program previously established a smart grid use-case repository and will also compile these valuable industry AMI experiences.

Demand Response – Integration of Intelligent Loads

The emergence of smart, communicating devices in both commercial and residential environments is changing the way utilities think about measurement, verification, and incentives for participation in demand response programs. The flexibility that these advanced products offer to consumers is seen as a positive thing, increasing participation as a result of an improved customer experience. However, privacy concerns and response adjustability require that utilities consider additional options for verifying participation. In 2013, the IntelliGrid program will perform hands-on evaluation of devices and work with members to understand the impact of these changes and to identify options and strategies for DR program design, supporting communication infrastructure, and measurement/verification.

Distributed Generation and Storage – Optimizing the Benefits of Customer-Sited DER

Utility customers of all types are increasingly likely to have some form of distributed generation and/or storage. Whether in the form of customer owned or sited photovoltaic systems, electric vehicles, backup generators, or fixed battery storage, these distributed energy resources (DER) bring great opportunity, but also great challenges. The IntelliGrid program is a leading contributor to international efforts to develop standards for the behaviors and communication integration of these resources. The industrial, commercial, and residential domains tend to use different communication technologies, and different communication protocols, so the cohesive integration of different types and sizes of resources into a single distribution system is challenging. In 2013, this project will continue to work with members to accelerate the development of standards for distributed energy resources and to support members in integration tests in both laboratory and field environments.

Smart Grid Roadmap Interest Group

The purpose of the Smart Grid Roadmap Interest Group is to bring together the people who have the responsibility for developing, maintaining or implementing their company's smart grid roadmap to share lessons learned and discuss topics of mutual interest. Members of the Interest Group make presentations on their company's roadmap, discuss how they maintain their roadmap and share change management strategies.

The Smart Grid Roadmap Interest Group meets primarily through webcasts. Four webcasts were held in 2012. During these webcasts, presentations were made by San Diego Gas and Electric and the Tennessee Valley Authority on their smart grid roadmaps. We also heard a presentation on EPRI's work on smart grid cost benefit analysis.

The IntelliGrid Program also held a Smart Grid Roadmap Workshop at its offices in Palo Alto, California on August 7-8 that brought group members together. Representatives from 9 utilities made presentations on their company's roadmap and panel sessions were held on "roadmap development methodology," "living with and maintaining your roadmap," and on "cost benefit analysis for smart grid investments."

Workshop participants agreed that additional research is needed in the areas of enterprise architecture and cost benefit analysis. Based on this feedback, the IntelliGrid program has launched new projects on smart grid cost benefit analysis and enterprise architecture in 2013.

Plans

In 2013, the Smart Grid Roadmap Interest Group will hold four webcasts and one workshop. Interest group members will continue to make presentations on their company's smart grid roadmaps. Additional topics for future webcasts include:

- methodology for roadmap development
- deployment experiences
- maintaining a roadmap
- architecture development
- standards adoption.

The Interest Group will also discuss issues relating to smart grid cost benefit analysis. Information on actual costs and realized benefits of Smart Grid applications will be shared and discussed.

How to Participate

To join the Smart Grid Roadmap Interest Group, contact Don Von Dollen at: dvondoll@epri.com or (650) 855-2210.

For More Information

The Smart Grid Roadmap Interest Group web page is at: http://smartgrid.epri.com/Roadmap.aspx

Several documents and presentations have been posted on the website including several utility smart grid roadmaps.

Communications Interest Group

The Communications Interest Group (CIG) serves utility communications directors and IT executives. The CIG provides a forum where new ideas and emerging technologies relevant to utility communications can be presented and discussed. The CIG also provides opportunities for members, whether or not they are IntelliGrid members, to provide feedback, direction, and prioritization for the IntelliGrid communications roadmap.

Input from CIG members aids EPRI's mid-term and long-term strategic planning, and identifies gaps and opportunities for new collaborative research in communications. The CIG offers webcasts on emerging communications standards and industry alliances, and holds face-to-face meetings at EPRI advisor meetings.

The first meeting of the CIG for 2012 was held at the EPRI advisors meeting in Huntington Beach, California. At that meeting the group reviewed the IntelliGrid Communications Roadmap, and communications-related activities that were ongoing during the year. Those included the EPRI Field Area Network Demo, the activities in OpenSG SG Network and PAP2, and the new research in Interoperable AMI in IntelliGrid program P161D.

Some highlights of 2012 include:

- After the advisors' meeting, several new members joined the CIG, bringing the count to 18 people.
- A webcast on the IEEE 802.22 standard for TV White Space Communication was held, presented by Apurva Mody, chair of 802.22.
- A webcast on the IEEE 802.11af standard for TV White Space Communications was held, presented by Rich Kennedy, chair of 802.11af.
- The CIG held a teleconference to review and update the IntelliGrid Communications Roadmap.

Plans

A face to face meeting is being held at the EPRI Winter Advisors Meeting, February 11-13, 2013, in Austin, Texas. Other activities will be announced to members by email.

How to Participate, or For More Information:

The Communications Interest Group web page is at this address: http://smartgrid.epri.com/Comms.aspx

Regular participation in the Communications Interest Group is limited to utility personnel. This limitation is intended to allow a high degree of freedom to share concerns and experiences with an all-peer group. On an as-needed basis, vendors and and others are invited to join meetings to provide the interest group with specific insights, reports on technology status and the like.

Contact Tim Godfrey (tgodfrey@epri.com) to be added to the group.

Smart Grid Enterprise Architect (SGEA) Interest Group

The Smart Grid Enterprise Architecture (SGEA) Interest Group is a forum for utilities to share experiences and best practices, discuss the tools and techniques, and explore research topics for the advancement of utility enterprise architecture as it relates to smart grid planning and implementation. It is one of the Tech Transfer outreach programs of IntelliGrid and is open to members and non-members alike, although at this time it is only open to utility enterprise architects (not vendors or consultants).

Many utilities face challenges as they begin to plan, design, or integrate new capabilities into their information technology (IT) and operational technology (OT) landscapes for supporting smart grid capabilities. It may be difficult to understand how to leverage artifacts such as the National Institute of Standards and Technology (NIST) conceptual model, Gridwise Architecture "stack," the NIST Catalog of Standards or other resources into a comprehensive architecture repository.

The SGEA Interest Group is examining existing resources that can be plugged into a repository that can then be reused by the utility industry. This repository leverages SparxSystems Enterprise Architect, facilitating the import/export of UML to transfer to/from other repositories. As utilities may not use Enterprise Architect, the diagrams, use cases, actors, etc., can be exported from the model in standard UML, and then imported into the utilities architecture tool of choice.

The work also leverages The Open Group Architecture Framework (TOGAF) for development and categorization of artifacts. However, while TOGAF's architecture development method (ADM) covers several phases, the focus will be on the architectural phases and less on the solution, migration, or governance phases. This effort focuses on artifacts that support the architecture vision, business architecture, information systems architecture (which includes data and application architecture) and technology architecture. Example artifacts may include guiding principles, data models, use cases, application architectures, or links to standards, e.g. NIST catalog. Data models that have already been added to the repository include the Common Information Model (CIM) as well as MultiSpeak™.

The group is soliciting contributions from interested members and there is collaboration around the development of new or existing artifacts. For example, in 2012 the interest group began to develop Distributed Energy Resource Management Systems (DERMS) application architecture diagrams to complement the CIM for DER work. Additionally, as related CIM for DER actors and use case were developed, they were also added to the repository.

The interest group has also heard from enterprise architects at utilities, with DTE Energy presenting at the interest group kick-off meeting about their EA journey, and Snohomish PUD presenting on their EA journey at the September meeting. Additionally, Snohomish contributed artifacts such as their business architecture scorecard, and a guiding principle about "organization first" that complemented the set of existing guiding principles in the repository. As EPRI interest group leader, Dr. Gerald Gray, also leads the SG-Enterprise task force within OpenSG, there is alignment with that effort; e.g. the SG-Enterprise reference architecture was updated by the SG-Enterprise Task Force and upon completion the diagram was added to the repository.

Links to webcasts of previous meetings, and the Enterprise Architecture repository (file extension .EAP) are available at http://smartgrid.epri.com/SGEA.aspx

To Participate and For More Information

The group also maintains a closed (invitation only) LinkedIn group page available at: http://www.linkedin.com/groups?gid=4440381&trk=hb_side_g where polls, discussions, and meeting announcements are posted.

For more information contact Dr. Gerald R. Gray, ggray@epri.com, 865-218-8113.

Geospatial Information Systems (GIS) Interest Group

The GIS Interest Group is a forum for utilities to share experiences, talk about tools and techniques and explore research topics. EPRI provides this forum without charge (EPRI membership is not required to participate) as a service to the industry and to promote the importance of good GIS data.While previously utilities lamented data issues, the need for accurate GISdata has become an imperative with widespread grid modernization efforts and has brought GIS data quality to the forefront of utilities' preoccupations. With the advent of AMI, DMS, and grid modernization, distribution companies can no longer ignore poor data quality. In many cases, utilities are finding that their capital intensive grid modernization investments are not yielding anticipated benefits simply because the utility does not have an adequately accurate representation of the distribution system. In more extreme cases, the safety of employees and the public has been compromised due to misrepresented facilities in the GIS. Utilities need a robust and reliable model from customer to transformer, through protective devices to substation by phase that is accurate and timely.

The GIS Interest Group helps review GIS quality issues, primarily related to:

- Gaps, e.g. certain key data is missing;
- Redundancies with other systems, e.g. data is captured in many systems and it is inconsistent or requires duplicate data entry to update;
- Lack of currency with system "as-built", e.g. untimely work order completion/ backlog;
- Inaccuracies with the field, e.g. GIS has data but does not represent the actual system in the field;
- Inaccurate or unavailable land-base, e.g. varying degrees of accuracy of land-base data based on the source;
- Customer to transformer connectivity by phase is in doubt; and
- GIS model itself allows for "bad" data.

Activities

Several webcasts were conducted in 2012. These webcasts covered data quality issues with GIS and the use of GIS in real-time systems. Links to webcasts of previous meetings are available at: http://www.smartgrid.epri.com/GIS.aspx

Results

The Interest Group participated directly in the production of the 2012 deliverable *Monetizing GIS: The Value of GIS Data Quality for Electric Utilities* (1024303) by participating in the two surveys that were central to the research.

Plans

In 2013, the Group will continue to explore methods of GIS data quality control and quality improvement. The Group will also be central to the 2013 GIS research into the data requirements of various distribution systems and the dependence on GIS. Finally, there will be more presentations on innovative uses of GIS.

How to Participate

The group holds monthly webcasts. To participate, simply contact Dr. John Simmins. The group also maintains a closed (invitation only) LinkedIn group page available here, where polls, discussions, and meeting announcements are posted.

For More Information

For more information, contact Dr. John J. Simmins, jsimmins@epri.com, 865-218-8110.

The GIS Interest Group will explore methods of improving GIS data quality by sharing with each other and participating in EPRI sponsored research.

The Metering and Advanced Metering Infrastructure (AMI) Interest Group is a forum for sharing and discussing issues associated with electricity metering and AMI systems. Topics are identified and prioritized by the participants.

The scope includes:

- Measurement methods and accuracy
- Interference and immunity
- Environmental factors
- Life expectancy and aging
- Reliability
- Interoperability
- Standards
- Test activities and findings

Regular participation in the Metering and AMI Interest Group is limited to utility personnel. This limitation is intended to allow a high degree of freedom to share concerns and experiences with an all-peer group. On an as-needed basis, meter manufacturers, AMI system providers and others are invited to join meetings to provide the interest group with specific insights, technology status, issue resolutions, etc.

Metering and Advanced Metering Infrastructure (AMI) Interest Group

The participants in the Metering and AMI Interest Group represent more than 40 utilities in the U.S. and Europe, each domain experts in the metering field. The forum provides an effective means for utility personnel to meet and work directly together to resolve critical issues. Through the group's activities, participants may be made aware of hidden metering issues and be able to proactively address needs. Unintentional replication of effort may be reduced or avoided by coordinating testing and evaluation activities across many utility laboratories.

In 2012, the interest group discussed and addressed several important issues, including:

- Meter accuracy in the presence of DC currents and DC magnetic fields. This topic carried over from 2011 and included DC current testing conducted in EPRI laboratories as well as DC magnetic field observations from utility laboratories
- Meter sensitivity to low-frequency conducted noise. This issue was first identified in Europe where voltage ripple from residential solar installations was found to be causing reductions in meter registration. This observation led to group discussion and fact-finding, development of new IEC standards, and ongoing laboratory evaluations
- Overheated meters/hot-sockets. With mass meter replacements associated with AMI rollouts, some utilities noted occurrences of overheating meter sockets. The interest group discussed the prevalence of such events, causes, practices relative to socket-jaw lubricants, and possible mitigation strategies.

Looking forward to 2013, the group is continuing to track testing of low-frequency noise immunity as well as hot-socket issues. New discussion topics are raisedby participants on each group call. The discussions and activities provide EPRI with insight into the issues that utilities are currently facing, giving guidance to the research to be conducted in the AMI System and Metering research programs. This interest group meets quarterly, by conference call and webcast, with additional meetings as required. Meetings are generally held at 11:00 AM U.S. Eastern time.

Who Should Participate

- Utility metering personnel, involved in the specification, selection, calibration, testing, certification, and deployment of electricity meters.
- Personnel associated with metering communication systems (AMI) from the perspectives of determining specifications and requirements, establishing performance criteria, protocols, data handling, testing, deployment, management and maintenance.
- Supervisors, managers, and directors responsible for metering departments, meter reading, and AMI systems.

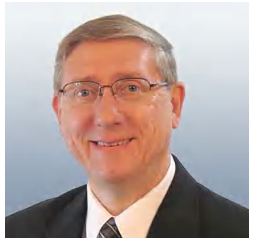
Getting Involved

To participate in this group, or for more information, contact:
Brian Seal, 865-218-8181, bseal@epri.com or
Ashley Eldredge, 650-855-2063, aeldredge@epri.com

IntelliGrid Team Members

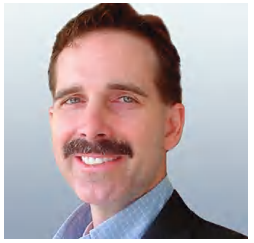
Matt Wakefield is Senior Program Manager at the Electric Power Research Institute (EPRI) managing EPRI's Smart Grid Research Programs. He has over 24 years of energy industry experience with a strong emphasis on applying information and communication technologies for real-time information transfer between control centers, generators, markets, and consumers. He received his BS degree in Technology Management from the University of Maryland University College.

Don Von Dollen is the Program Manager for the IntelliGrid Program. He has been the Chairman of the IEEE PES Intelligent Grid Coordinating Committee and a Peer Reviewer for the DOE GridWise Program. In 2009, he led a team of industry experts to develop a roadmap for the development and harmonization of Smart Grid interoperability standards for NIST. He has worked with several utilities on company-specific Smart Grid Roadmaps.



Paul Myrda is a Technical Executive with EPRI and manages the IntelliGrid transmission program and coordinates Smarter Transmission System activity. Paul represents EPRI on advisory boards for the Power Systems Engineering and Research Council, Trustworthy Cyber Infrastructure for the Power Grid Center and North American Synchrophasor Initiative. He has an MBA from Kellogg; MSEE and BSEE from Illinois Institute of Technology; he is a licensed professional engineer, and member of IEEE and CIGRE.

John Simmins is Senior Project Manager at EPRI and manages several Smart Grid Demonstration Projects as well as the IntelliGrid distribution program. John is involved in the UCA, IEC TC57-WG 14, OpenSG and holds several positions within the NIST SGIP effort. He has a BS and a PhD in engineering and is a member of IEEE, GITA and the Project Management Institute.



Brian Seal is a Technical Executive with EPRI. His research is centered on utility communication systems. Recent focus areas include metering, demand response, and distributed resources. Prior to joining EPRI, Brian worked for Cellnet+Hunt (now Landis+Gyr) and Schlumberger (now Itron) where he directed product design and development. He holds several patents related to advanced metering and utility communication systems. He received BSEE and MSEE degrees from Georgia Tech.

Pat Brown is a Senior Project Manager with EPRI, and has spent over 25 years supporting utility control center applications. Her focus is industry standards, including the Common Information Model (CIM), in the deployment of data sharing solutions for transmission. Pat serves as an industry expert on IEC TC57 Working Group 13 (CIM for Transmission) and as the EPRI liaison to UCA International. She has a BS in Architecture from the University of Michigan and is a certified Project Management Professional.

Tim Godfrey is a Senior Project Manager with EPRI. Tim directs projects involving wired and wireless communications and he has worked in the area of wireless networking and communications for more than 20 years. Tim has 16 granted and 9 pending patents. He is active in standards development, serving as vice-chair of the IEEE 802.24 Smart Grid Technical Advisory Group, and chair of the IEEE 802.16n (GRIDMAN) task group. He holds a BSEE from the University of Kansas.

Gerald Gray, Ph.D. is a Senior Project Manager with EPRI and specializes in enterprise architecture and utility enterprise integration. Gerald participates in the development of numerous industry standards such as IEC CIM, MultiSpeak, SAE, and OASIS EMIX and Energy-Interop. He was a contributing author to OpenAMI-ENT, OpenADE, OpenADR, and OpenHAN. He has a BS in Management/CIS from Park University, a Masters degree in MIS from the University of Montana and a PhD in Organization and Management from Capella University.

Gary Aumaugher is a Senior Project Engineer with EPRI. Gary joined EPRI in 2009 to assist in smart grid communication development, testing, and analysis. He has led efforts on smart inverter communication using DNP3 and SEP2, evaluated uses for AMI data within the Volt/VAR arena, evaluated inverter control strategies for PV and storage, and developed PV data collection systems used to track solar variation.

Chuck Thomas is a Senior Project Engineer/Scientist with EPRI. He has contributed to research and services that touch customers in all energy sectors. Currently, Chuck is contributing to research efforts designed to evaluate and advance smart grid enabling communication technologies such as OpenADR, which defines an open information model to automate demand response. He is also working on a modular interface standard to enable ubiquitous residential demand response.

Scott Sternfeld is a licensed professional engineer who serves as a Project Manager within the EPRI Security and IntelliGrid programs. His background includes mechanical engineering, power system controls, and cyber security. He is responsible for the Smart Grid Substation Labs located in Knoxville, TN; Charlotte, NC; and Lenox, MA. His current work includes synchrophasor testing, data integration, and substation security solutions. He has a BSME from the University of Illinois and is a member of IEEE and CIGRE.

Ashley Eldredge is a Technical Assistant II with EPRI. She has supported IntelliGrid and Cyber Security Programs within EPRI's Power Delivery and Utilization group for 5 years. Ashley is responsible for member communications, tracking deliverables, contracts, event coordination, government projects and providing administrative support.

Summary of Deliverables

161A Deliverables

2012

Standards and Technology Adoption Case Study: Inter-Control Center Protocol (ICCP/TASE.2)
Product ID (1024294)

Smart Grid Interoperability Standards Tracking and Analysis
Product ID (1025471)

Smart Grid Roadmap Guidebook
Product ID (1025470)

Communications Intelligencer Newsletter
Product ID (1024295), (1025757), (1025756)

2011

A Utility Standards and Technology Adoption Roadmap
Product ID (1023041)

California Utility Vision and Roadmap for the Smart Grid of 2020
Product ID (1022220)

Coordination and Collaboration in the Electric Sector
Product ID (1022497)
(links to updated version)

Proposed Comprehensive Cyber Security Legislation, May 2011
Product ID (1024549)

Technical Analysis of the Federal Energy Regulatory Commission Order on Smart Grid Interoperability Standards
Product ID (1024594)

Technical Analysis of the Federal Energy Regulatory Commission Technical Conference on Smart Grid Interoperability Standards and the Responses to Questions Asked by the Commission
Product ID (1024547)

Technical Analysis of the "International Strategy for Cyberspace" Issued by the Office of the President of the United States in May 2011
Product ID (1024548)

2010

Achieving N-2 Contingency from a Virtual Power Plant (VPP): A Consolidated Edison Case Study
Product ID (1021631)

AEP Interoperability Test Plan, Vol 1: In Support of the AEP Ohio GridSmart℠ Demonstration Project, and Volume 2: Use Cases
Product ID (1021464)

A Framework for Assessing the Net Benefits of Home Area Networks to Enable Demand Response
Product ID (1021628)

Harmonizing the International Electro-technical Commission Common Information Model (CIM) and 61850
Product ID (1020098)

Implementation of International Electrotechnical Commission (IEC) 61850: A Coherent Approach to Substation Automation and the Smart Grid
Product ID (1021609)

Smart Metering: Lessons Learned
Product ID (1021627)

Wireless Field Area Network Spectrum Assessment
Product ID (1022421)

2008

2008 Update of the Profiling and Mapping of Intelligent Grid R&D Programs
Product ID (1016931)

Characterizing and Quantifying the Societal Benefits Attributable to Smart Metering Investments
Product ID (1017006)

Integrating New and Emerging Technologies into the California Smart Grid Infrastructure: A Report on a Smart Grid for California
Product ID (1018191)

2007

Scoping Study for Identifying the Need for New Tools for the Planning of Transmission and Distribution Systems
Product ID (1015285)

161B Deliverables

2012

IEC 61850 Implementation
Product ID (1024299)

Synchrophasor Communication Infrastructure
Product ID (1024298)

Standards Based Integration Specification
Product ID (1024297)

Network Model Manager and Repository
Product ID (1024296)

Transition from Legacy Protocols to IEC 61850
Product ID (1024300)

2011

CIM Harmonization and Implementation Examples
Product ID (1021943)

IEC 61850 Implementation and Transition
Product ID (1021759)

Synchrophasor Communication Infrastructure
Product ID (1021758)

The Data Heap Specification
Product ID (1021757)

2010

Implementation Strategy Assessment: Smart Transmission System Implementation Strategies
Product ID (1020099)

Information Sharing Across Transmission and Distribution Operations: Coordinated Management of Distributed Resources
Product ID (1020100)

2009

EPRI CIM and 61850 Harmonization 2009 Project Report
Product ID (1017851)

Reference Manual for Exchanging Standard Power System Dynamic Models
Product ID (1020200)

The Communication Networks Guidebook for Intelligent Transmission Systems
Product ID (1017848)

2008

Distribution Fast Simulation and Modeling Technical Update: First Sensor Location Strategy for the Enhancement of Distribution State Estimation
Product ID (1013831)

IntelliGrid Transmission Architecture Development
Product ID (1013833)

Phasor Measurement Unit Deployment, Networking, Data Collection and Applications Utilizing the IntelliGrid Architecture
Product ID (1016114)

Technical Architecture for Transmission Operations and Protection: Envisioning the Transmission Smart Grid
Product ID (1016055)

Transmission Fast Simulation and Modeling: Application at PSE-Operator in Poland
Product ID (1016843)

2007

Transmission Fast Simulation and Modeling Tech Update: Monitoring and Voltage Security Prediction in the Northern Area of the Polish Power Grid
Product ID (1014782)

Transmission Fast Simulation and Modeling Tech Update: Telecommunications Infrastructure Assessment for Monitoring and Voltage Security Prediction in the Northern Area of the Polish Power Grid
Product ID (1014781)

161C Deliverables

2012

Application of CIM in Distribution Enterprise Applications
Product ID (1024302)

GIS Data Improvement
Product ID (1024303)

Field Force Data Visualization: A Mobile Integrated Data Access Platform
Product ID (1024304)

Field Force Data Visualization
Product ID (1023399)

2011

Advanced Smart Grid Communications – Research Reports
Product ID (1023051)

Advanced Smart Grid Communications – Simulation Tools
Product ID (1021716)

CIM Conformity and Interoperability Test Procedure Development
Product ID (1024448)

CIM Meter Outage Interoperability Test Procedure – ECITP 2.05
Product ID (1024445)

CIM Meter Disconnect/Reconnect Interoperability Test Procedure – ECITP 2.09
Product ID (1024447)

CIM Meter Tamper Detection Interoperability Test Procedure – ECITP 2.07
Product ID (1024446)

CIM – MultiSpeak Harmonization Report
Product ID (1024443)
(links to updated version)

CIM On Demand Meter Read Interoperability Test Procedure – ECITP 2.03
Product ID (1024444)

CIM Primer
Product ID (1024449)

CIM Scheduled Meter Read Interoperability Test Procedure – ECITP 2.03
Product ID (1024450)

Guidebook: Communications Infrastructure for Distribution Applications and Automation
Product ID (1020101)

Results of OpenDSS CIM Interoperability Testing: Paris Interoperability Test, March 2011
Product ID (1023218)

Smart Grid Communications Intelligencer – Fall 2011
Product ID (1024654)

Summary of Deliverables

2010
Development of the Common Information Model for Distribution and A Survey of Adoption
Product ID (1020103)

Distributed Energy Resources and Management of Future Distribution
Product ID (1020832)

Distribution Operations Guide to Enterprise Service Bus Suites
Product ID (1020102)

Smart Meter Information Interoperability Test (61968 Part 9)
Product ID (1017855)
(links to updated version)

The Communication Networks Guidebook for Intelligent Distribution Systems
Product ID (1020894)

2009
CIM for Distribution Interoperability Testing Preparation
Product ID (1018778)

Distribution Fast Simulation and Modeling
Product ID (1016059)

Enterprise Service Bus Implementation Profile Integration Using IEC 61968
Product ID (1018795)

2008
Assessment of the Case for IEC 61850 in Advanced Distribution Automation
Product ID (1016838)

IntelliGrid Architecture Development for Distribution Systems Requirements and Device Information Models for Integrated Advanced Distribution Automation Applications
Product ID (1013843)

The Common Information Model for Distribution
Product ID (1016058)

2007
Distribution Fast Simulation and Modeling: Requirements for a Mockup of a Situation Awareness Based on a Distribution State Estimator
Product ID (1013840)

Distribution Fast Simulation and Modeling State-of-the-Art, Prototype and Performance Analysis of Distribution State Estimator
Product ID (1014693)

Fast Simulation and Modeling: Roadmap
Product ID (1016259)

161D Deliverables

2012
Scoping Study for Secure and Cost-Effective Sub-Metering
Product ID (1024305)

Open Advanced Metering Infrastructure (AMI) Systems: Leveraging Customer Broadband for Grid Integration
Product ID (1024306)

Assessment of Smart Energy Support of Residential Distributed Generation and Storage
Product ID (1024307)

Generation and Storage Standard Interfaces for Smart Building Integration
Product ID (1024308)

Processing of Interval Meter Data to Determine Demand Response Participation
Product ID (1025415)

Standard Interfaces for Smart Building Integration
Product ID (1026509)

2011
Advanced Security Acceleration Project for the Smart Grid 2010
Product ID (1022395)

HAN Performance Metrics and Monitoring, Phase 3
Product ID (1021946)

IntelliGrid Security Lessons Learned from Existing Internet Protocol Based Technologies in Shared Networks: Metering, Network Operations, and Mobility
Product ID (1023052)

Metering, Network, in the Field Operations, and Information System (MENOFIS) Platform
Product ID (1021944)

Customer Communications Architecture Development: Metrics for Standards and Product Assessment
Product ID (1021945)

2010
Customer Communications Architecture Development: Metrics for Standards and Product Assessment
Product ID (1020105)

Home Area Network Performance Metrics and Monitoring - Phase 2: Test Tools Guide for PET, WET, and Central Site Programs
Product ID (1020106)

Home Area Network Performance and Reliability: Emerging Standards, Prototype Software
Product ID (1018982)

Home Area Network Performance and Reliability Smart Meter-to-HAN Interface
Product ID (1018986)

2009
Advanced Metering Infrastructure (AMI)/ Home Area Network (HAN) Economic Benefits Analysis for Utilities
Product ID (1018985)

Advanced Metering Infrastructure (AMI) Roadmap for the Tennessee Valley
Product ID (1019330)

Benefits of Utilizing Advanced Metering Provided Information Support and Control Capabilities in Distribution Automation Applications
Product ID (1018984)

HomePlug AV Specification Assessment
Product ID (1018983)

IEEE 802.15.4 Communication Protocol Field Test Results and Analysis
Product ID (1020440)

ZigBee-Enabled Home Area Network System Deployment Test Parameter Determination and Evaluation
Product ID (1016839)

ZigBee Stack, ZigBee PRO Profile, and Smart Energy Profile Technical Assessments
Product ID (1019625)

2008
AMI and Demand Response Evaluator, Version 2.0
Product ID (1018294)

A Review of ANSI C12.22
Product ID (1018530)

Residential Common Communications Language Assessment and Roadmap for Energy Services and Demand Response
Product ID (1013854)

161E Deliverables

2012
Evaluation of Secure Authentication Supplement to the Distribution Network Protocol, v.3
Product ID (1025671)

2011
Best Practices in the Control Center: Securing the Substation End of the Control System
Product ID (1021948)

Coordination and Collaboration Quarterly Newsletter – May 2011
Product ID (1023162)

Coordination and Collaboration Quarterly Newsletter — September 2011
Product ID (1023163)

Coordination and Collaboration Quarterly Newsletter — December 2011
Product ID (1023164)

SEP 2.0 Security Interoperability Testing
Product ID (1023055)

DNP Security Interoperability Testing
Product ID (1023054)

Lemnos Interoperability Testing
Product ID (1023053)

2010
Advanced Metering Infrastructure Security Management Guidelines
Product ID (1020112)

Best Practices in the Control Center: Sustaining Control System Security during Emergency Operations
Product ID (1020108)

Distribution System Cyber Security Architecture: Guidelines for Applying Security Measures to Meet Distribution Cyber Security Requirements
Product ID (1020110)

Lemnos Interoperable Security: Demonstration and Evaluation
Product ID (1017865)

Secure Distributed Network Protocol 3 Interoperability
Product ID (1020109)

Secure Inter Control Center Protocol Digital Certificate Management
Product ID (1020107)

2009
AMI Risk Assessment and Security Requirements
Product ID (1017866)

Advanced Metering Infrastructure (AMI) Security Acceleration Project – Phase 1
Product ID (1020235)
(links to updated version)

Advanced Metering Infrastructure (AMI) System Security Requirements
Product ID (1020601)

Best Practices in the Control Center
Product ID (1017864)

Best Practices Guide to Securing Wireless Substation Applications
Product ID (1016066)

Demonstration of Wireless Technology Security in Substation Network Architecture
Product ID (1018454)

HAN System Security Requirements
Product ID (1020600)

2008
Secure ICCP (TASE.2) Digital Certificate Management
Product ID (1018285)

Wireless Connectivity for Electric Substations
Product ID (1016145)

2007
Communications Security Analysis for Control System Networks: Preliminary Report
Product ID (1013609)

NERC Cyber Security Standards (CSS) Electronic and Physical Perimeter Considerations
Product ID (1013812)

PowerSec Generic Security Analysis Report
Product ID (1015531)

The Electric Power Research Institute, Inc.
(EPRI, www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, affordability, health, safety and the environment. EPRI also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI's members represent approximately 90 percent of the electricity generated and delivered in the United States, and international participation extends to more than 30 countries. EPRI's principal offices and laboratories are located in Palo Alto, Calif.; Charlotte, N.C.; Knoxville, Tenn.; and Lenox, Mass.

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