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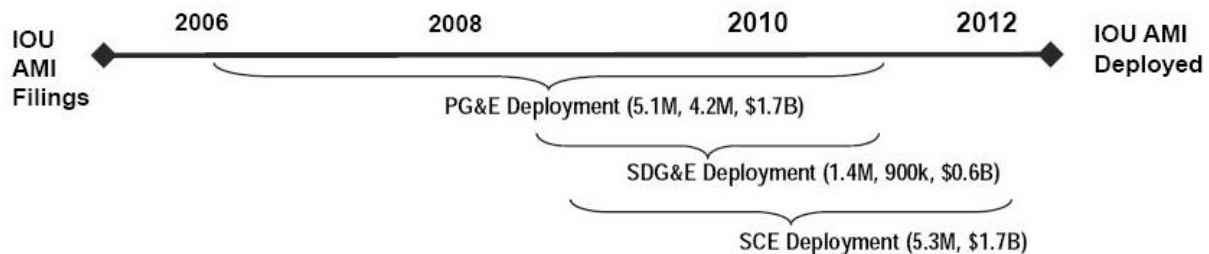
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Advanced Meter Infrastructure (AMI)

By 2012, every electricity consumer of the three big utilities in California will have smart meters which will give consumers detailed information about how they use energy and will enable new technologies automating customers' responses.

California AMI Deployment



(Electric Meters, Gas Meters, Budget)

1. Background

2. Acronyms/Definitions

3. Business Case

4. Benefits

5. Risks/Issues

1. Background

- People are often confused by the terms “Smart Grid” and “Smart Meters.” Metering is just one of hundreds of possible applications that constitute the Smart Grid. Smart meters have been used by commercial and industrial customers for decades, but in recent years they have become cheap enough for wider deployment.
- Advanced Metering Infrastructure (AMI) systems are the primary means for utilities to interact with their meters at customer sites. However, in addition to basic meter reading, AMI systems provide two-way communications that can be used by many functions and, as authorized, by third parties to exchange information with customer devices and systems.
- The number of smart electricity meters with two-way communications is poised to mushroom in the next two years. [According to a study](#) by Research company Park Associates smart-meter there are 8 million smart meters installed in the U.S, about 6 percent of all meters. As utilities upgrade equipment as part of smart-grid trials, the number of smart meters is forecast to grow to 13.6 million installed next year and to over 33 million in 2011.
- Currently, AMI composes about 4.7% of total U.S. electric meters ([FERC 2006a](#)). Activity in the use of advanced metering has been increasing rapidly, growing nearly 700% from 2006 to 2008. While it is difficult to assess precisely which functions these AMI deployments support, the penetration rates indicate that this enabling technology is being positioned to support greater participation by distributed energy resources to the benefit of operational resiliency.

2. Acronyms/Definitions

- **AMI** – Automated Meter Infrastructure
Systems that measure collect and analyze energy usage, from advanced devices such as electricity meters, gas meters, and/or water meters, through various communication media on request or on a pre-defined schedule. This infrastructure includes hardware, software, communications, customer

associated systems and meter data management software. First generation smart meters, which were only capable of meter readings, don't qualify as AMI systems.

- **AMR** - Automatic meter reading, is the technology of automatically collecting consumption, diagnostic, and status data from water meter or energy metering devices (water, gas, electric) and transferring that data to a central database for billing, troubleshooting, and analyzing. AMR technologies include handheld, mobile and network technologies based on telephony platforms (wired and wireless), radio frequency (RF), or power line transmission. When metering residential customers, drive-by and walk-by meters (AMR) are considered a competing technology and currently are out-shipping AMI products. Other than the more-convenient data gathering over traditional meters, AMR meters offer very few to none of the benefits and functions necessary to enable residential customers to meaningfully participate in a smart grid.
- **MDMS** – Meter Data Management System Smart meters can collect customer readings as often as every 15 minutes, rather than every month, so utilities need new software to cope with all the extra data.
- **Smart Meter** - An advanced meter (usually an electrical meter) that identifies consumption in more detail than a conventional meter; and optionally, but generally, communicates that information via some network back to the local utility for monitoring and billing purposes.

California Advanced Metering Initiative Summary

	Pacific Gas & Electric	San Diego Gas & Electric	Southern California Edison
# of Electric Meters	5.1M	1.4M	5.3M
# of Gas Meters	4.2M	0.9M	Gas Utility may connect to AMI
Costs Approved	\$1.7B in July 2006	\$0.6B in April 2007	\$1.7B
Costs Pending Approval	\$0.6B to upgrade	-	-
Deployment Schedule	2006 to 2012	2008 to 2011	2009 to 2012

➤ Note: The table pertains to meters for utility customers with maximum load less than 200 kW. Customers with maximum load greater than 200 kW already have advanced meters.

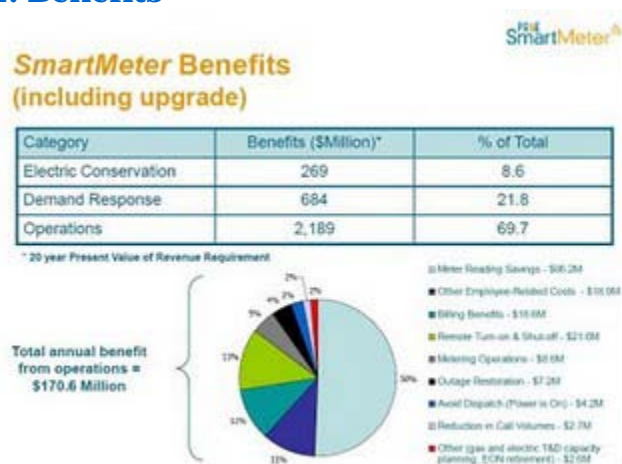
3. Business Case

- NIST identified the need for a meter upgradeability standard as a high priority requiring immediate attention. The National Electrical Manufacturers Association (NEMA) led an effort to develop standards for smart meter firmware upgradeability and the standard was completed in less than 90 days. It will be titled NEMA Smart Grid Standards Publication SG-AMI 1-2009 -Requirements for Smart Grid Upgradeability.
- Smart meters establish a two-way data connection between the customer and the power company, by sending information over a communications network that may include power-line, radio or cellular-network connections. Once smart meters are installed, power companies can determine the location of outages more easily, and no longer need to send staff to read meters, or to turn the power on or off at a particular property.
- Transforming today's "dumb" electric meter into a smart consumer portal that allows price signals, decisions, communications and network intelligence to flow back and forth through the two-way energy/information portal is a key to achieving consumer control of electricity costs and consumption.
- Advanced devices such as two-way communicating meters, communicating thermostats, and home automation devices such as programmable and communicating outlet controllers will assist energy customers in managing their demand for energy.
- Vendors are building "last mile" AMI communications solutions around wired and wireless technologies. A wireless technology is needed to reach any device not receiving electric service. The major disadvantage of wired technologies for last mile communication is that they are often incompatible with water and gas meters due to their use of the electrical distribution wires as the transmission media. Five technologies are being used:
 1. **Wireless Star** - Wireless star technologies are available in both licensed (200 MHz, 900MHz) and unlicensed spectra (900 MHz, 2.4GHz). Advantages of licensed technology include greater allowable transmission power (2 Watts vs. 1 Watt) and blocking of interference sources. The principal disadvantage is the need to obtain a jurisdiction-by-jurisdiction license to operate. The desired frequency may also have been already allocated. Advantages of unlicensed technology are elimination of

licensing requirements due to the use of the “free” spectra and more choices in which set of frequencies to use within the spectral bands. These two aspects often offset the potential interference and lower allowable transmission power.

2. **Wireless Mesh** – A communications network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways. A mesh network is reliable and offers redundancy. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes.
3. **PLC** - Power Line Carrier - the principal hurdle is propagation of the signal across power system equipment such as transformers. Transformers act as natural filters to the radio frequency signal. Another difficulty is maximizing the bi-directional communication rate.
4. **BPL** - Broadband over Power Line - the communications rate is solved by choice of the frequency band; however, equipment often interferes with other wireless communication technologies (amateur radio).
5. **Fiber Optics**. It is often difficult to justify “fiber to the home” for a single purpose use, such as advanced metering. Smaller utilities, including municipalities, have successfully invested in fiber optics as they can then offer cable television, phone service, and internet service first with enough bandwidth available for their utility operations.

4. Benefits



- **Remote Meter Readings** - AMR mainly saves utility providers the expense of sending out employees to take readings. This reduction in transportation requirements means less fuel consumption and less carbon emissions from the vehicle tailpipe. Advanced metering will also virtually eliminate meter reading errors
- **Remote Configuration** - Diagnostics, software and firmware changes including: upgradeable WAN/HAN communications, leveraged open architecture principles in system design and future customer service offerings. In other words the thing will work like a Sky or TiVo set-top box, under the control of its master authority outside the home.
- **Improve Reliability** – Remote diagnostics can detect a service outage. Today, a utility may not know about an outage until the customer calls to complain. Similarly, they may not know when service is restored.
- **Remote Cut Off** - The ability for energy firms to cut off supplies remotely. Gas meters would probably include a remotely-operable shutoff valve for this purpose.
- **Enables Real Time Visibility** - Home-network abilities, allowing an in-home meter display and possibly the ability to watch one's meter reading on other devices such as computers, TVs etc.
- **Requisite for Distributed Generation** - Intelligent net metering , the ability to measure "exported" electricity, as when a house sells electricity back to the grid - perhaps from a plugged-in electric car or other storage system. Similarly the meter must be able to work with micro-generation equipment so as to let people sell electricity to the grid.
- **Enables Conservation through ADR** (Auto Demand Response) - The "ability to remotely [i.e. from outside the premises] control electricity load for more sophisticated control of devices in the home". AMI can lower electricity costs to consumers from flatter load curves that result from smart meter applications and changes in consumer behavior in response to tariffs that provide incentive to use less electricity during peak hours, but more than just installing smart meters is required to achieve this benefit.
- **Improved Billing** - Billing can be based on near real time consumption rather than on estimates based on previous or predicted consumption. This timely

information coupled with analysis, can help both Utility providers and customers better control the use and production of electric energy, gas usage, or water consumption. AMI can change the maximum amount of electricity that a customer can demand at any time; and remotely change the meter's billing plan from credit to prepay as well as from flat-rate to multi-tariff.

- **Theft Prevention**- Smart meters can detect the unauthorized use of electricity and help to curtail the theft of electricity.
- **Operational Efficiencies** - Including; field communication links to distribution, revenue cycle improvements, situational data in near real-time, and wholesale - retail markets integration.

5. Risks/Issues

- **Meter Upgradeability** - Utilities need to ensure that technologies or solutions that are selected will be interoperable and comply with the yet-to-be-established national standards. Utilities also want to ensure that the system they select will allow for evolution and growth as Smart Grid standards evolve. It is essential to be able to upgrade firmware, such as meters, in the field without replacing the equipment or "rolling a truck" to manually upgrade the meter firmware.
- **Technological Complexity**- Deployment of technologies still under development. Although most of the technologies necessary to build AMI already exist, products for cost-effectively applying some of them in the power system have only become available in the past few years. Utilities wishing to deploy AMI technologies right now often need to work in partnership with vendors to define requirements, provide design feedback and evaluate prototypes. After downsizing and deregulation, many utilities do not have the research and development resources available to make this happen.
- **Cost** - Implementing all this will not be cheap. A smart meter costs about \$125, and can cost several hundred dollars more to install, once the necessary communications network and data-management software at the utility are taken into account. California's investor-owned utilities alone are spending about \$4.5 billion on deploying smart meters over the next few years. That implies that a nationwide implementation could cost around \$50 billion. But PNNL estimates

that \$450 billion would have to be poured into conventional grid infrastructure to meet America's expected growth over the next decade anyway.

- **Stranded Investment** – If the wrong technologies are selected, the rate payer may have to pay for technology write-offs.
- **Gold Plating** - You don't necessarily need to have a Smart Meter with communications functionality built into it to be able to realize smart grid functionality and benefits. There are a lot of AMR meters out there that have one way communication what their usage information is, and there are other ways to communicate back to the utility or whoever that third party service provider may be.
- **Market Access** - Degree of Utility Control in Home - A 2006 survey of utility executive by GF Energy showed that nearly 90% if the executive believe that it is the utility companies that will be introducing end user electricity controls rather than independent entrepreneurs.
- **Lack of market power for smaller utilities.** Deploying advanced technology is easier for bigger utilities for two reasons: firstly, they simply have more internal resources to apply to the project; and secondly, they must deploy to a larger number of sites and therefore can offer bigger incentives to vendors to implement the features they need. Smaller utilities do not have economies of scale, cannot offer large incentives and therefore must often take off-the-shelf technology. This may mean their Smart Grid projects are "not as smart", or must be deferred because they are not yet cost-effective.
- **Information Security** - One deficiency common among many of the meters is the use of insecure programming functions, such as memcpy() and strcpy(), which are two of the most common sources of exploitable software bugs. In many cases, the devices use general purpose hardware and software that aren't designed for highly targeted or mission critical systems. [Security firm IOActive, claimed in March 2009](#), it had proven that networks of smart meters, which allow two-way communications and controls between customers and utilities, could be hacked to boost or cut power to millions of homes at once. That could crash the grid, all with as little as \$500 worth of equipment and the proper training, the firm said

- **Decoupled Alternatives** – As an alternative to AMI system, market information such as prices and grid conditions can be decoupled from communication of energy consumption. Thus, the meter can be separate while pricing signals and the like can be transmitted via other public communication mechanisms such as phone, internet, cable, and wireless radio. A decoupled situation can make sense for commercial buildings and industrial uses where energy savings can be significant, while a more traditional bundled AMI package may be more desirable for residential consumers due to its “all-in-one” and “plug-and-play” aspects.
- **Regional Customization** - AMI billing techniques and the machines themselves may require regional customization reducing potential economies of scale in production and deployment. Regional customization may be required because of differences in consumer preferences, aggressiveness of service providers, state and local regulations, and the speed with which smart grid structures and technology change over time. Not all regions are likely to respond identically and may have different needs.

Links

- Electricity Smart Metering Business Drivers** A 2009 PDF White Paper by Atos Origin. A good non-commercial assessment. Presents a dedicated method to assess the financial returns of particular smart metering projects.
- Coincident has developed an **interactive web application** to help users discover and explore advanced metering projects occurring around the world. Presently in a free beta period with coverage maps for the United States and Canada.
- CPUC Decision on **PG&E’s Proposed Upgrade** to the Smart Meter Program
- CPUC Decision on SCE’s **Proposed Smart Meter Program**
- FERC 2006a - **FERC - Federal Energy Regulatory Commission. 2006a. Assessment of Demand Response and Advanced Metering Staff Report.** Docket Number AD06-2-000, FERC,