Protecting Investments in Advanced Metering Infrastructure Using IntelliGrid® Architecture

Advanced electricity meters with two-way communications, also known as advanced metering infrastructure (AMI) are part of the foundation of the intelligent grid, or IntelliGrid®. The automated and programmable functions of AMI can reduce costs for numerous utility functions and support the increasingly important goals of providing customers with time-differentiated pricing options, and real-time feedback on energy use.

AMI represents a major investment on the part of utilities. To help ensure that system equipment and software is easily upgraded as technology and the power grid evolve—and thus ensure that utilities receive maximum return on their investments—the EPRI IntelliGrid® Architecture is being applied to AMI deployments.

Created by a consortium of utilities, public agencies, and vendors, IntelliGrid Architecture recommends standards along with well-documented processes for designing and deploying intelligent systems, including AMI. It is being applied by utilities from California to Poland including Southern California Edison and TXU Electric Delivery, which are featured on pages 4-5.

The automated and programmable functions of advanced metering infrastructure enable utilities to reduce costs for operations such as meter reading, load profiling, theft detection, outage detection, billing and other operations. AMI also supports demand response and energy management. Energy service providers can send dynamic price signals and energy-use data to customers, who, in response, can manage their energy consumption and fuel bills.

For example:

In 2006, Hydro One in Ontario, Canada found that residential customers reduced energy usage by more than 6% in response to having a real-time feedback device in their households that showed energy use, cost, and CO_2 emissions.

A 2001 estimate by the United Kingdom's Department of Trade and Industry Smart Metering Working Group predicted results of AMI that are in keeping with the tests by Hydro One. The UK group estimated that even fairly basic advanced metering technology was likely to reduce domestic energy consumption by between 5-10% and cut the country's carbon dioxide emissions by around 2.5 million tons a year.

Test results in the U.S. show energy and demand savings from AMI as well. In the California Statewide Pricing Pilot, for example, enabling technology such as AMI and smart thermostats made a significant impact on demand response. Customer response varied by rate, customer class, and climate, but in one 2-year test with residential customers, consumers reduced energy use during peak periods (2:00PM to 7:00PM) by an average of 14% statewide—and by 30% in air conditioned households with automated controls.

Electricity service with AMI is enhanced by levels of automation and information exchange previously unavailable. In fact, AMI represents one of the first opportunities to start building a modern, intelligent electricity grid, or IntelliGrid®.

The Status of AMI

Since advanced metering infrastructure can streamline utility operations and provide customers with new rate options and information about electricity service never before attainable, it has considerable benefit and appeal. However, it also has high costs. For example, in Northern California, Pacific Gas & Electric's Smart Meter™ plan will cost $1.7 billon for 9.3 million devices serving 5.1 million electric and 4.2 million gas customers. Southern California Edison's AMI deployment is estimated to be $1.5 billion for its 4.6 million customers. The need for such large investments has been a significant barrier to date, but the business case is changing, at least in some areas, largely in response to a new regulatory and policy environment.

AMI will be deployed by California investor-owned utilities in accordance with state requirements for AMI, promulgated by the California Public Utilities Commission. The State of California's energy action plan specifies that energy efficiency and demand response are first in the "loading order" as a means to increase the state's energy needs, and both are enabled by AMI. For more information, see http://www.cpuc.ca.gov.

Regulators and governing bodies in states other than California are paying increased attention to AMI for several reasons:

- The benefits of dynamic pricing and demand response for system reliability and cost reduction can be compelling in some regions with capacity constraints and rising peak demand.

California is serving as a model for deployment elsewhere as are several other locations conducting tests on AMI.

A provision in the U.S. Energy Policy Act of 2005 mandates that state regulatory bodies examine the feasibility of establishing time-based electricity pricing programs and implementation of advanced metering necessary to support such programs.

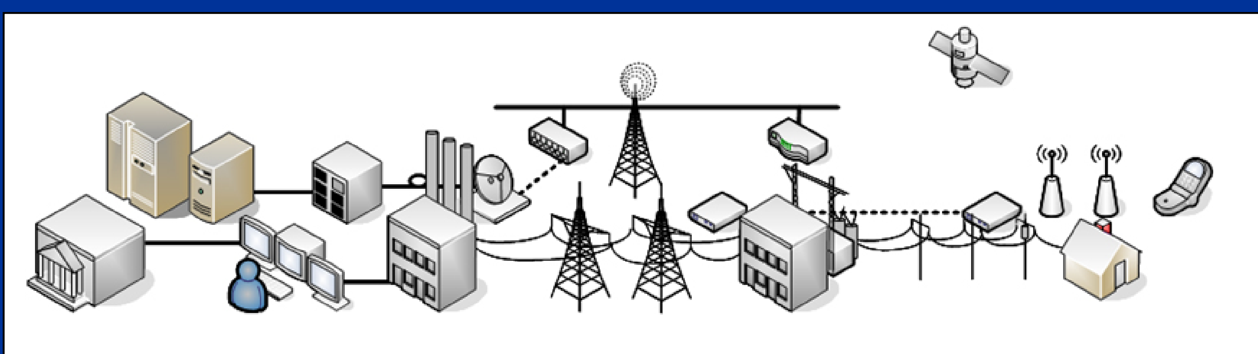
Benefits of AMI

The ability to automate meter readings (AMR) is one of the many benefits of AMI. Although several utilities have invested in systems that can perform automated meter reading, they are not able to perform multiple additional functions utilities want and need. AMR systems typically have only basic, one-way communication. And they usually have only a single "client"—the utility's billing system. AMI, however, provides data to multiple clients, enabling a variety of new and different applications within the utility. On any given day, AMI may enable these scenarios:

- A distribution operator detects an outage in a quarter of the time it used to require
- An energy trader prevents his utility from having to buy expensive power
- A transmission system operator prevents grid instability by shaving off a demand peak

The IntelliGrid®

The intelligent electricity grid, or IntelliGrid®, is EPRI's vision of the "smart" power delivery system. The IntelliGrid® integrates the latest communications technology and computing ability with the power system to provide greater reliability, security, and efficiency, allowing growth of services while keeping costs down.



EPRI's IntelliGrid® Program is developing the concepts, methods, tools, and integration technologies that will enable utilities to deploy intelligent systems today, such as advanced metering infrastructure, The IntelliGrid® Architecture can help companies meet immediate business needs, while also laying the foundation for a smart electricity grid that will meet future needs.

- An account manager prevents a contract dispute by detecting power quality problems in a neighborhood with many critical customers
- A customer service agent helps a caller quickly resolve a billing question by reading her meter while on the phone with the customer
- A distribution engineer saves costs by reducing line losses
- A third-party energy aggregator sells reactive power from his customers' photovoltaic arrays so that the utility can more readily balance VARs and maintain appropriate voltage in the system
- A network planner selects an optimal size for a substation transformer in a new neighborhood based on load profiles in nearby areas
- AMI represents a key component of a smart power delivery system that streamlines processes, reduces costs, avoids problems, and opens market opportunities. But AMI requires a major investment: one that utilities cannot afford to waste as they change out technology, make grid improvements, and upgrade communications systems.

Why use IntelliGrid® Architecture for AMI Deployment?

EPRI offers an industry-developed set of tools, processes, and best practices collectively known as IntelliGrid® Architecture. Adaptable to individual company needs, and reliant on open, standards-based systems, the IntelliGrid® Architecture makes it possible for utilities to design and deploy an advanced metering infrastructure that can be more easily be integrated into a utility's enterprise systems, outage management, asset management, customer management, and other functions.

An AMI that follows IntelliGrid® principles will be

- More easily integrated with existing and future systems
- Flexible enough to adapt to new uses as they are discovered
- Lower cost in due to the use of standard interfaces that avoid "vendor lock-in"
- Secure and reliable because it was designed with those principles in mind from the start
- Resistant to obsolescence due to changing technologies

What IntelliGrid® Architecture Offers

Utilities can benefit from following and adapting the IntelliGrid® Architecture when implementing AMI systems.

Here's what is available:

- Methods to follow when designing, specifying, procuring, implementing, and integrating an AMI system
- A process for defining applications that best meet an individual utility's business needs
- A process for collecting requirements from all parts of the organization and covering both near-term and long-term needs
- A process for determining the technologies that best meet the identified requirements
- A set of tools to help utilities apply the IntelliGrid® methodology

Characteristics of an AMI system based on IntelliGrid® Architecture

OPEN. An IntelliGrid® AMI has standardized interfaces, permitting access to data provided by equipment from multiple vendors. This reduces costs through competition and avoidance of "vendor lock-in."

SECURE. An IntelliGrid® AMI is able to protect customer data and utility information regardless of the number of clients, the number of equipment vendors, or the number of points of access to the AMI network.

RELIABLE An IntelliGrid® AMI includes redundancy and network management in its design from the beginning, and interacts with outage management and intrusion detection systems to quickly detect the root cause of network problems.

UPGRADEABLE. An IntelliGrid® AMI is based on technology layering so that as new technologies and applications are developed, it can be upgraded without major loss of investment. It includes equipment that can be reprogrammed and reconfigured remotely over the metering network.

A template for collecting requirements:

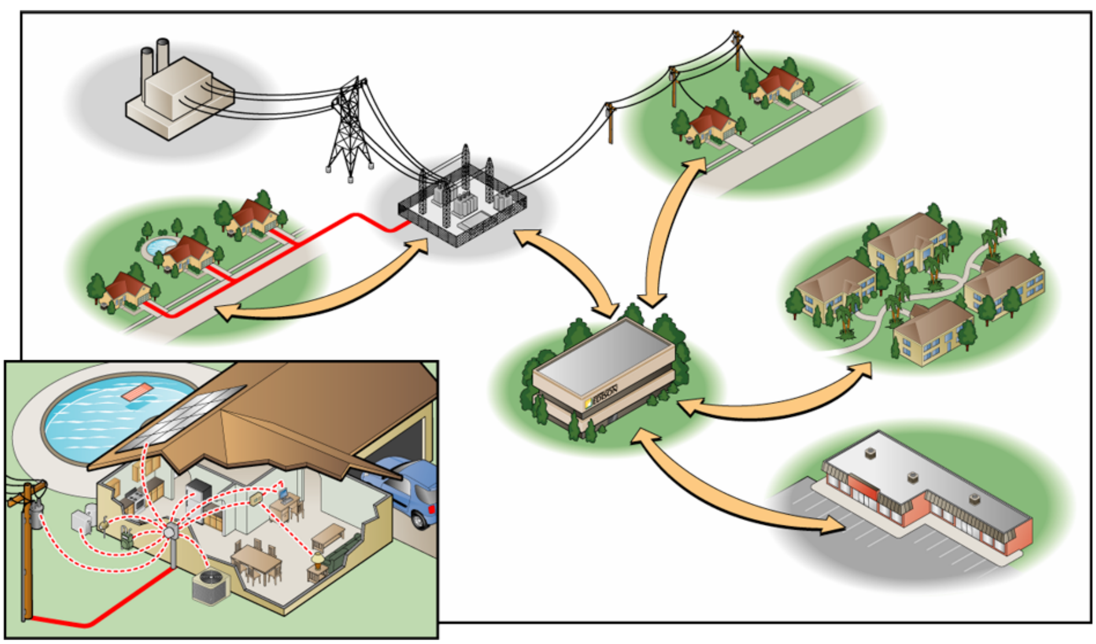
- Examples of applications and requirements that have been developed by industry experts and other utilities that are implementing AMI
- An object-oriented utility system model, which is basically a graphic depiction of information flows in the AMI, accessible online
- A set of "best practices" from the information technology and software industries
- How to apply open standards and technologies to the architecture, based on individual utility requirements
- An approach for "layering" technologies to ensure that the bulk of the system is independent of the underlying technology, thus ensuring minimal impact from technology obsolescence and change-out
- A set of strategies for ensuring that security and network management are incorporated into the AMI design
- Recommendations for standards and technologies to apply
- Recommendations for standards to apply when designing AMI
- A catalog of established and existing communications technologies and an assessment of technologies particular to AMI
- Applying IntelliGrid® Methods to AMI: Southern California Edison readies for massive deployment

IntelliGrid® processes, tools, and recommendations are playing a key role in the development of Southern California Edison's (SCE) advanced metering infrastructure (AMI) initiative. SCE plans to replace all 5 million meters in its service territory by 2012.

"A central objective of our advanced metering program is developing an open architecture device, consistent with IntelliGrid® design guidelines, so our new meters are compatible with household and business devices of the future," says Lynda Ziegler, SCE's Senior Vice President of Customer Service.

SCE's overall systems engineering approach is based on IntelliGrid® guidelines published in 2004. Specifically, SCE is using the "use-case"-based IntelliGrid® method to ensure that all aspects of an AMI system—the meters, communication infrastructure, and enterprise software—are evaluated in a rigorous manner. A *use case* documents the tasks or series of tasks that end users will accomplish using software in the system, and includes the responses of the software to user actions. It requires input by all the departments and "clients" of the system. SCE selected this approach since this documentation process results in high quality, traceable, and defendable project requirements.

To tackle the use case process, which is a standard approach in other industries doing software and system development, SCE created cross-organizational teams. These teams



Southern California Edison is adapting IntelliGrid AMI design guidelines to create an advanced metering infrastructure for its entire 4.6 million-customer base. The system will rely on open-source architecture to ensure compatibility of multiple types of equipment and products, and accommodate grid enhancements and technology changes going forward.

Source: Southern California Edison

developed 18 use cases, or narratives, describing the expected near- and long-term function of the AMI system. The teams divided each use case into multiple alternate scenarios and then developed a detailed sequence of steps for each scenario.

Finally, the teams translated each step into one or more requirements to be placed on the components of the AMI system. The IntelliGrid® process permitted teams to map these requirements to specific customer and business needs.

After an 8-month process involving more than 200 subject-matter experts and 40 workshops, SCE released a preliminary set of requirements for its AMI system in June 2006.

These preliminary requirements were used to perform cost-benefit analyses and create an AMI system architecture and design, leading to a complete set of requirements to engage vendors in next-generation product development.

The process SCE has followed developing its AMI program ensures its customers will receive lasting value for their investment in advanced metering.

Applying IntelliGrid® Methods to AMI: TXU Aims for First Smart Grid

TXU Electric Delivery, a regulated T&D company serving central Texas, is using IntelliGrid® Architecture to create what the company calls "the nation's first multipurpose broadband-enabled smart grid." This modernized grid features advanced metering infrastructure.

The TXU AMI system will support two million homes and businesses in the Dallas-Fort Worth area. TXU anticipates that this new infrastructure will enable the company to deliver the highest levels of network reliability and power quality; help them prevent, detect and restore customer outages more effectively; as well as establish an effective automated meter reading system. AMI will also allow retail electric providers to offer new products and services and allow businesses and households to manage their electricity use and costs.

IntelliGrid® Architecture was critical throughout TXU's AMI development phases, and focused primarily on TXU's middleware definition and implementation project:

- IntelliGrid® methods for identifying project requirements helped TXU staff define business goals and core requirements
- IntelliGrid® principles of open systems, open standards, and well defined points of interoperability were applied
- Relevant IntelliGrid® Architecture standards are being implemented over time as the system evolves

To assist in the AMI development and design process, EPRI IntelliGrid® program staff and consultants conducted workshops to train TXU staff on the use of the IntelliGrid® Architecture and methods. The same personnel also participated in the vendor interview and evaluation process
for the middleware project.

According to Jovita Williams, TXU Enterprise Architect, "Using EPRI IntelliGrid®, TXU was able to successfully develop a high level assessment of TXU processes required to implement an AMI system, develop use cases to identify information needs and corporate information demands, and define the information system interfaces using standardized adapters."

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