Smarter Transmission

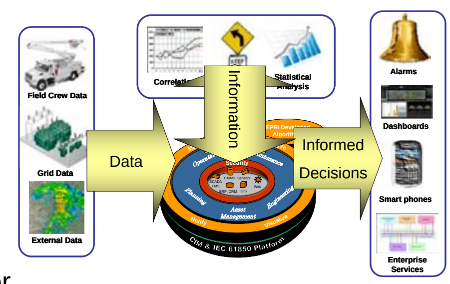
An EPRI Progress Report **August 2011**

ABOUT THE NEWSLETTER

This is the second edition of the "Smarter Transmission" newsletter. I want to thank those of you that have provided feedback to the inaugural issue and encourage others to provide feedback. In this edition we provide an update on an interesting project that may set the stage for an "electric utility" application store, a new strategic technology initiative on Grid Transformation, Costs and Benefits of the Smart Grid, information on a new DOE funded PSERC effort called "The Future Grid to Enable Sustainable Energy Systems." We also have the usual information related to Recent and Upcoming Events and a feature article on "ASSET MANAGEMENT and the SMART GRID" which I hope gets you thinking about how to leverage all the existing and future EPRI Research at your disposal to benefit your Smarter Transmission System. As always I appreciate your comments, suggestions, and contributions. Paul Myrda - Smarter Transmission Coordinator. pmyrda@epri.com

PROJECT UPDATE

Control Center Display of Asset Health Information – EPRI Supplemental Project



A new supplemental project entitled "Control Center Display of Asset Health Information" is getting started that will focus on enhancing operations staff awareness of asset health. The project will be using real asset condition information from participating utilities that will be sent to EPRI's Smart Grid Substations Lab where it will be mapped into IEC61850 and the CIM standards (IEC61968 & 61970) as appropriate. It will then be analyzed using existing asset health algorithms and combined with other relevant information into an information display suitable for control center operations. This project will also investigate the feasibility of transferring the result to a tablet environment so that the display can be portable within the control center. One of the goals of this project is to explore the development of an "electric utility" application store. Keep an eye out for further updates in this newsletter.

USEFUL INFORMATION

Recent Publications

"Needed: A Grid Operating System to Facilitate Grid Transformation" – (EPRI_Report_1023223)

In the last newsletter we mentioned that another white paper was in the final stages of publication related to Grid Transformation and it was released in July 2011. The paper peers into the future and identifies four core research areas including: seamless geospatial three phase power system model requirements concept, seamless power system analytics requirements development, integrated energy management system coupled with the above analytics and grid measurements and also a setting-less protection method. The next step in the process is to hold a workshop where various thought leaders from utilities, vendors and academia will work through the issues to help better define the challenges, needs, gaps, technologies and programs needed to achieve the future vision. The workshop will be held on November 1-2, 2011 at Argonne National Lab near Chicago, IL (additional information below)

Estimating the Costs and Benefits of the Smart Grid - White Paper – (EPRI_Report_1022519)

A broad assessment of the costs and benefits to modernize the U.S. electricity system and deploy what has become known as "the smart grid." Factoring a wide range of new technologies, applications and consumer benefits the investment needed to implement a fully functional smart grid ranges from $338 billion to $476 billion and can result in benefits between $1.3 trillion and $2 trillion.

The estimate reflects new technologies related to the grid, information, and communication technologies; market structures; demands of an increasingly digital society; more widespread deployment of renewable power production and its integration into the grid; expansion and maintenance of existing infrastructure; and technologies and systems to address grid security.

The report balances costs with benefits, which include:

- More reliable power delivery and quality, with fewer and briefer outages;
- Enhanced cyber security and safety with a grid that monitors itself and detects and responds to security and safety situations;
- A more efficient grid, with reduced energy losses and a greater capacity to manage peak demand, lessening the need for new generation;
- Environmental and conservation benefits, better support for renewable energy and electric-drive vehicles; and,
- Potentially lower costs for customers through greater pricing choices and access to energy information.

The analysis updates EPRI's 2004 EPRI assessment, which estimated the cost of implementing a smart grid at $165 billion. The updated analysis assumes steady deployment of smart grid technologies beginning in 2010 and continuing through 2030.

Transformer Overloading and Assessment of Loss-of-Life for Liquid-Filled Transformers-PSERC Report

This is the final project report for research on Transformer Overloading and Assessment of Loss-of-Life for Liquid-Filled Transformers in electric power systems. This subject has been addressed by many researchers and standards over the years, however, still with no clear consensus. There are several areas where the addition of more advanced sensor and monitoring technology can improve the remaining life expectancy estimations. This research developed an optimization methodology to minimize the cost and select the proper transformer size for new applications and to optimize the replacement of transformer for an existing system (retrofit applications). It is anticipated that the method described here will help utilities in making decisions to minimize revenue requirements of the transformer over the long run to attain overall economic efficiency.

Recent Events

IEC 61850 Training and Workshop a Success!

EPRIs Substations team hosted an IEC 61850 training and workshop in New York, NY on August 3-5, 2011. There were 14 companies and 38 attendees at the training session. The workshop addressed the "real world" issues and challenges in field deployment of IEC 61850 standard. National Grid, Northeast Utilities, Con Edison, Xcel Energy, NYPA and Hydro One presented on a variety of topics from architecture, adoption, protection and control, upgrades and maintenance considerations. A future report will be published capturing the highlights of the workshop.

Technology Innovation

The Future Grid to Enable Sustainable Energy Systems

The Power Systems Energy Research Center (PSERC) has been awarded a $5.5 million grant from the Department of Energy to investigate requirements for a systematic transformation of today's electric grid. The future grid needs to support high penetrations of highly variable distributed energy resources mixed with large central generation sources, energy storage, and responsive users equipped with embedded intelligence and automation. These sustainable energy systems require more than improvements to the existing system; they require transformative changes in planning and operating electric power systems. An overview of the Future Grid Initiative is available at: http://www.pserc.wisc.edu/research/FutureGrid.aspx

Upcoming Events

IEEE Power System Relaying Committee - PSRC

The IEEE Power System Relaying Committee (PSRC) will meet in Minneapolis, MN on September 12-15, 2011. The PSRC has a number of sessions that are dealing with a number of transmission related smart grid standards activities. Some of these topics are IEEE/IEC Phasor Measurement standard, The Role of Protective Relaying in the Smart Grid, IEEE 1588 Profile for Power System Applications (PC37.238), Synchrophasor Data Transfer for Power Systems, Considerations for “Aurora” Protection, Cyber Security for Protection Related Data Files C37.118 Power Systems Synchrophasors Standard Harmonization with IEC 61850 and Guide for Synchronization, Calibration, Testing, and Installation of Phasor Measurement Units. Many of these activities are driven by the NIST Priority Action Plans activity. http://pes-psrc.org/

GridWeek 2011

GridWeek 2011: “Defining Smart Grid’s Future, Today” will be held in Washington, DC September 12-15, 2011. GridWeek - Defining the Agenda for Smart Grid Advancement: Strategies for energy business, policy and solutions. Globally recognized as the must-attend Smart Grid gathering, GridWeek is the only event that attracts the complete diversity of global Smart Grid stakeholders to explore Smart Grid’s impact on the economy, utility infrastructure, consumers and the environment, while answering the industry’s most pressing questions. http://gridweek.com/2011/#home

North American SynchroPhasor Initiative - NASPI

The next North American SynchroPhasor Initiative - Working Group Meeting is scheduled for October 12-13, 2011, in San Francisco, CA. The meeting theme is Recovery Act Project Update and proposed topic areas are: Smart Grid Investment Grant presentations, Lessons learned from the field, Synchrophasor system testing and PMU Signal Registry.
https://www.naspi.org/Site/Module/Meeting/Reports/SubReports/workgroup.aspx

Grid Transformation Workshop 2011

In this workshop we will begin the process of detailing out the features and benefits of each of four key research areas. They are: geospatial three phase power system model, seamless power system analytics, integrated energy management system coupled with the above analytics and grid model and simplified (setting-less) protection method. While there will be four distinct workshop sessions the sessions are inter-related and will be organized to maximize the synergies between topics. The purpose of the workshops is to further expand the details of the concept and to identify further the research needs of the topic.

Registration for this event is by invitation only. If you have not received an invitation and would like to attend, please contact Paul Myrda (pmyrda@epri.com or 708-479-5543). Details Tuesday, November 1, 2011 7:30 AM - Wednesday, November 2, 2011 5:00 PM at Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, Illinois, USA

GridWeek 2011: “Defining Smart Grid’s Future, Today” will be held in Washington, DC September 12-15, 2011. GridWeek - Defining the Agenda for Smart Grid Advancement: Strategies for energy business, policy

Innovative Smart Grid Technologies (ISGT 2012)

The third IEEE PES Conference on Innovative Smart Grid Technologies (ISGT 2012), sponsored by the IEEE Power & Energy Society (PES), will be held January 16-19, 2012 at the Washington Marriott Wardman Park in the District of Columbia, USA. The Conference will be a forum for the participants to discuss state-of-the-art innovations in smart grid technologies. The Conference will feature plenary sessions, technical papers, and tutorials by international experts on smart grid applications. http://ewh.ieee.org/conf/isgt/2012/

FEATURE ARTICLE

ASSET MANAGEMENT and the SMART GRID – *Related Report 1017828*

Electric power delivery is under pressure from several business and technical directions. In the United States, recent legislation is becoming a driving force for the industry. The Energy Independence and Security Act (EISA) of 2007 and also The American Recovery and Reinvestment Act (ARRA) of 2009 have mobilized significant efforts to modernize the grid. One key aspect of the ARRA is the funding of Smart Grid Demonstration Projects. These projects will significantly enable new learning about the smart grid functionality and its ultimate benefits. The projects are demonstrating the build out of communication and information infrastructures that will enable integration of widespread distributed resources. The challenges of this integration must be met while preserving the reliability and availability of the existing system that has been in operation for several decades.

Electric transmission systems form a critical power transport backbone that is seeing increasing demands for integration of new and more diverse power generation from a variety of sources, including variable sources like wind generation. Furthermore, several new operating strategies are envisioned including operating closer to performance limits, and engaging customers in the provision of ancillary services. All of these new operating paradigms will require the careful application of communications, networks, and embedded computing in what can be broadly described as "distributed computing".

The use of more sophisticated control algorithms and technologies such as expert systems, inference engines, knowledge bases and other advanced processing approaches have been studied for over twenty years. In trying to move forward with these ideas in power delivery systems, the field has typically run into implementation challenges due to the high cost of communications systems. There were no cost effective mechanisms established to effectively integrate field equipment to enable the widespread use of advanced control algorithms. With the smart grid deployment, communications infrastructures are being designed based on open standards which will allow more widespread integration with field equipment for asset management applications.

Current State

Today's transmission systems have a fair amount of intelligence. Energy management systems (EMS) employ advanced applications such as state estimation, contingency analysis, and voltage stability for continuous management of generation and power flow on the grid. These applications are based on data collection from substations throughout the grid with a scan rate ranging from 2-4 seconds.

Besides the EMS system, there is other information available to the operator. Some of these are dynamic line ratings, synchrophasor data and variety of condition monitoring information. The majority of this information tends to reside outside the EMS and may not be well integrated into the overall situational awareness capabilities in the control center.

Much of the condition monitoring information is implemented within stand alone systems that monitor transformer conditions or circuit breaker conditions. The goal of the smart grid is to make monitoring information more generally available to a wide range of applications which would include a broader range of asset management functions. Data historians are examples of data repositories that provide the infrastructure for this objective.

Benefit of Smart Grid

The NIST Interoperability Framework (Related reports 1020342 and 1021423)provides extensive references to a number of standards that are suggested to be used as the foundation for the smart grid. Most if not all of these standards are designed to have interoperability and self description as key elements of their make up. The interoperability feature minimizes the work effort to interface applications and data between domains. The self description feature further minimizes the labour component by automatically describing a given data element. It also eliminates many of the human errors associated with typing and labelling data points since the labels get derived from predefined objects.

Sensor Deployment

Sensors and actuators in the smart grid are fundamental elements required for successful operation of the grid. It is through these devices that the actual power system's reaction to various inputs and outputs is measured. As in classic control systems, it is through sensors that vital information about a variety of conditions is received. The sensors convert voltage, current, phase angle, position status and other data into manageable signals that are either analog or digital in nature.

Today, these sensor signals are usually sent to a centralized operations center for a geographic region. At the operations center various control computers process this sensor data into information and control signals. Some of the information is routed to displays in the control center for system operator to use in the constant monitoring and management of the grid. The information is also routed to generators to provide the continuous balancing of load and generation and other automatic functions. The system is also capable of responding to manual inputs from system operators for manual actions such as energizing and de-energizing lines for maintenance.

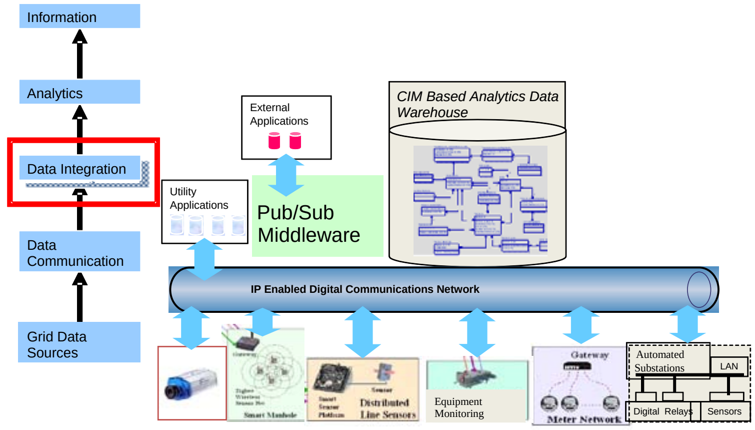
In the power delivery smart grid, sensors will increase in both type and quantity. In fact, over the last 10-15 years, a number of new commercially produced sensors have been introduced by suppliers. These have included transformer monitors, circuit breaker monitors, infrared cameras and others. Also, EPRI has been very active in the development and commercialization of a whole host of sensors for not only typical substation assets but also for transmission lines. These include sensors like the corona camera, sag-o-meter, partial discharge, and acoustic sensor. While all of these sensors provide useful information to the utility operators and managers, they have been difficult to apply due to the lack of wide area, high bandwidth communications out to the field assets. As a result, many of these remote sensors have been limited to periodic data collection, local controls that are not integrated with the overall grid management and asset management functions, and specialized, proprietary communication systems.

One prevalent sensor at every utility is the microprocessor relay. Each of these relays contains within it a significant number of data values that go beyond what is necessary for protection. Included in many of these devices are digital fault records, sequence of event recorders, calculation of I^2t, synchrophasor measurement, breaker contact status and timing, etc. System wide communications infrastructure and standard interfaces for collecting and managing this information will make this valuable data source available to a wide range of applications. A simple example - by accumulating the I^2t value for each circuit breaker over time an algorithm can trigger maintenance of the breaker at a prescribed value that would be indicative of contact wearing. Also, by monitoring the contact timing values one could identify breakers that operated slowly and once again perform maintenance. Simple targeted maintenance can prevent costly device failures and also minimize costs by maximizing the value of the maintenance efforts.

The influx of sensors into the electric utility marketplace has been extensive (including the installed base of microprocessor based relays). The limitation to fully utilize this data for both operations and asset management has been limited bandwidth connecting the field assets to the utility enterprise and lack of standards for sharing and managing the data.

Data Integration

The figure to the right illustrates the general concept of utilizing the smart grid to enable asset management functions. Grid data sources are enabled by a widespread communication network. Standards for data integration are based on the IEC Common Information Model so that the data can be shared by many applications across an enterprise service bus. New analytics will process and evaluate this information to optimize the performance and maintenance of assets throughout the grid.



CONCLUSION

Asset management and the smart grid will be a powerful tool for electric utility companies in many ways. It is one of the five fundamental technologies that will drive the Smart Grid, according to the US Department of Energy (along with integrated communications, sensing and measurement, advanced control methods and improved interfaces with decision support).

Asset management functions are made possible through the implementation of a Smart Grid Conceptual Model and architecture that facilitates interconnection within and between power system domains with standard interfaces that facilitate interoperability. Asset management functions primarily cut across the Operations, Transmission and Distribution domains of the Conceptual Model. Asset management functions will take advantage of widespread sensors that are integrated with operational functions in each of the domains but can be used for a wide variety of functions even across domains through interoperability standards like the Common Information Model (CIM). More information and current EPRI activity in this area can found at the **Infrastructure for Intelligent Transmission Systems**

Future research in asset management applications within the smart grid should take place in two areas. The first should be with respect to specific assets, such as transformers, circuit breakers, etc. These research efforts should analyze the data sources available associated with these assets and look for ways to tap into the data for more comprehensive diagnostics, performance assessment, lifetime estimation, maintenance optimization, and replacement strategies. Upcoming activity will be part of a 2012 supplemental project (**Using Standards to Disperse Field Data Across The Enterprise**) The other area of future work will need to be in enhancing the computational capabilities to deal with the large volumes of asset specific data and developing algorithms to adequately interpret the data and turn it into actionable information.

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