INTERNATIONAL
SMART GRID
ACTION NETWORK

CASE BOOK

SPOTLIGHT ON ADVANCED METERING INFRASTRUCTURE

AMI Case Book Version 1.0

Lead author and editor | Jennifer Hiscock, ISGAN Annex 2 National Expert, Natural Resources Canada

MESSAGE FROM THE CHAIR

The International Smart Grid Action Network (ISGAN) is proud to present this Case Book on Advanced Metering Infrastructure as part of its deliverables to the 4th Clean Energy Ministerial.

Grid modernization efforts underway throughout the world represent a paradigm shift for electricity from a commodity-based sector to one focused on energy services. Along the way, many lessons are being learned, assumptions tested and best practices developed across a diverse range of advanced information, sensing, communications, control, and energy technologies that is collectively known as the "smart grid." In many jurisdictions over the last 10 years or so, decision makers and network operators have made the choice to enter into smart grid development on their distribution grids by investing in a specific subset of smart grid technologies known as advanced metering infrastructure (AMI). These investments have produced a wealth of experience and insights about AMI among the different markets, with their diversity of grid architectures and motivating drivers for pursuing smart grids. This Case Book was created to capture the most compelling insights from some of those experiences in a case study format.

Case studies offer the reader points of comparison but, more importantly, tell stories in a brief and concise way that makes it easier for the reader to extract key points and gain important insights that facts and figures alone cannot convey. They point out opportunities, pitfalls, and other lessons learned in developing and deploying these technologies that can help stakeholders engaged in developing smart grids make more effective decisions and avoid costly missteps. This Case Book attempts to structure the case studies in such a way that their stories can be understood and leveraged by others. Each lists a contact person who can offer further information and details.

This Case Book reflects one way that ISGAN brings together experts and stakeholders from around the world to accelerate the development and deployment of smarter electric grids. It is the first of what will be a series of Case Books, each focusing on key smart grid systems or applications with results, lessons learned and best practices to be shared. ISGAN is also exploring making these Case Books so-called "living documents," to be periodically updated with new case studies from ISGAN participants and affiliated organizations.

One note of caution. The term "smart grid" captures a diverse range of technologies and systems. Not every country will choose to develop or deploy every subset of technologies to which the smart grid label applies, including the focus of this Case Book, AMI. Although, AMI can be indeed valued as the cornerstone around which to organise the progressive evolution of the network infrastructure also in a smart grid perspective, not all countries are deploying or considering deploying AMI as part of their broader smart grid development. Therefore, readers are encouraged to consider how this Case Book might apply within their own national circumstances and to look also for future ISGAN Case Books that will focus on other elements of smart grid, with opportunities to share their experiences and learn from others.

I would like to thank the participants from the ISGAN community who contributed data and information to this Case Book, to Jennifer Hiscock from Canada for so ably guiding its development, and to DJ Kang and others from Korea for their skillful management of ISGAN Annex 2, under which this Case Book was created. I wish them all the best in their continued efforts.

Michel de Nigris
Chairman of the Executive Committee
ISGAN - International Smart Grid Action Network

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This Case Book can be downloaded from www.iea-isgan.org

KEY FINDINGS

The lessons learned and best practices presented in the six case studies included in this case book provide qualitative insights into the potential costs and benefits of advanced metering infrastructure (AMI), and the associated business cases for investment. Each case presented has its own unique set of characteristics and drivers, which is indicative of the diverse range of motivating drivers for smart grid and AMI globally. It follows then that the specific costs, benefits and business cases vary from case to case. Still, there are a number of best practices and common themes emerging from these cases that are likely to be useful for any jurisdiction investigating or deploying AMI. Those common best practices and insights are presented here.

It should be noted that these six cases represent only a portion of global experience in considering and deploying AMI. In addition, AMI is only one system of technologies among a broad menu of options that can constitute a "smart grid." Some countries consider an AMI a prerequisite for their smart grid, while others have dismissed the importance of AMI to grid modernization. Additional cases have been solicited or are under development that will enlarge global understanding of the role AMI can play as one possible component of smarter electricity networks worldwide.

Customer engagement

The messaging to customers is a critical component to the success of AMI projects. A number of jurisdictions have learned to be cautious with the promise of direct customer benefits and savings related to smart meter and AMI installation. In fact, there are cases where customer bills increased following smart meter deployment because of more accurate meter readings than the old electromechanical meters could provide. In other cases, customers believed, inaccurately, smart meters and AMI caused higher electricity bills when weather events occurring at the same time as the AMI deployment were the reason for increases in customer consumption and the amount owed. These reasons aside, a primary reason for careful articulation of customer benefits related to AMI is because the actual potential for savings or benefits is often dependent on some aspects on customer behavior. While interval readings of customer consumption and dynamic rate plans can signal opportunities for savings, customers must choose to act on those signals. Not surprisingly, in a number of cases, distribution companies have found it easier to be transparent about the savings that will accrue on the grid side, and to describe how those savings will be passed to the customer, than to predict how customer behaviour change might lead to savings.

The means of reaching the customers can be as important of the message. A 90/60/30 day communications strategy before AMI deployment has become a best practice in the United States, allowing distribution companies to grow customer understanding and anticipation for AMI in the days leading up to deployment. Customer engagement in the planning phases prior to roll-out has also emerged as a best practice. It appears that more is better than less for customer communication and creating the engagement strategy. Many distribution companies that invested in extensive planning and engagement prior to roll-out have experienced less opposition to AMI deployment than others in neighbouring jurisdictions who tried to advance deployment more quickly.

KEY FINDINGS >>

Mandatory versus opt-out smart meter roll-outs

Most AMI deployments have been successful without suffering significant customer opposition. However, a vocal minority in a number of jurisdictions has captured a lot of media attention. In these cases, utilities with pro-active customer engagement plans and alternative options have fared better than those without. In some cases, the cost of addressing customer concerns outweighs the cost of providing alternative solutions. While some jurisdictions have deployed with mandatory deployments of smart meters, others have created opt-out and opt-in policies intended to avoid customer opposition. At present, there does not appear to be any consensus on a best practice for this yet, beyond that extensive customer engagement and alternative options should be available to reconcile customer concerns in a cost-effective manner.

Combining pricing plans with AMI

Rate structures should balance system and customer benefits. Moving away from averaged billing has the potential to be a positive experience for customer awareness but, in some cases, can also lead to negative experiences. Distribution companies may choose to phase-in these rate plans over a period of time to allow customers to become more aware of their consumption habits as well as the opportunities they have to change their demand profile before having to pay more for consumption during peak pricing periods. For example, one jurisdiction identified a challenge in determining the Time of Use rate structure that balanced both the customer and system benefits intended from implementing that rate plan. They learned that the daily rate structure timing (i.e. when the different rates were in effect each day) had to be adjusted to help customers transition to dynamic rates more gradually. Other jurisdictions have found that having multiple rate options provides customers with more opportunities to capture value from AMI and increase their awareness of energy costs.

Privacy and cyber security

Digitizing meter data introduces a wealth of possibilities for innovation and new customer services. It also introduces a new set of challenges. The questions of who owns the data and, separately, who should have access to the data have implications on the types of meter data management systems that need to be in place. Issues of cyber security and privacy received varying degrees of public attention across the cases presented in this book. In some cases, AMI was deployed before there was broad customer awareness of potential privacy and cyber security risks. These issues have, however, been at the forefront for privacy commissioners and regulators in some of the jurisdictions making early moves on AMI. Privacy By Design[1] (PbD) principles, created by the Ontario (Canada) Privacy Commissioner, are a best practice for AMI design that have been adopted in jurisdictions around the world. Unanimously passed and adopted as an International Framework for protecting privacy at the International Conference of Privacy Commissioners in 2010, PbD continues to publish on emerging issues for smart grid and "big data."

[1] PbD principles for third party access to customer energy use data: http://www.ipc.on.ca/images/Resources/pbd-thirdparty-CEUD.pdf

Big data

The primary purpose of most Meter Data Management Systems (MDMS) is to ensure that meter reads are validated, estimated and edited to ensure accurate and complete billing. Beyond the aspects of billing and customer use of meter data, countries can benefit from analyzing meter data with other data sets to draw important insight into the effectiveness of current programming and regulation, and into future policy needs. It is possible to leverage further value from meter data while maintaining privacy and security issues. These issues are being explored where jurisdictions have access to MDMS data sets (noting the privacy concerns discussed above).

The business case for AMI

The business cases presented in this book for investment in AMI included one or more of the capabilities listed below. In many cases, these benefits were anticipated, but in others, they were discovered during or after deployment.

> Low voltage grid monitoring capability, outage and theft detection. Distribution companies have recognized significant value simply from having increased real-time visibility of events on the distribution network. Operational savings from reduced truck rolls, more detailed asset management and investment, and strategic planning for further smart grid deployment are all a result of AMI data.

> Automatic meter reading (AMR). The operational savings from a reduction in the number of truck rolls required for manual meter reading and more accurate billing are direct benefits of AMI. Some smart meters only have these AMR capabilities, without additional functionalities such as remote connect and disconnect and interval metering. Other meters, however, are capable of supporting these additional functionalities, though in some cases software and communications system components are not in place to enable them. Countries are exploring which functionalities need to be linked directly to the meter and which can be part of the broader AMI system without needing to add the specific functionality to the smart meter itself.

> Remote connect and disconnect. This capability is also tied to operational savings from reduced number of truck rolls, and to improved customer service. It also enables prepayment and other customer billing options which can reduce the number of instances of bad debt, and help customers manage their consumption.

The immediate benefits described above are all grid-side benefits. A business case also exists for the customer side, largely from increased customer awareness of their consumption and simpler methods for switching to more competitive suppliers. However, some experiences presented in this book illustrate the challenges of making a business case centred on customer value. Because a business case dependent on customer behaviour is not entirely predictable, the grid-side benefits are often where the value proposition is clearer for utilities.

The cases also highlighted that identifying the business case is one challenge, but that realizing or maintaining the identified benefits can be quite another. Cases noted the importance of up-front data gathering and planning to avoid a costly series of modifications and adjustments in the field that can quickly consume the value of any anticipated savings.

Looking forward

The forward-looking business case for AMI goes beyond the direct effects to billing and is linked to the potential to leverage value from other smart grid capabilities enabled by AMI. While direct benefits such as remote meter reading, remote connect and disconnect, or reducing losses can pay for the costs of implementation, the business case is not limited to these benefits. It is important for jurisdictions to consider the leveraged grid-side benefits when assessing the case for investment in partial or full AMI capabilities. New billing options, new rates, distributed generation with smart inverters, demand response controls and smart appliances are all examples of smart grid technologies that are anticipated to leverage further value from AMI. AMI can also facilitate the integration of multiple energy flows. So-called "smart energy networks" explore the possibility of integrating energy and resource uses such as electricity, heat, transportation and water in an integrated way for the customer. Future case books will explore the advancements and potential costs and benefits of implementing these integrated systems, enabled in part through AMI.

INTRODUCTION

Advanced metering infrastructure (AMI) refers to a system of technologies that measure, collect, communicate, aggregate, and analyze energy usage data from metering devices. AMI is often viewed as a platform technology, because once a basic level of monitoring and communications capability is in place, other systems and new applications can be built onto it. At its core, AMI involves advanced metering, or smart meters, broadly defined as meters that offer functionalities such as interval metering, automatic meter reading, two-way communication, meter data communicated to in-home displays and management systems, outage and theft detection, and remote client connect and disconnect.

Through increased data measurement and collection, these meters offer much more detailed information to both customers and distribution companies, which can be valuable in its own right. However, the value proposition grows when other technologies such as home energy management systems, distributed generation (from roof-top solar, biomass or wind for example), electric vehicles (EVs) and electricity storage allow customers to participate in the electricity system as a buyer and seller of power. This shift in the customer role is often referred to as the shift from consumer to prosumer (i.e. a producing consumer), and AMI can support many of the related value propositions.

Table 1 shows the level of deployment of AMI in each of the ISGAN's participating countries. The functionalities listed in the table are defined as:

- **Remote meter collection:**
  utilities collect customer consumption data from smart meters electronically and digitally communicate that data for billing.
- **Dynamic tariffication:**
  customers have rate plans that include different prices for consumption which change as a function of the time of day, season or energy market prices.
- **Interval metering:**
  smart meters log hourly or sub-hourly data on customer consumption.
- **Theft detection:**
  smart meter consumption data can be compared with system data to detect when electricity theft is occurring.
- **Outage detection:**
  smart meters communicate an outage event to the utility control room.
- **Remote connect/disconnect:**
  customer premises can be connected to grid power or disconnected from grid power through the smart meter, without needing a physical visit by utility staff.
- **Customer web portal:**
  customers have online access to data from their smart meter, made available by their utility or other appropriate body.

- Meter-to-home:
  communication is enabled between a customer's smart meter and an in-home device, such as an in-home display, smart appliance or energy management system.

This is Version 1 of the ISGAN AMI Case Book. Version 2 will include additional country cases, and is expected to be published near the end of 2013.

Case Book Structure

This case book focuses on advanced metering infrastructure (AMI) projects. ISGAN Participants have volunteered these cases for the purposes of increasing knowledge and cooperation among stakeholders on smart grid project planning, implementation and management. Each case is approximately eight pages long and is organized to have the following general characteristics:

- Project description
- Main objectives of the project
- Discussion of key points to the approach and lessons learned.

The discussion is supported by the following quick reference tables and discussion boxes:

- Table providing the regional electricity system context
- Table listing project statistics
- Discussion box on policy approach or political environment for smart grid and AMI.

The cases included in this book represent a broad range of contexts: economic, political, geographical, structural, cultural and market. They are intended to promote more sophisticated conversation about lessons learned and best practices across jurisdictions. To that end, each project has a contact person identified for further information regarding the projects.

Key terms used throughout this case book are:

> AMI – Advanced Metering Infrastructure, which includes smart meters communication devices and systems capable of remote control operations, reporting interval readings and two-way communication between the customer and the distribution network.
>
> AMR – Automated Meter Reading, which is enabled by smart meters, but does not necessarily include interval reading or other functional aspects of AMI.
>
> MDMS – Meter Data Management System, the central data collection system responsible for validating, estimating and editing data for accurate customer billing.

Table 1: AMI deployment by participating ISGAN country

	Functionalities enabled							
	Remote meter collection	Dynamic tariffication	Interval metering	Theft detection	Outage detection	Remote connect/ disconnect	Customer web portal	Meter-to-home
Australia	D	D	D	D	D	D	D	D
	*Comment : Full infrastructure deployment in 1 State; tariffs and other products available							
Austria	D	P	D	D	D	D	D	P
	*Comment : Full deployment all over Austria until 2020							
Belgium	P	P	P	P	P	P	P	P
Canada	D	D	D	D	D	D	D	P
	*Comment : Full deployment in 2 provinces							
China	D		D	D	D	D	D	D
Finland	D	D	D	D	D	D	D	P
France	P	P	P	P	P	P	P	P
	*Comment : Full-deployment should start at end of 2014							
Germany	P	P	P	P	P	P	P	P
India	D	P	D	D	P	P	P	P
	*Comment : Remote meter collection, interval metering and theft detection for HT consumers under progress as part of RAPDRP							
Ireland	P	P	P	P	P	P		P
Italy	D	D	D	D	D	D	D	P
Japan	D	D	D	D note)	D	D	D	D
	*Note) deter illegal access to a meter and falsification of data							
Korea	P	P	P	P	P	P	P	P
	*Comment : Pilot Project in Jeju Full deployment by 2020							
Mexico	P		P	P	P	P		P
	*Comment : Pilots are conducted by CFE in some geographical areas							
The Netherlands	D	D	D	D	D	D	D	D
	*Comment : Partial deployment. Dynamic tarrification not yet deployed							
Norway	D	D	D	D	D	D	D	D
	*Comment : The majority of utilities will have these functionalities fully deployed							
Russia	P	D	D	P	D	P	P	P
South Africa	Data Pending							
Spain	Data Pending							
Sweden	D	D	D	D	D	D	D	P
Switzerland	P	P	P		P	D	P	P
	*Comment : No national smart meter law (in preparation new energy strategy 2050)							
United Kingdom	D	D	D	D	D	D	D	D
	*Comment : Some functionality GB wide only, some at Utility or consumer discretion. Mass Smart Met -er roll out planned for completion by 2020							
United States	D	D	D	D	D	D	D	P
	*Comment : Full deployment in some states							

Nation-wide effort · Jurisdictional effort (province or state) · No coverage · D = Planned, Partial or Full Deployment · P = Pilot

Ontario

Market structure	A hybrid wholesale electricity market with significant amounts of centrally procured or regulated supply. Retail market created with no active participants. Smart meters are owned, installed and maintained by the Local Distribution Companies (LDCs)
Number of retail customers	4.8 million
Electricity consumed (2011)	141.5 TWh
Peak Demand for Power (2011)	24, 707 MW
Net Revenue to Distribution Companies (2011)	$3.2 billion CDN
Distribution Network	158,951 km of overhead lines 38,637 km of underground lines 674,966 km2 of rural area 6,714 km2 of urban area 80 LDCs (most are small municipally owned utilities, 72% of the province is served by 10 utilities, 25% is served by Hydro One)
Contact	Usman Syed / Ontario Ministry of Energy Usman.Syed@ontario.ca

CASE 1. CANADA_Ontario

Ontario Smart Meter Deployment Project

In April 2004 Ontario announced the deployment of smart meters in all homes and small business by the end of 2010. In 2010, the energy regulator, Ontario Energy Board, set mandatory dates for the adoption of time of use prices for smart metered customers. As of December 2012, smart meter installation is complete with 4.8 million smart meters installed in the province and 4.5 million customers on time of use (TOU) rates. The TOU rates have 3 bands:

On-peak	Mid-peak	Off-peak

Prices are regulated by the Ontario Energy Board and set twice a year for the summer and winter periods.

Each local distribution company in Ontario has deployed its own smart metering infrastructure and each is integrated with a central meter data management repository (MDM/R). The MDM/R is currently operated by the Independent Electricity System Operator (IESO) in its capacity as the "Smart Metering Entity". The IESO developed the specifications and through a competitive bidding process awarded a contract to IBM Canada to build and operate the system. As a centralized system, the MDM/R serves to provide hourly billing quantity data for the distribution companies so they may use the data to bill their customers on TOU rates. The data that the MDM/R receives is completely anonymized, with only time-stamped consumption data. As a central database which stores valuable data from across the province, the MDM/R is strategically positioned to leverage the data for analysis at an aggregate level and to provide important evidence from which to base conservation and demand management programs off of, and to use in evaluation of those programs. In the future, this data may also be made accessible to companies who want to develop innovative smart grid technologies based off of real consumption data.

Objectives & Benefits

The smart meters project was designed as a step toward modernizing the electricity system with would yield the following benefits to the customer and the electricity system:

Smart meter benefits to the Electricity System

- Facilitates conservation and demand management programs
- Accurate meter reads (no more estimates)
- Timely information to help manage consumption
- Proactive customer service (e.g. immediate outage notification)

Smart meter benefits to the Electricity

- Reduces the number of crew visits to read and service meters
- Reduces tampering and theft of electricity

• Provides significant operational benefits
(better outage management and system control)

The smart metering infrastructure on its own provides significant near-term value to the utilities with the additional information it provides that helps drive operational efficiencies. However, it also provides a strong foundation for building additional value-add products and services on top of it such as home energy management systems and electric vehicle charging, and other technologies that would be components of smart homes.

Following the smart meter deployment, the TOU pricing was intended to leverage smart meter capabilities to enable peak-shifting and build customer understanding of how to control their consumption and how their consumption decisions affect the long-term cost of electricity supply. The intended benefits were:

TOU benefits to the Customer

• Gives customers ability to move discretionary load to cheaper hours
• Reduces long-term cost of electricity supply
• Increases awareness of consumption

TOU benefits to the Electricity System

• Environmental benefits as a result of load shifting
• Savings in avoided/deferred capacity investments in new generation and transmission

> The Energy Information Loop

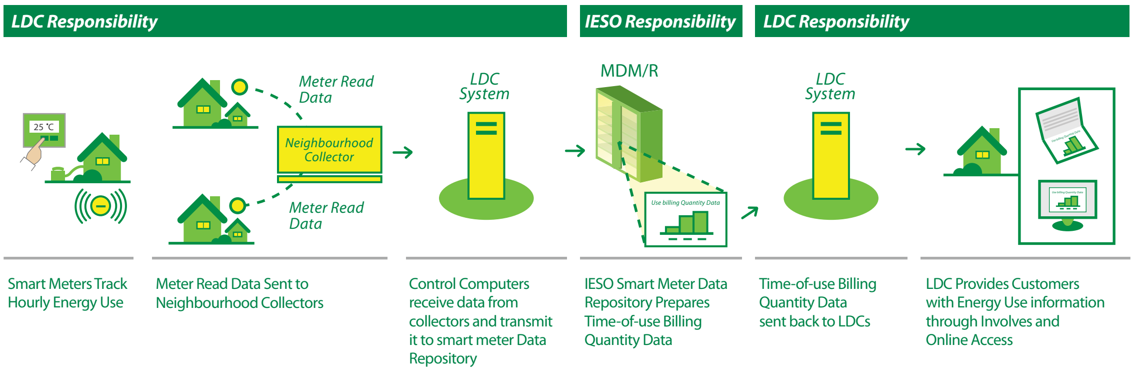


Figure 1: Areas of responsibility for AMI communications and data processing

CASE 1. CANADA_Ontario

Planning for Success & Making the Business Case

Ontario's smart meter implementation was the product of a coordinated approach between legislation, regulation and the development of guidelines and best practices. The Ontario Energy Board (OEB) as the distribution regulator provided the Energy Minister with a Smart Meter Implementation Plan in 2005, which was a product of working groups that included distribution regulator provided the Energy Minister with a Smart Meter Implementation Plan in 2005, which was a product of working groups that included distribution companies, consumer agencies, vendors, federal standards agencies and unions. The plan provided the estimated costs, key features of the technology and program, and the implementation timeline. Subsequently a benefit/cost review was conducted of the proposed program which calculated that the $1 billion CDN project would be worth $1.6 billion CDN once fully implemented.

With 80 LDCs in Ontario, that could have meant building and maintaining 80 data management systems for meter data. A series of Ministry-led consultations on managing the meter data led to the decision to build a single centralized MDM/R in order to reduce the cost to customers, and to provide access to aggregated consumption data across the provinces for future program planning and policy purposes. The MDM/R receives information from 5 different types of AMI systems operated by the distribution companies across the province, as such the MDM/R had to be built to be interoperable with the communications protocols of each of those systems. It also repackages that information into a common format with facilitates simpler analysis and downstream infrastructure related to billing and other enterprise systems. The MDM/R is now processing over 90 million reads per day, and is designed to process over 120 million meter reads per day – which, on an annual basis, exceeds the number of debit card transactions processed in Canada and rivals the average payment transactions processed world-wide by VisaNet.

Ontario's Privacy Commissioner worked with the Ministry and stakeholders to ensure that all smart grid initiatives would be designed to uphold the highest standards in data privacy and security. Working with distribution companies, the Privacy by Design principles were developed and incorporated into a guideline of best practices for smart grid companies to follow when designing their systems. The Privacy Commissioner's office also helped to produce material that would explain to the public the measures taken to ensure the safety and security of smart grid.

The Energy Conservation Leadership Act (2006) and later the Green Energy and Green Economy Act (2009) housed the smart meter initiative within broader plans to build an economy around clean energy and promote conservation. Home energy management systems have been piloted in several distribution territories to develop technologies and programs that encourage customer empowerment and result in load shifting. The impact and of these programs and technologies have will be attributed in part to the smart meter initiative.

Current Status & Results

As of December 2012, smart meters and AMI have been deployed for all residential and commercial customers in Ontario, with TOU adopted by 94% of customers across the province. The project's total cost for installation came in at the estimated $1 billion CDN. At this stage it is too early to measure the overall progress on some of the project objectives, with many customers having been included in TOU for less than 1 year. Consumption data is being collected by the OEB for the whole province in order to evaluate the impact of this project once a significant period of time has passed.

In the absence of an aggregate study, some progress has been evaluated in territories that have implemented TOU over a longer period. For example the Newmarket distribution company commissioned a study by Navigant Consulting, published in 2010, to determine if load shifting behaviours could be observed from their customers as a result of TOU pricing. Importantly, they found that during an analysis period of over 800 days that spanned before TOU and after TOU customers shifted approximately 3% of their consumption from peak to off-peak periods.

Project Details	
Smart Meters and Advanced Meter Infrastructure	• 4.8 million smart meters deployed • 5 different meters installed across the province • All communications infrastructure in place
Time of Use Pricing	• 4.5 million customers, fully implemented by 2012
Meter Data Management Repository	• 4.5 million meters enrolled (Dec 2012)
Project Cost	• $1 billion CDN for AMI installation
Project Cost Recovery	• ~$3-4 CDN /customer/ month through customer rates (declining over time as principle is paid down)
Project Benefit/ Value	$1.6 billion CDN

Lessons Learned & Best Practices

Project management

As part of maintaining a momentum and making the project implementation transparent and accountable, the OEB required the distribution companies to report every month on their progress of smart meter installation and TOU implementation. The OEB also required the smart metering entity to report on their enrolment of LDC AMI systems into the MDM/R. These reports were used to track the overall progress and were posted online.

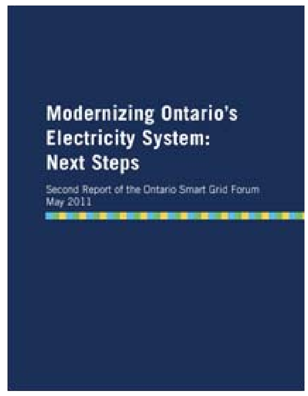
Customer Engagement

The government wanted to centralize the communication as much as possible to make it easier for distribution companies to communicate the changes to customers and to help set their expectations for future smart grid initiatives. It created a TOU Rollout working group which developed various customer engagement materials including brochures, bus ads, posters, bill boards etc. All distribution companies were offered these templates for materials which they could brand, and print themselves. The smaller distribution companies, with smaller public engagement budgets, made the most use of these materials. Others commissioned their own materials, and used other methods including hosting town halls, writing articles about it in local newspapers, and engaging customers at community events. Ontario was one of the earliest jurisdictions to deploy smart meters and in comparison to others in North America it has experienced relatively little opposition.

Despite this early success, there is still a fair amount of engagement required help customers fully appreciate how they can leverage their smart meter's capabilities. As smart meters were deployed along with the implementation of TOU pricing, many customers saw smart meters as tied to TOU and not part of a greater smart grid value proposition. In order to communicate the greater vision for smart grid in Ontario, programs for developing home energy management systems and demand management programs relate back to the smart metering infrastructure that they are building off of. At a policy level, the government has identified "increased customer control of their own energy use" as one of the 3 smart grid objectives. These 3 objectives have helped government, politicians and distribution companies communicate to customers the benefit of smart grid.

Building Smart Grid Policy

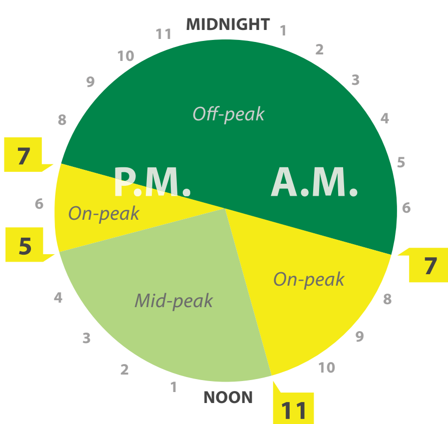
Much of the ongoing thinking for smart grid initiatives in the province is captured in the annual reports of Ontario's Smart Grid Forum. This forum is an independent body, administered by the IESO, which draws together stakeholders from the government, regulator, distribution companies and corporate partners looking to develop new technologies and services for smart grid. In addition to the formal consultative processes, the regular meetings of the Smart Grid Forum have served as a valuable sounding board for government smart grid policy ideas.



Privacy by Design

Ontario's Privacy Commissioner not only helped to create a robust set of guidelines for managing smart data, once she was satisfied that the program was meeting all of the necessary standards, she became a champion for Privacy by Design (PbD) in smart grid. Working with smart grid stakeholders around the world, she helps industries to incorporate the PbD principles into smart grid planning, and to communicate the integrity of smart grid to customers. Unanimously passed and adopted as an International Framework for protecting privacy at the International Conference of Privacy Commissioners in 2010, PbD has become a best practice around the world.PbD continues to publish on emerging issues for smart grid and "big data."

Time of Use Pricing



When customers were fist exposed to TOU pricing, the OEB originally set the TOU schedule so that the off-peak period began at 10pm based, on when the demand profile for electricity drops off significantly across the province. The public reaction to this was negative, with many complaints of the impracticality of waiting to run laundry machines (for example) after 10pm. The government and the OEB responded by adjusting the schedule so that off-peak prices applied at 9pm, and then in light of an on-going recession they were adjusted to 7pm ~ 7am. Mid-peak prices were adjusted to be from 7am ~ 11am and 5pm-7pm, on-peak prices run from 11am ~ 5pm.

Procurement Lessons

The OEB, representing the interests of rate payers, implemented the government's Smart Meters: Discretionary Metering Activity and Procurement Principles regulation in 2008. This regulation stipulated a minimum functionality for meters, including their ability to charge TOU rates. To ensure that all investments in smart meters were prudent, the OEB ruled that if distribution companies wanted to invest above and beyond the minimum requirement, those additional functions would have to be defended with a business case that would demonstrate the added value for the customer. While this has proven a cost effective measure for customers, few distribution companies have chosen to invest in meters with additional technology capabilities that have emerged to serve future smart grid technologies such as home area networks. This decision will continue to be evaluated into the future as more technologies and systems interact with the meters. However, each meter can be upgraded or outfitted with additional technologies so the question of future adaptability is not a technical concern.

Distribution companies also had to be authorized by law before they could procure. This encouraged buying-groups to form that could take advantage of economies of scale. Despite that, the service territories of the various distribution companies across the province ranged from dense urban centres to rural and remote communities. This dictated a variety of technical capabilities, where some distributors procured meters to operate on a mesh-network for urban areas, while others procured meters to operate on tower-based communication system. The result is 5 different AMI systems (Trilliant, Elster, Sensus, Silver Springs, Tantalus). This proved an effective price measure as the average installed price for the AMI averaged around $250 per customer. Technically it required additional programming to repackage the data into the same format for the MDM/R to process and store.

Next Steps

Ontario's decision to create a central MDM/R for all smart meter data across the province offers a wealth of opportunity for data analysis linking a rich data set of energy demand profiles with other public data sets. The analysis can lead to important insight with which to inform policy and provide feedback on the effects of current programs and regulation. The data also provides a valuable resource for entrepreneurs to create innovative projects and services for customers. To enable this innovation, Ontario is conducting a Green Button pilot to determine best practices for granting customers and third parties safe access to customer data.

Key Regulations, Legislation & Guidelines

Smart Meter Implementation Plan (2005)
http://www.ontarioenergyboard.ca/documents/communications/pressreleases/2005/press_release_sm_implementationplan_260105.pdf

Functional Specification for Advanced Metering Infrastructure (2007)
www.energy.gov.on.ca/docs/en/AMI-Specifications-July-20071.pdf

Ontario Green Energy and Green Economy Act (2009)
http://www.energy.gov.on.ca/en/green-energy-act/

SmartPrivacy for the Smart Grid: Embedding Privacy into the Design of Electricity Conservation (2009)
http://www.privacybydesign.ca/content/uploads/2009/11/pbd-smartpriv-smartgrid.pdf

Ontario Green Button pilot
http://www.marsdd.com/2012/11/22/bringing-the-green-button-program-to-ontario-enabling-innovation-in-the-energy-data-space/

Ontario's Smart Grid Policy

Smart grid policy is set provincially in Canada. Ontario's policy environment for smart grid is the most defined in Canada. Ontario's large power consumers are connected with interval meters and billed according to the Hourly Ontario Energy Price which tracks market prices. With the deployment of smart meters and time-of-use pricing for residential and commercial customers virtually all of Ontario's electricity customers are now paying prices that reflect market demand. This has unlocked potentials for new business models and system innovations in the province. Under the Green Energy and Green Economy Act of 2009, Ontario's Minister of Energy directed the Ontario Energy Board to promote the implementation of smart grid capabilities. The directive also required that the regulator guide the development of mandatory Smart Grid Plans for distribution utilities, and that those plans be regionally coordinated. Ontario smart grid policy objectives are captured under the 3 focus areas: customer control, power system flexibility, and adaptive infrastructure. These policies coupled with feed-in tariffs for renewable energy, aggressive conservation targets, as well as the Smart Grid Fund, have attracted entrepreneurs, businesses, utilities and venture capitalists to invest in Ontario.

※ This case was written with contributions from the Ontario Ministry of Energy, images were taken from the Ontario Energy Board and Independent Electricity System Operator.

IRELAND

Market structure	Transmission and 1 Distribution company (both regulated). All island single energy market, retail fully deregulated.
Number of retail customers	2.24 million
Electricity consumed (2011)	24,881 GWh
Peak Demand for Power (2011)	4,644 MW
Net Revenue to Distribution	—
Distribution Network	160,000 KM
Contact	Joe Durkan Sustainable Energy Authority of Ireland Joe.durkan@seai.ie

Smart Meter Pilot – Customer Behaviour Trial

In 2009, over 6,000 smart meters were deployed in homes and businesses throughout Ireland as part of a national pilot to determine the most cost beneficial and effective way of achieving a full scale national smart metering rollout. This one year pilot led to the decision to proceed with a nation-wide roll-out of AMI from 2015-2019.

The primary focus of the pilot was on the response of consumers to smart meter specific energy efficiency measures with a view to measuring the impact on their energy consumption. The pilot was lead by the Commission for Energy Regulation (CER), the independent body responsible for overseeing the regulation of Ireland's electricity and gas sectors in Ireland. The CER established a steering and a working group for the project comprising of representatives from the Department of Communications, Energy and Natural Resources (DCENR), Sustainable Energy Authority of Ireland (SEAI), the Northern Ireland Authority for Utility Regulation (NIAUR) and Irish Gas and Electricity Industry Participants.

For the customer behaviour trial, 5,375 residential electricity customers were recruited and smart meters were installed in their dwellings. A further 700 meters were installed in small businesses and commercial enterprises. The purpose of the trial was to measure the effect of smart meters, in conjunction with TOU tariffs and informational stimuli (detailed bills, in-home displays etc) on participant's consumption behaviour.

Objectives & Benefits

Smart meters can facilitate energy efficiency by empowering consumers with more detailed, accurate and timely information regarding their energy consumption and costs, thus helping consumers reduce any unnecessary energy usage and shift any discretionary electricity usage away from peak consumption times. The goal of the customer behaviour trial was to ascertain the potential for smart meter enabled, energy efficiency initiatives to drive behavioural changes that would, in turn, reduce or shift peak electricity demand and reduce overall electricity consumption. Specifically, the aim of the behavioural trial was to determine:

- if smart meters could achieve an overall reduction in electricity / energy consumption
- if TOU tariffs could cause peak shifting (i.e. causing load to shift away from peak times), and if some of this load shift resulted in lower consumption, and,
- the effect of various informational stimuli, in conjunction with TOU tariffs.

Use Case description

Profile of Participants

A key requirement of the trial was that the outcome would be statistically robust and representative of the national population. To achieve this, a phased recruitment process was implemented. Participant selection and recruitment followed a voluntary "opt-in" model using a tear off slip and achieved an average response rate of 30%. After each phase the respondents who opted in were profiled to confirm that they were representative of the national profile.

Customer research

During the trial, a number of focus groups were conducted to explore different aspects of the trial design with relevant consumer groups. The trial sought to incorporate consumer feedback for critical consumer impacting decisions during the project. The objective of enlisting consumer support at these stages was to ensure the efficient deployment of communications (letters of invitation, allocation etc), ToU tariffs and DSM stimuli that would be understood from a consumer perspective. Those selected for participation in the qualitative research were selected to mirror the usage and socio-economic attributes of the trial participants.

In order to explore how consumer behaviour changed as a result of the trial and to collect feedback on the participant's experience and the impact of the trial on their engagement and interest in energy, it was necessary to collect and analyse experiential, behavioural and attitudinal data from the participants of the test and control groups. This data was collected in two surveys: one at the start of the pilot and one at the end of the pilot. Participants were required to take part in these surveys as part of their involvement in the trial and consequently the level of participation was high (79% of households which were part of the trial completed the pretrial survey; 80% of households which had completed the pre-trial survey also completed the post-trial survey).

Design and description of Stimuli

Four different sets of tariffs (each with day, night and peak rates) and 4 associated stimuli (monthly and bi-monthly detailed bills, in-home displays and an overall load reduction reward) were designed for use in the residential trial. The tariffs varied from modest to more onerous (e.g. from 20 cents to 38 cents for peak rate) with commensurate off-peak and night rates, but all were designed to be neutral in comparison with the standard tariff. This was to ensure that the "average" participant who did not alter their electricity consumption pattern was not penalised financially and to reflect the underlying cost of energy transmission, distribution, generation and supply as per standard tariffs.

CASE 2. IRELAND

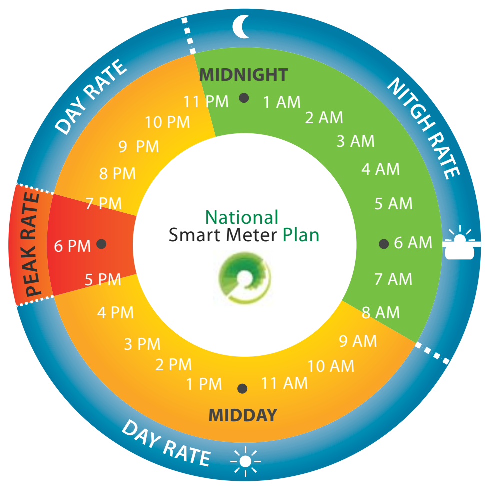
Like the tariffs, the DSM stimuli in the Customer Behaviour Trial (the energy usage statement, the electricity monitor and the overall load reduction incentive) were designed specifically for the Trial using learnings from other international trials and extensive consumer feedback.

Figure 2: Customer fridge magnet explaining Time-of-Use time bands

'Different Time, different prices'

DAY	PEAK	DAY	NIGHT
8 AM ~ 5 PM	*5 PM ~ 7 PM*	*7 PM ~ 11 PM*	*11 PM ~ 8 AM*
14c	20c	14c	12c

Peak rate applies Monday to Friday only excluding Public Holidays. Time of Use pricing will apply from 1st january ~ 31st december 2010. Rates may be subject to change in line with ESB Customer supply traff changes.
Prices exdube VAT.



During the Trial all participants in the stimulus test groups received a bill, combined with an energy usage statement. The first page presented the bill, was similar to the existing supplier's bill, with additional lines for time of use (TOU) tariffs. The second page (the energy usage statement) provided additional detail on usage and supplied tips on energy reduction. The majority of participants received this energy statement on a twice monthly basis. One grouping however received the statement monthly to test for the effect of frequency.

The electricity monitor, or in-home display, was designed and developed specifically for the Customer Behaviour Trial. Its aim was to help consumers be more energy efficient by providing additional information on how much electricity they were using and how much it was costing them. The electricity monitor also included a budget setting mechanism, where consumers could decide the maximum they wanted to spend on electricity per day. A usage bar on the home screen showed consumers their usage against their daily budget. (Prior to deployment of the electricity monitor, the historical daily consumption of each participant was calculated and converted to a monetary value based on the new tariffs.)

Participants also received supporting information in the form of a fridge magnet and sticker. The fridge magnet outlined the different timebands and cost per band, customized for each tariff group.

Details of Trial

In July 2009 a 6 month baseline/ benchmark data collection period began. This was to give an indication of "normal" customer behaviour over a demi-seasonal cycle. All meters had been installed prior to the start of the benchmark period. Data was collected on a half-hourly basis from meters during this period in order to establish a benchmark level of use for participants.

Towards the end of the Benchmark period, participants were allocated to either a test or control group. There were 16 "test cells" (i.e. a tariff / stimuli combination). The allocation to a particular tariff and stimulus set was on the basis of profiling of participants across all available survey and usage data. The set of participants allocated to each cell was similar to the allocation in every other cell.

The behavioural stimulus trials commenced at the beginning of 2010 and ran for the full year. During the test period, participants were in either a test group or the control group. The control group were billed on their existing flat rate tariff and were provided with no DSM stimuli and their normal 1-page bill. Participants in the test groups received a bill, combined with an energy usage statement. Some of the groups also tested an electricity monitor or an overall load reduction incentive.

Current Status & Results

The customer behaviour trial found that smart meters in conjunction with TOU tariffs and informational aids (e.g. in home displays, detailed energy statements) deliver an overall reduction consumption of 2.5% and a reduction in consumption at peak times of 8.8%. These results are statistically significant at the 90% confidence level

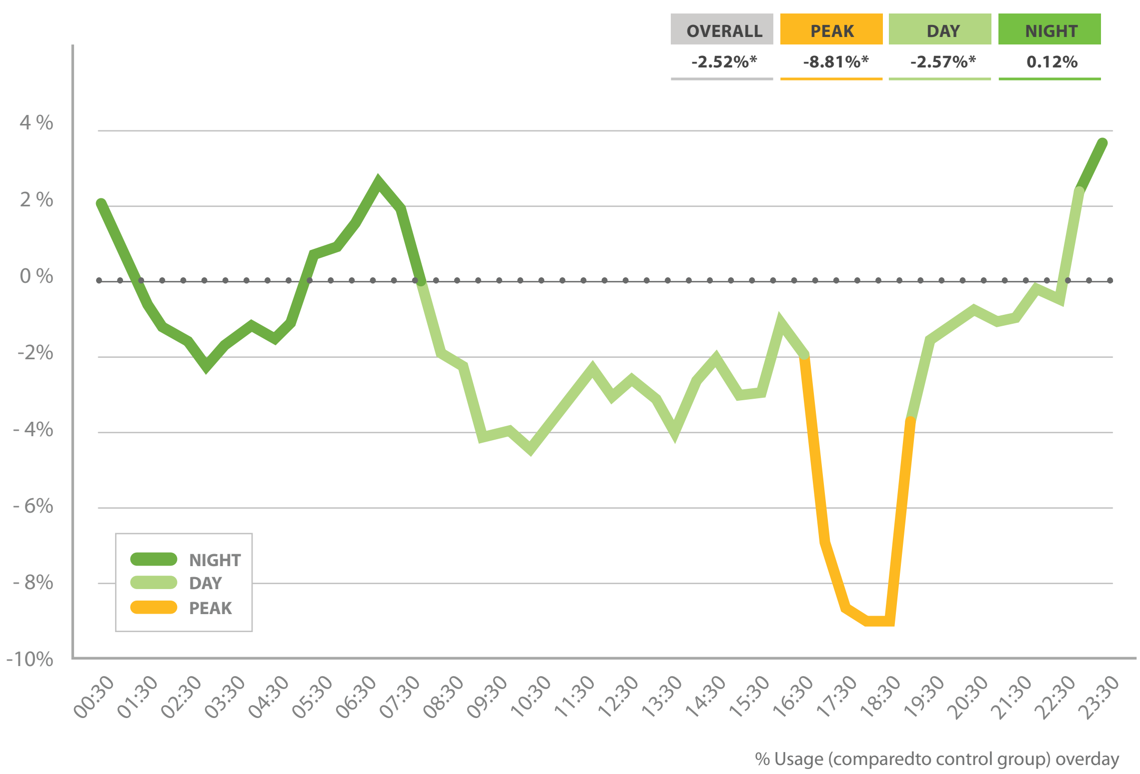
The study found that TOU tariffs are effective in both reducing and shifting consumption. The fact that there are different prices at different times, and not the actual price differentials themselves, was found to be the cause for the change in behaviour. Whereas all TOU tariffs tested delivered reductions, the trial found no statistical difference between a TOU tariff that had a peak time cost of €0.20 (42% higher than the day cost) versus one that had a peak time cost of €0.38 (300% higher than the day cost).

With regards to consumer information, the participants who had an In-home display were able to reduce their consumption by 3.2% overall and by 11.3% at peak times. Monthly detailed information statements also delivered significant reductions at 2.7% and 8.4% respectively.

The results of the trial fed into a cost benefit analysis carried out by the Economic and Social Research Institute (ESRI). The ESRI analysed 12 main national electricity smart metering rollout scenarios and found that the estimated total net present values (NPVs) were generally positive, and often substantially so. It was also found that were the results to be borne out in an actual deployment of smart metering, the project would bring about substantial net benefits for Ireland in comparison with the base case (counterfactual) scenario.

In July 2012, the CER published the decision that there will be a national smart meter rollout. Work is currently being carried out on the High Level Design phase. A partial rollout or test deployment of around 10,000 to 20,000 smart meters is scheduled to begin in Quarter 2, 2015. Pending the success of this, the full nationwide rollout is scheduled to begin in Quarter 1, 2016 with a completion date of Quarter 2, 2019.

Figure 3: Consumption Reduction by TOU over 24 hours



Lessons Learned & Best Practices

Customer Engagement

Customer engagement at the design stages is vital for later acceptance. When communicating to the customer in the initial stages of a planning, it is important to highlight the role of the smart meter as an enabler of individual understanding and control and emphasising the opportunity for the consumers to reduce their bill.

Consumers tend to understand the basic concepts of a TOU tariff and the concept will be welcomed in general. This is because TOU tariffs are perceived as giving greater control to the consumer and it is expected that 'electricity packages' to suit their needs will be offered. However, consumers often do not have an awareness of how and when they actually consume their energy. For example they tend to overestimate the amount of energy they use at peak times and underestimate the amount they use in off peak and at night time in particular.

Communications dealing with TOU tariffs should illustrate how shifting non essential loads to off-peak times can provide an additional way to save money aside from reducing consumption. Explanations of the likely impact of current use patterns were effective, with messages such as "with your level of peak usage, your bill would increase by 10% if you did not reduce your usage during the two peak hours a day."

Related to this, consumers may have difficulty in accurately estimating their actual cost reductions and tend to have exaggerated expectations of savings (and similarly exaggerated expectations of consequences). 40% of participants in the trial who believed that they had reduced their usage felt that reduction in the bill was not to the degree expected.

Simple information can also be effective. The fridge magnet and stickers supplied to all participants in the electricity Customer Behaviour Trial achieved 80% recall with 75% finding the magnet useful and 63% finding the sticker useful.

Project Details	
Overall Reduction	• 2.5% (3.2% with IHD)
Peak reduction	• 8.8% (11.3% with IHD)
Net Present Value	• €174 million (if implemented)
CO_2 Reduction	• 150,000 Tons per year (if implemented)

CASE 2. IRELAND

Key Regulations, Legislation & Guidelines

The full details on Ireland's Smart Meter trial and rollout can be found here on the CER website:
http://www.cer.ie/en/electricity-retail-market-current-consultations.aspx?article=04f4f85c-fba0-44df-a07f-64e6ff2136e3

Smart Meters and Smart Grid play a key role in enabling Ireland's commitment to a 20% energy savings target in 2020.
http://www.dcenr.gov.ie/energy/energy+efficiency+and+affordability+division/national+energy+efficiency+action+plan.htm

Ireland has published a Smart Grid Roadmap:
http://www.seai.ie/Publications/SEAI_Roadmaps/

Ireland's Smart Grid Policy

Smart Ireland recognises that for its economy to become carbon neutral by 2050 it must create an energy system built on wind and other renewables, using a smart grid and integrated into a clean EU energy system. Ireland has a small and relatively isolated grid that is already integrating high levels of non-synchronous generation (predominantly wind). This has spurred the deployment of aspects of the smart grid.

There is a supportive regulatory regime which is generally open to investment in smart grid deployment and appropriate R&D activities. Ireland has published a Smart Grid roadmap which indentifies a number of measures required for the successful implementation of a Smart Grid. These include developing market structures and policies that encourage: increasing electrification of potentially flexible loads (residential and commercial space heating and cooling and water heating), demand side management, and deployment of technologies that provide greater system flexibility such as energy storage, distributed generation and load aggregators. This in turn will require equipment, control systems and communications networks to operate on harmonised protocols.

The national smart meter rollout, scheduled to be completed by early 2019, is a key requirement of the roadmap as this will enable real time monitoring of the system at the low voltage network level which will allow the participation in the market of distributed generation and virtual power plants. In addition, it will allow electricity suppliers to offer pricing packages that provide customers with options and incentives to manage their electricity usage and costs. This increased level of customer participation is essential as it is this which creates the opportunity to shift electricity consumption to periods where variable renewable energy is available.

※ Information in this case was provided by the Sustainable Energy Authority of Ireland.

ITALY [2,3]

Market structure	Liberalized demand market; all customers may choose their supplier. About 17% of household and 36% of non-residential customers have chosen free market retailers. The remaining is served by the universal supply regime. DSOs are responsible for metering activities[4]
Number of retail customers (2011)	Approx. 37 million
Electricity consumed (2011)	> 300 TWh
Peak Demand for Power (2011)	50,000 MW
Net Revenue to Distribution Companies (2011)	> 8 billion euro
Distribution Network (2011)	830,696 km of LV lines 379,705 km of MV lines 143 DSOs operate the electricity distribution networks in Italy (54 DSOs with less than 1000 customers) 1 main distribution company: ENEL Distribuzione is the first national DSO, covering the 86% of Italy's electricity demand
Contact	Marco Cotti Enel Distribuzione SpA marco.cotti@enel.com

Telegestore, Automated Meter Management Project

In 1999, Enel began developing the Telegestore® Project (Italian Automated Meter Management (AMM) System), a system for low-voltage (LV) concentrators and remote meter management. This was ahead of the mandatory installation programme of electronic meters set by the Italian Regulatory Body in 2006. The Project provided the installation of more than 32 million smart meters. These smart meters allow Enel to periodically collect data on voltage quality and interruptions, daily consumption, active and reactive energy measurements, and to remotely manage contractual activities. Meters are able to transmit data regarding consumption, receive updates of the contractual parameters and remotely manage the supply connectivity.

Today with over 99% of electronic meters already installed in Italy, Enel is well ahead of the timetable fixed by the European Commission, of at least 80% by 2020.[5]

The Telegestore infrastructure is composed of the following main elements, shown graphically in Figure 4:

- Smart meter units (with integrated metering, data transmission and management equipment)
- Concentrators, transmitting data to and from the smart meters, installed in the MV/LV substations. The concentrator supports four main applications:
  - Aggregation of data from the meters and subsequent transfer to the AMM Control Centre at regular intervals or as required for specific AMM requests
  - Performing remote operations on meters upon AMM request (e.g. Deactivation, Tariffs or contractual changes)
  - Alarm signal detection for communication problems, meter tampering, metering failure, and communication of these signals to the AMM Control Centre
  - Remote firmware download for electronic meter and LV-C software upgrade
- The central system for remote management of meters, processing of billing information as well as quality of service monitoring
- Telecommunication network (power line carrier (PLC) between the meter and the concentrator, mobile communication between the concentrator and the central systems.

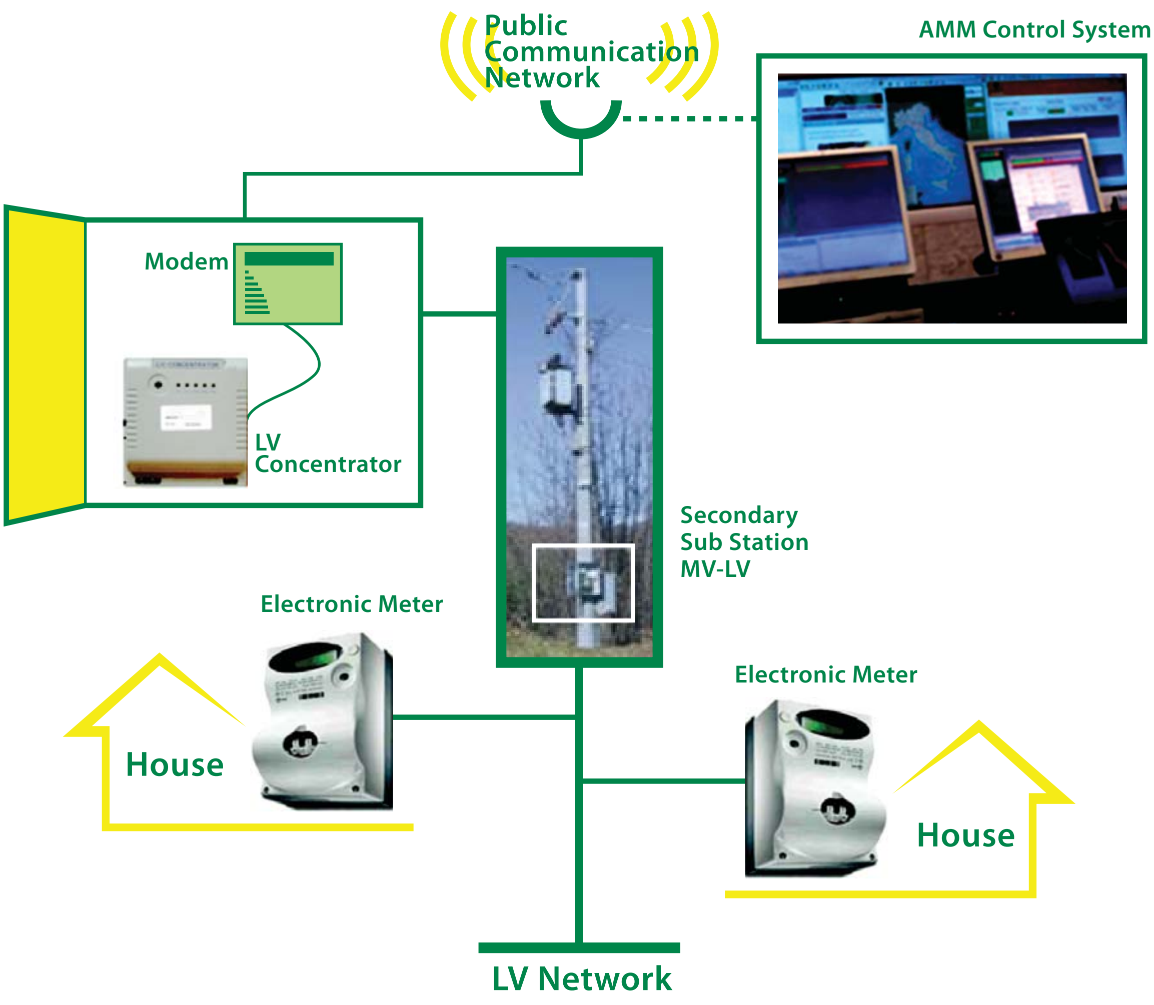
Enel designed the overall system, setting out specifications for the meters and data concentrators and leaving the production of the equipments to contract manufacturers. With this equipment, the Telegestore project enabled the following smart grid functionalities:

- Improved fault identification and optimal grid reconfiguration after faults

[2] Terna http://www.terna.it/LinkClick.aspx?fileticket=3pVRglbZa3k%3d&tabid=6020
[3] AEEG http://www.autorita.energia.it/allegati/relaz_ann/12/ra12_1.pdf
[4] AEEG 11/07, Resolution on functional unbundling http://www.autorita.energia.it/allegati/docs/07/011-07old.pdf
[5] Directive 2009/72/EC http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2009:211:SOM:EN:HTML

- Enhanced monitoring and control of power flows and voltages
- Identification of technical and non technical losses through power flow analys
- Additional information on supply quality and consumption to support network investment planning
- Sufficient frequency of meter readings, measurement granularity for consumption / injection metering data (e.g. interval metering, active and reactive power, etc.)
- Remote meter management

Figure 4 : The Telegestore Architecture



CASE 3. ITALY

Objectives & Benefits

The Telegestore project was created with the objectives of enabling greater reliability and power quality for customers, creating more customer choice, offering competitive services and complying with regulation. Customers have benefitted in terms of:

- Transparency as customers can read their energy consumption, rates, and contract on the meter display
- Billing based on up-to-date meter readings
- Flexible rate structures with the possibility of daily, weekly, monthly and seasonal modulation, together with the flexibility of billing periods, depending on the retailer's offer
- Remote and fast contract changes (connections, disconnections, rates, voltage, subscription transfers etc.), eliminating the customer inconvenience of on-site visits
- Elimination of human error in meter readings, reducing complaints and disputes
- Reduction of power disruption events and repair time

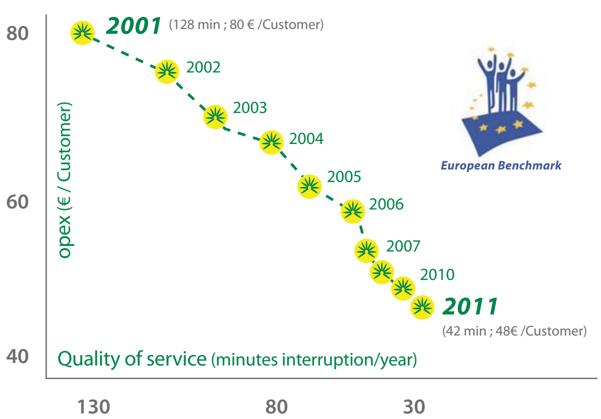
Customer Engagement

The full deployment of a smart metering solution represented a revolution, not only in the technology, but also in the business processes, starting from the relationship with customers. Enel built a communication plan to share with customers the details of the innovation project. The plan included: a brochure and documents sent to customer premises, congresses, promotional billboards, press releases in main national newspapers and dedicated trade papers. The aim was to inform customers about the replacement campaign, and to spread the awareness of the benefits Telegestore would bring, such as improving the quality of service. Moreover many dedicated meetings were organized with all the main Italian customer associations as influencing bodies to be properly informed. Following this plan was critical to completing the roll-out in the scheduled time-frame.

Current Status & Results

With a budget of 2.1 billion euro over a five year period, the project, being completed in 2006, has allowed approximately 500 million euro of yearly savings with reference to field operation, purchasing and logistics, revenue protection and customer service. 95% of this cost was associated with the production and installation of smart meters and LV concentrators. The remaining 5% corresponds to costs associated with IT system development, R&D costs and other expenses.

Figure 5:
Cost per customer and quality of service improvements



In 2011 more than 400 million remote readings and more than 9 million remote operations had been performed.

The development of the AMM system within the Telegestore, as well as remote control and automation of more than 100,000 MV/LV substations, the Work Force Management system and the optimization of asset management led to a drastic cost per customer reduction and an improved quality of service.

The first phase of the deployment resulted in a remarkable amount of energy recovered. In 2006, the yearly energy recovered had been 1.5 TWh (around 0.75% of the overall energy distributed in Italy). This is the result of several factors:

- Replacement of worn-out meters, which no longer worked correctly and measured a lower than actual consumption
- Correction of database records (i.e. Current transformer rates incorrectly reported)
- Detection of irregular and tampered installations from fraud and theft
- Accessibility of meter data and the elimination of consumption estimation

The installation of smart meters in the MV/LV substations has allowed energy balance activities to value energy losses and fraud detection. With the energy balance data from the AMM system, the success rate of the meter verification activity has increased from 5% (before the AMM) to 60%.

Moreover, approximately 30,000 tons of CO_2 emissions were estimated to be reduced from remote execution of customer management activities and meter readings in 2010.

Lessons Learned & Best Practices

Customer Service

With quality and reliability of customer service as main objectives for Telegestore, there were two key customer service initiatives that serve as best practices: the provision of a minimum social supply to bad payers and the development of the Enel smart info® device.

The remote curtailment functionality ensures in fact minimum social supply to all for a limited period of time, instead of outright cut-offs. Customers with bad payment history have their available power limited to 10% of their contract value. Remote power restoration is performed soon after payment.

Moreover, Enel Smart meters laid the ground for customers' involvement in consumption management. Enel developed a device it calls smart info®[6] that communicates with the electronic meter and enables customers to have easy local access to metering data, enabling also advanced customer services and active demand. A number of different devices such as personal computers, entertainment equipment, electrical appliances, mobile devices, and dedicated displays can show customers their energy data in easy to understand visual formats. The Enel smart info® uses a standard and open communication protocol to transmit the metering data to the other devices.

Project Details	
Smart Meters and Advanced Meter Management System	• 32 million smart meters deployed • System designed and meters specified by Enel • 358,000 data concentrators at MV/LV substations • Central AMM Control Center for remote management of meters
Tariffs	• Time of Use is mandatory for about 24 million household customers and about 5 million non-residential under the universal supply regime • Time of Use or Flat rates are optional for the free market customers (about 8 million)
Funding	• 100% by Enel (investment recognized within the Regulatory Asset Base since 2003)
Project Cost	• 2.1 billion euro/ 5 years
Project Payback	• 5 years, 500 million euro yearly
Benefits	• 30,000 tonnes of CO_2 emissions reduced in 2010

System Design

Enel developed its charging infrastructure able to serve both electric vehicle owners, through innovative mobility services, and DSOs who must manage the distribution grid in real time.[7] This result was achieved by exploiting Enel's experiences in design, development, deployment and management of remote control and network automation and in the Telegestore project, over the last 10 years.

The broad deployment of smart meters opened also a new scenario for the development of a dedicated application to fully exploit the potential of smart meters data for network and

[6] http://www.enel.com/en-GB/innovation/smart_grids/smart_homes/smart_info/
[7] http://www.enel.com/en-GB/innovation/smart_grids/electric_vehicles/

business purposes. STAmi (Advanced Metering Interface Fully Integrated with remote control system) provides network operators with a dedicated web interface to collect, on demand and real-time, specific high quality and accurate data stored in smart meters without additional load for the AMM system.

Market Impact

The Enel Smart meter technology has become a de facto standard in Italy: 4 million of smart meters have been sold to other distribution system operators in Italy and additionally over 1 million smart meters to other European utilities. Moreover, thanks to the experience gained in the Telegestore, Enel has designed a new AMM generation system, based on the evolution of the Italian solution. Endesa, the Spanish utility within the Enel Group, is deploying the new field components and AMM system modules in Spain with the commitment to install more than 13 million meters. These projects will allow Enel technology to establish itself as the standard de facto for remote management with over 50 million electronic meters worldwide, the most extensive implementation in the world.

Enel Distribuzione and Endesa Distribución Electrica created a non-profit association, Meters and More, to make the communication protocol used by their electronic meters open. The members of the association include major electricity distribution companies and other enterprises. The Open Meter project sponsored by the European Union deemed the Meters and More protocol a potential European standard for automated Metering infrastructure and nowadays it is one of the protocols under the standardization process by CENELEC.

The Enel Group's smart meters have passed all the quality and safety tests provided for by current laws and comply with applicable EU directives. Enel's smart meter complies with current European standards and is therefore certified MID (D.lgs.n.22 of February 2, 2007). At the international level it has been certified in the Netherlands by the Institute NMI (Nederlands Meetinstituut) in Dordrecht, by two Spanish centres, CEM (Centro Español de Metrología) in Madrid and ITE (Instituto Tecnológico de Energía) in Valencia, and also in Germany, Poland, Sweden, Chile, China and Russia.

The Telegestore project has also developed the local economy. The transparent and indiscriminate provision of relevant data to all the electricity providers has enabled an easier growth of the free-market. In 2011 alone, more than 2.9 million switching operations had been remotely performed.

Cyber security

Within the Telegestore system the data protection is performed not only by hardware mode inside meters and concentrators but also by means of a dedicated set of software features. To each meter installed at customer premises there is a dedicated security key. They are necessary to access customer data through all possible channels (PLC, optical port). The communication between the concentrator and the central system through the GSM/GPRS network is authenticated. The communication between the meter and the concentrator relies on authentication, with no encryption but as the data on the distribution line carrier cannot be directly related to the client (the association is possible only at the level of the central system) the Telegestore system ensures a fair level of data protection and privacy for each customer.

Next Steps

The design and development of a second generation of smart meters to replace the current smart meters at their end of life (expected lifetime 15 years) is underway. This includes a proposal to exploit potential synergies between electricity metering and other utilities metering systems, which could include gas and water. Drawing on the experience from the deployment carried out in Italy in the electricity sector and levering on the existing infrastructure, Enel is framing the basis for smart infrastructural integration between different energy services, representing also a crucial enabler for the massive deployment of gas smart meters set by the Italian Authority by 2018[8]. Alongside time and operational efficiency, the converging architecture proposed by Enel provides gas distribution system operators with a capillary infrastructure over the territory, guaranteeing a high level of communication and monitoring and assuring security and reliability of the service provision. Multi-utility pilot projects are going to be launched in Italy in late 2013 to validate the technical solutions and provide the Authority with insights and information about the governance models. The technical flexibility of the solution proposed by Enel allows it to fit all of the governance models currently under evaluation by the regulatory body.

[8] Resolution ARG/gas 28/12 www.autorita.energia.it/allegati/docs/.../028-12.pdf

Key Regulations, Legislation & Guidelines

Directive 2006/32/EC on energy end-use efficiency and energy services (translated in Italy into Legislative Decree 115/08)
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0064:en:pdf

Resolution ARG/elt 292/06 on smart meters roll out for LV customers
http://www.autorita.energia.it/it/docs/06/292-06.htm

Directive 96/92/CE on common rules for the internal market in electricity (translated in Italy into Legislative Decree n. 79/99)
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0092:EN:HTML

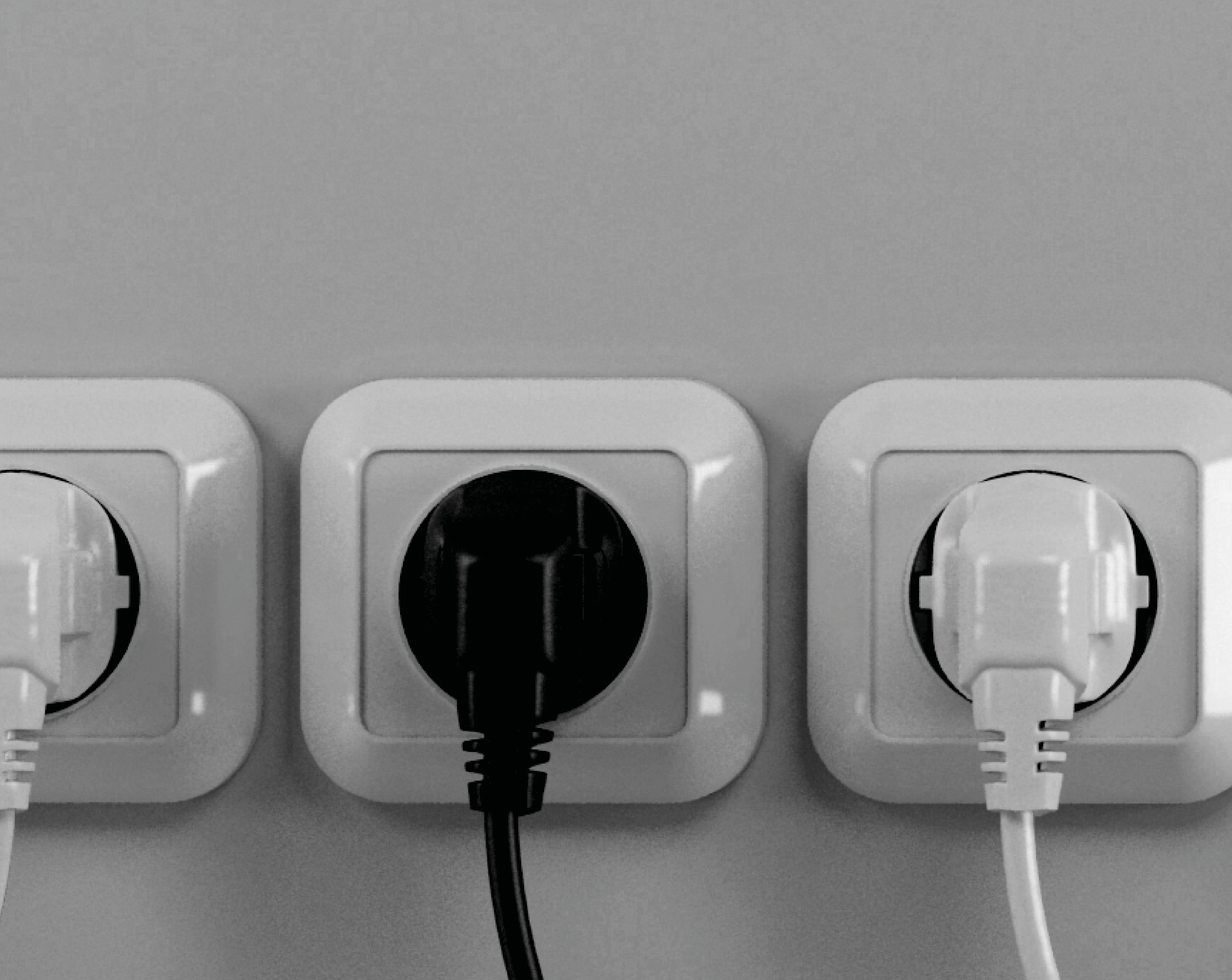
Resolution ARG/elt 22/10 on ToU tariff for residential customers under the universal supply *regime http://www.autorita.energia.it/allegati/docs/10/022-10arg.pdf*

Italy's Smart Grid Policy

The electricity context has been evolving in Italy driven by policy needs and objectives for increased quantity and quality of information about energy supply for service operation, enabled customers with more information and choice over their consumption, and compliance with the regulatory directive of the European Union. EU Directive 2006/32/EC on energy end-use efficiency and energy services, was translated in Italy into Legislative Decree 115/08, and addressed enabling consumers to make better informed decisions on individual energy consumption, while ensuring system efficiency and reliability. In 2006 the Regulatory Body (AEEG) set the mandatory installation of electronic meters in Italy, with minimum functional requirements for all the DSOs and LV customers starting from 2008 and reaching 95% of them in 2011. Nevertheless, the Enel's Telegestore® project, launched in 1999, was a voluntary project, bringing forward the massive smart meters installation programme.

Market deregulation has also provided customers with the ability to choose their own energy provider. The increased competition among energy providers required improvements in the electricity distribution system performance levels for higher reliability and power quality to meet customer demand. This increased customer-centric commercial approach has required differentiated tariffs, value added services and reduced service provisioning time. In 2010 AEEG set the introduction of Time-of-Use tariffs for residential customers under the universal supply regime, which was possible because of the massive installation of electronic meters within the Telegestore® project.

※ Sections of this case were provided by Enel



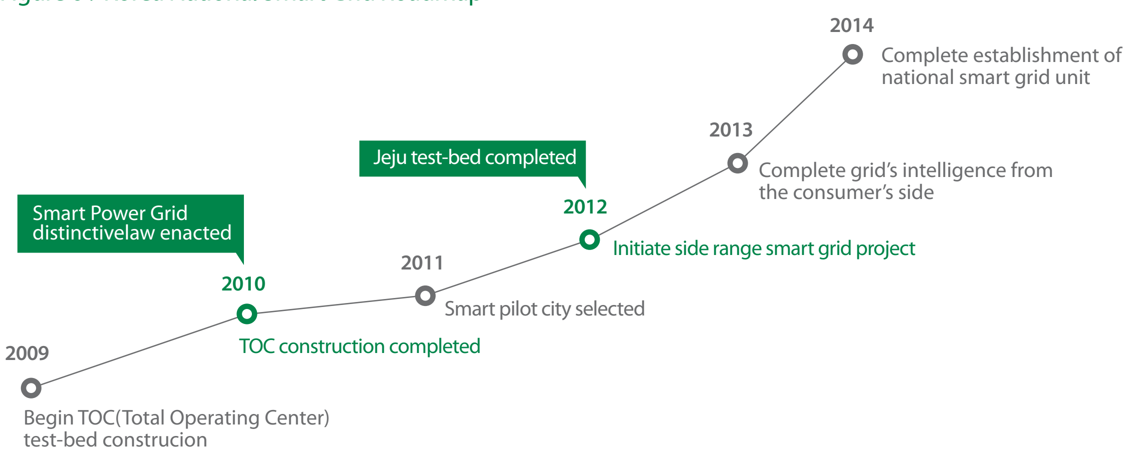
KOREA

Market structure	Hybrid structure of vertically integrated and single buyer utility.(KEPCO) KEPCO owns, installs and maintains all meters.
Number of retail customers	50 million
Electricity consumed (2011)	443.4 TWh
Peak Demand for Power (2011)	73,137 MW
Net Revenue to Distribution	Over 600V : 209,604 km Under 600V : 225,945 km
Distribution Network	–
Contact	Dong-Joo Kang djkang@keri.re.kr Sung-Hwan Song karysong@keri.re.kr Korea Electrotechnology Research Institute (KERI)

AMI as a Prerequisite to the Nationwide Smart Grid

Korea's National Smart Grid Roadmap places Advanced Metering Infrastructure (AMI) as the core to its smart grid functionality. Korea's approach began with the Power IT project, from 2005 to 2009. It was an R&D project, which mainly focused on core component technologies for applying IT to the power system. The next phase is the Jeju Smart Grid Demonstration project, which is acting as a test-bed for a number of smart grid technologies and use cases. According to the final phase of the Roadmap, it is planned for AMI deployment to take place in major citiesof Korea from 2013 to 2020 followed by the nationwide deployment which should be completed by 2030. AMI is positioned as a prerequisite infrastructure for smart grid and customer engagement.

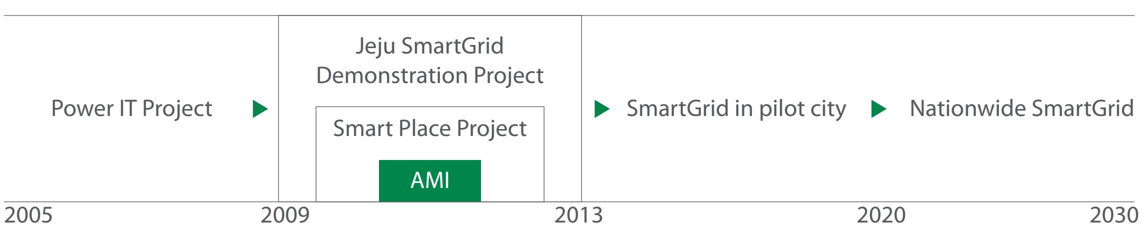
Figure 6 : Korea National Smart Grid Roadmap



Objectives & Benefits

Under the National Smart Grid Roadmap, the government has promoted AMI technology development for the accommodation of new renewable energy and for the increase of demand response. When making use of the Jeju Smart Place, the optimization of power supply and demand has been promoted based on the real-time information between the consumers and power providers. This has been done through AMI, Energy Management System (EMS) and bidirectional communication technology.

Figure 7 : AMI Deployment Plan



The project objectives and benefits are:

Objectives

Establishment of new market for two-way power trades with various resources in the demand side (facilitating negative generation: demand response)

Smart Grid ICT Infrastructure for bidirectional information exchange based on Power IT technology. This technology is expected to facilitate electricity market trading and create new value added services

Development of smart systems and smart appliances to enable customers with demand response and automatic controls responding to time-variant or real-time tariffs

Benefits

Improvementsin power quality, reliability, and cost-effectiveness of the system operation from AMI and related technologies

The reduction of greenhouse gas emission and the stimulation of green energy use

The development of value-added services such as demand side management by optimizing power consumption patterns

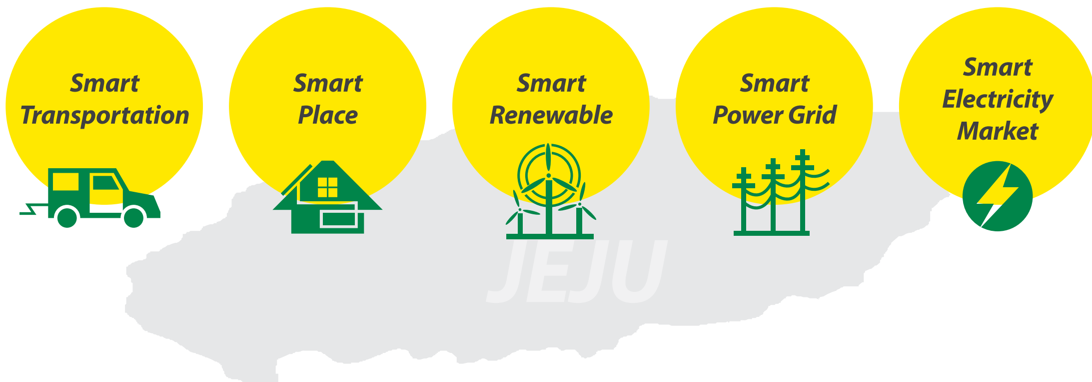
Cost savings through load shifting to cheaper hours with economic incentives

AMI in the Jeju Smart Grid Demonstration Project

The Jeju SmartGrid Demonstration was established in Gujwa-eup, in the northeastern region of Jeju Island, in December 2009. The project will be completed in May 2013, as a precursor to the nation-wide implementation of smart grid which is expected to be completed by 2030. The Jeju project was designed to promote the commercialization and export of smart grid technologies. This project consists of the five smart grid technology areas:Smart Place(SP), Smart Transportation(ST), Smart Renewable(SR), Smart Power Grid(SPG) and Smart Electricity Service(SES).

Three of the technology areas: SP, ST, and SR are currently available, while SPG and SES will be enabled once the nationwide smart grid is in effect. There are 12 consortiums involved in the project representing 170 participating companies from various business sectors such as power, communication, automobile and home appliances.

Figure 8 : Five technology areas of Jeju smart grid demonstration project



Advanced Metering Infrastructure (AMI) is included in the Smart Place technology area, with four consortiums participating as shown in Table 2. These consortiums are focusing on finding and verifying new business models for the new smart grid environment, with new electric power. The developed technologies and business models would be tested through a virtual market with real-time tariffs, a demand management market, and electric vehicle-related business. The AMI will also interact with the renewable energy interconnection and power storage devices, and by doing so, it will upgrade the current power grid. More details on individual consortiums have been provided in Table 3.

Table 2 : Jeju project consortiums participating in the Smart Place technology area

Area	Consortium	Participants	Budget
Smart Place	**A** Consortium	29	Government: $16M Private: $75M
	B Consortium	14	
	C Consortium	15	
	D Consortium	38	

Table 3 : Jeju Project Use Case Descriptions

Consortium	Description
A Consortium	• 600 households and 3 places (Jeju Venture Maru, etc.) • Formation of five kinds of the demonstration households group by combination of smart meter (SM), in-home display (IHD), solar battery and electric vehicle (EV) • Application of various electricity tariff system (TOU, TOU+CPP, RTP, etc.)[9] • Implementation of energy consumption efficiency by providing of incentive-based Demand Response (DR) service • Increases of consumer participation awareness • Providing smart grid information by utilizing D-CATV and DMB broadcasting

[9] TOU (Time-of-Use), CPP (Critical Peak Pricing), RTP (Real Time Pricing)

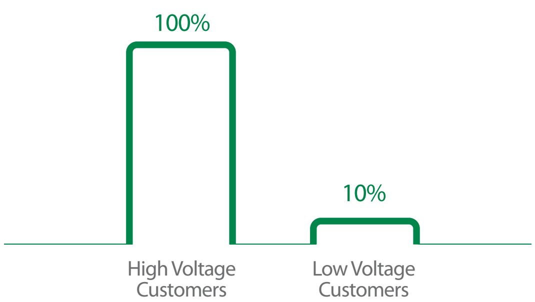
Consortium	Description
B Consortium	• 600 households and buildings of 7 places • Construction of Building Energy Management Systems (BEMS) for high-voltage consumer such as Convention Center and University • Excavation of a new business model of an energy sector by performing an energy service provider role. This should provide the energy management services such as load management and load shift in households, buildings and factories. • Expanding customer choice and maximizing energy efficiency by conducting various electricity pricing system with a consulting service and ananalysis of the electric power usage pattern by each customer
C Consortium	• 30 households and a large-scale consumer of 5 households • Verification of energy efficiency through the building and demonstration of Smart appliances (air-conditioners, washing machine, refrigerators, etc.) which have been approved by the world's first appliance, ZigBee's communication standard. • Providing home energy care service based on the demonstration results of smart server, appliances and renewable facilities in the first step • Verification of energy efficiency technology through an operation of micro-grid system in Pensions (21 buildings and administrative building) → getting electricity and gas price for 10% cheaper
D Consortium	• 560 households and large-scale consumer of 10 households • Verification of the interoperability and technical excellence between heterogeneous systems with AMI infrastructure based on PLC, Zigbee, and Wibro communication technology • Identification of outage information from smart meters, and the demonstration of the Out age Management System (OMS) for supporting the rapid recovery • Demonstration of HEMS providing the energy management services, depending on the pattern of the consumer's life such as age, region, occupation, etc • The optimal demand resource management and market participation by developing regional-based demand resource management system • Providing and DR service with an incentive-based real-time tariff system, and its effect analysis

CASE 4. KOREA

Current Status & Results

Currently most high-voltage customers in Korea have the AMI implemented, but only 10%, or 1 million, of the 18 million low voltage customers have AMI, outside of the Jeju Smart Place project. 170,000 households in multi-residential buildings with high-voltage connections have AMI. 110,000 of those customers have a TOU tariff system based on a bilateral contract to consumers of more than 300kW. For these high-voltage customers, the potential for electricity savings could be enhanced with tools for smart phones, tablets or PCs providing usage information communicated through the AMI.

Figure 9 : Korea smart meter penetration rate



Low-voltage residential customers have uniform (fixed) pricing, and as such, little has been recognized in terms of energy savings through conservation or demand response. AMI is being deployed with priority given to buildings consuming large energy in the cities such as the apartments, shopping districts and apartment-type factories.

Project Details	
Korea AMI deployment	• 10% of low-voltage customers with AMI • 100% of high-voltage customers with AMI
Korea tariffs	• TOU for high-voltage customers • Fixed rate for low-voltage customers
Jeju demonstration project use cases	• 4 Use cases with 2190 households and 46 larger customers participating • Use cases with various smart appliances, In-Home Displays and Energy Management Systems • Range of communication PLC, Zigbee and Wibro technology • Demand Response cases • Outage Management System connection
Jeju demonstration project tariffs	• Cases with Time-of-Use, Critical Peak Pricing and Real Time Pricing
Jeju AMI Project Cost	• Government: $16M • Private: $75M
Project Benefit/ Value	• To be evaluated

Through a phased deployment, Korea aims to have up to 55% (10 million households) of low-voltage customers connected with AMI by 2016. The complete AMI deployment for all households (low-voltage consumers, high-voltage consumers) is planned by 2020.

The AMI deployment has been planned in the National Smart Grid Roadmap as follows:

In 2013	• Promoting AMI supply after consultation with the corresponding operators for apartments and Area Electrical Business areas, etc
In 2014	• Preferential supply of AMI system in the pilot city • Development and supply of an energy integrated metering system that can uniformly read the usage information of electricity, tap water, gas, heat, etc.
In 2015	• Obligation of AMI system in construction of Housing, Commercial Area, Buildings and Apartments
In 2016	• Phased supply of AMI for 55% (10 million households) of low-voltage customers in the whole country
In 2020	• Completion of AMI for all households (low-voltage consumers, high-voltage consumers) in the whole country

While it is still early to determine the results of the Jeju AMI demonstration, a 2012 pilot study on the deployment and demonstration of smart metering system technology with in-home displays found a 12% reduction in energy consumption.

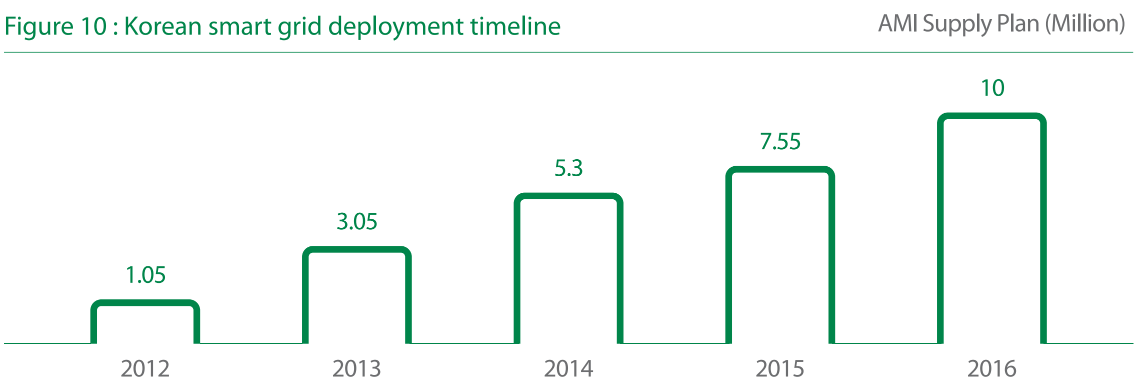
Lessons Learned & Best Practices

Korea has been investing in AMI projects since 2005 with the Power IT R&D project, followed by the Smart Grid Demonstration Project in Jeju island, that started in 2009.Korea is planning to invest approximately $7 billion until 2030 for the development of smart grid core technologies. AMI in particular, is the core infrastructure of the smart grid, and prerequisite for the realization of the green growth policy of the Korean government and global CO2 reduction polices. It is also required to create various value-added service models such as energy monitoring and automated demand response.

Tariff system

The AMI deployment will be combined with various time-variant pricing step-by-step such as TOU, CPP and RTP on the process ofreplacing current mechanical meters with the smart meters. Consumers can have multiple options considering their unique usage patterns and there by optimize their consumption and cost. This is expected to bring out the innovative transformation of captive consumers to active prosumers, as well as the overall reduction of energy costs. In addition, power service providers could ensure the stable and efficient services through the collection and analysis of information from real-time data through AMI.

Figure 10 : Korean smart grid deployment timeline



Standardization and Interoperability

In the case of the Jeju smart grid demonstration project, the lack of interoperability is causing disturbances in the process of information interchange and system integration between the consortiums and Total Operation Center. This is due to product or vendor-specific proprietary systems. Therefore, securing the interoperability standards is critical for multiple devices and systems. In this context, the standard development is on-going for the core devicesand systems used and will be introduced in the demonstration project, deployment project and the smart grid pilot cities.

Software Development

Once various pricing systems are developed based on AMI, the cyber security technology must be procured to process large-scale information in a secure way. The back-up metering plan is also needed to prevent a failure of cycle-by-cycle meter reading of the load and price profile data. It is expected that AMI business will grow rapidly in the power sector and will be diffused to other industries such as water and gas. Related software and service markets are expected to contribute value-added services to the AMI sector.

Export Strategy

Business models for overseas expansion will need to accommodate common AMI architecture and adhere to global standards. These aspects can be built into the domestic demonstration stages to develop an integrated package model for the overseas business marketing. Demonstration projects should be used to promote the development of strategic technologies and business models, which will have been applied to a broad range of markets such as urban areas, islands and developing countries.

Key Regulations, Legislation & Guidelines

Further information for Korea's Smart Grid Roadmap, Jeju Test-bed, and Power IT projects:
http://www.smartgrid.or.kr/eng.htm

Further information for R&D strategy on overall energy technologies:
http://ketep.re.kr/english/index.jsp

Smart Grid Stimulus Law, 2011.11
The 1st Basic Plan of Smart Grid in Korea, 2012.07
http://www.korea.smartgrid.com/first-smart-grid-plan/#

Further information can be found at the Jeju Smart Grid website:
http://smartgrid.jeju.go.kr/eng/

Korea's Smart Grid Policy

Korea released a National Smart Grid Roadmap in 2010, which built off of the outcomes of its Power IT R&D project from 2005-2010. The Roadmap is toward smart grid deployment across the major cities by 2020 and the whole country by 2030. This Roadmap complements the country's strategy for ubiquitous connectivity and the convergence of a number of its IT business capabilities. The main focus of Korea's smart grid policy is placed on the development of new services and business models for the green growth strategy of Korean government.

※ Further information can be found at the Jeju Smart Grid website: http://smartgrid.jeju.go.kr/eng/

SWEDEN

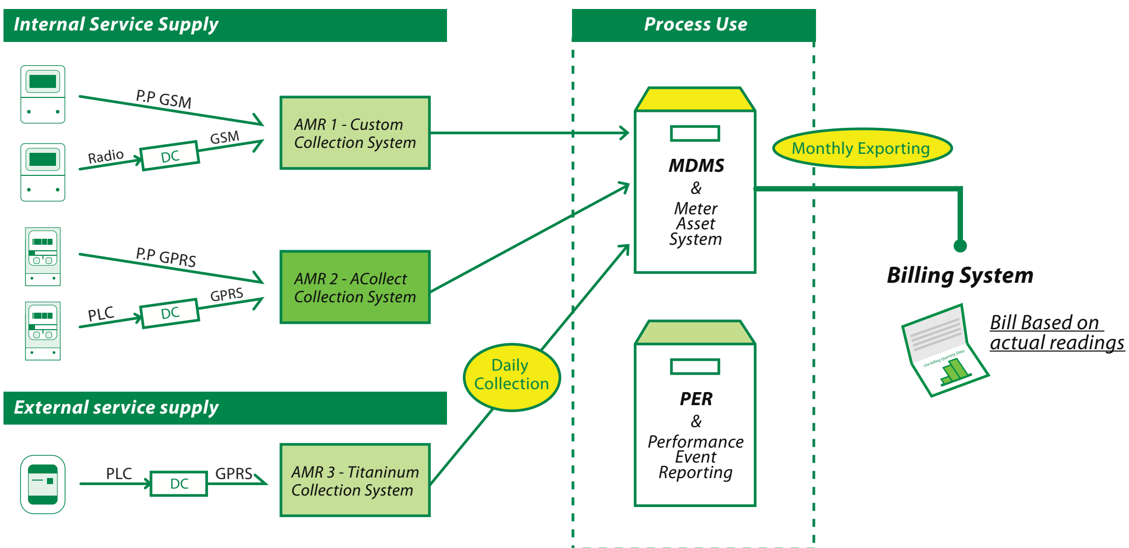
Market structure	Electricity market is deregulated for supply and production of electricity. The Network Companies operate the distribution network on a monopoly market. Network Companies are responsible for installing, reading and maintaining them. In most cases they own the meters.
Number of retail customers	5.2 million
Electricity consumed (2011)	139.3 TWh
Peak Demand for Power (2011)	27 000 MW (approx.)
Net Revenue to Distribution Companies (2011)	41 billion SEK (4.8 billion euro, approx.) ※This is only for the network service
Transmission and Distribution Network	545 000 km lines of which 329 500 km underground and 215 500 km overhead lines Transmission lines are 15 000 km at 400 kV and 220 kV 170 Network Companies (various size, some publicly and privately owned)
Contact	Magnus Olofsson / Elforsk - Swedish Electrical Utilities' R & D Company magnus.olofsson@elforsk.se

CASE 5. SWEDEN

Smart Meter Roll Out

Sweden's large scale deployment of Advanced Meter Infrastructure began in 2003 when the Swedish parliament decided that by 2009 all electricity customers should have monthly billing based on actual consumption from monthly meter readings for residential and small business customers. Action following the legislation was delayed over a relatively long time period in effort to ease the transition. In 2006 the legislation was amended to require hourly readings from larger customers with fuses above 63 A. Altogether, these requirements resulted in a full scale installation of AMR/AMI systems for nearly all Swedish consumers (5.2 million). The total cost for the full roll out of AMR/AMI systems is estimated at 1.5 billion euro.

Figure 7 : Vattenfall type example of different AMR/AMI system used in their smart meter roll -out



The AMR/AMI system architecture consists of the meters, data collectors and the network company's data management system for billing. Over the six years of the roll-out smart meter technology advanced significantly, resulting in different types of meters throughout Sweden based on when a network company procured the meters.

In 2012, a bill was passed enforcing hourly metering at no extra cost for any consumers subscribing to an hourly-based electricity supply contract. Early experiences show that few end-customers sign up for this type of contract.

Regulatory Objectives & Benefits

The main goal of the 2003 electricity meter reform was increased consumer awareness and ability to control their consumption with more accurate electricity bills, simplification of the supplier switching processes, and better information about their actual consumption. It should be noted that there was no regulation as regards to functionalities of the metering system. Smart meters rather became a consequence of the regulation for billing based on actual consumption, requiring automatic and remote meter reading.

Before the reform, electricity for most private customers was read on a yearly basis with billing based on the previous year's consumption. Customers received a reconciliation bill for the difference between the previous year's consumption and the actual consumption, as the network company didn't know the actual consumption until the end of the year. To a large degree this also meant that the customers unaware of their actual consumption, causing frustration once a year when customers were at risk of receiving a large reconciliation bill for the whole year before learning about any change to their consumption. Since July 2009, customers receive monthly bills based on their actual consumption which has led to increased customer awareness and activity in the retail electricity market.

Current Status & Results

By 2009 all Swedish customers had smart meters and AMR systems. Over the years since deployment, many network companies have found their roll-out led to both expected financial benefits and to non-financial benefits in service quality, customer satisfaction and improved safety on the network.

There wasn't much public opposition to Sweden's smart meter roll-out. In part this was because the majority of the electricity bill in Sweden is the cost of energy and taxes, not the network costs, so the cost of implementing the AMI/AMR was only a fraction of the bill. In the initial proposal for the meter reform the regulator requested hourly metering instead of monthly metering, this was however strongly opposed by the network companies. In Sweden concerns about the accuracy of data and customer privacy in conjunction with the smart meters has rendered little discussion. In general the handling of meter data is regarded as acceptable by the customer.

In terms of AMI/AMR functionality, Sweden's infrastructure does not yet have all of the components for customer demand response activities. Dynamic pricing, easy customer access to their own data with visualization tools or other components that improve a customer's control over their consumption are not yet common across the systems, however the functionalities are in most cases sufficient to deliver significant benefits compared to the alternative of not rolling out the smart meters. As - the Swedish regulator is shifting the market to hourly metering and considers hourly energy prices, customers will need support to facilitate their response to price signals from the market and any other load management programs. Some of these capabilities are currently under development through the Proactive Forum discussed at the end of this case, while others will be implemented via other channels.

Project Details	
Smart Meters and Advanced Meter Management System	• 5.2 million smart meters deployed • Local communication - 50 % PLC (power-line carried communication) - 30 % LPR (Low power radio) - 15 % GPRS - 5 % other • Communication to central system - 70 % GPRS - 20 % POTS (plain old telephony service) - 5 % SWR (short wave radio) - 5 % private fixed wire copper or fiber optic networks
Tariffs	Currently most customers are charged a price for consumption based on a monthly average but may opt-in to hourly spot-tariffs reflecting to capture more value from AMI/AMR.
Project Cost	1.5 billion euro/ 6 years
Project ROI	Individual network companies have measured operational savings and increased value related to the decreased costs of switching retailers with the AMI/AMR. Nation-wide benefits are still TBD.

Lessons Learned & Best Practices

Customer Engagement

For Sweden, the first step for enabling the customer to participate in a more efficient market was to build their awareness of their consumption and of what type of contract they had signed with their current retailer. Increased customer activity in the retail market was a major driver for AMI/AMR deployment in Sweden. Once customers began to move from annual meter readings to monthly readings, they also became more aware and concerned with their electricity use. This has set the stage for future technology and market pricing that will allow the customer to participate in a more active retail market.

There were some opponents to the process of the meter reform, which occurred because important aspects of the customer-utility relationship weren't clearly investigated before the roll-out. With the initial focus on intended billing and market changes, smart meter installation and customer conservation benefits were a later evolution in the project objectives. With this shift in objectives, customer communication and engagement became more central to the roll-out.

The Role of the Regulator

As with many jurisdictions, a critical factor for the Swedish roll-out of smart meters was the allowance for network companies to include smart meters as part of the asset base to ensure cost coverage. Born out of the initial focus on accurate billing and a more active retail market, the Swedish regulator is now pushing for future customer capabilities built on the AMI system. This pro-active role for the regulator is somewhat unique to Sweden.

The Business Case for AMI

The capability for remote upgrades of the meter software is critical to the overall functionality of the AMI system, and to the value proposition for the customer. Still, all that value was threatened if there wasn't enough preparation for system accuracy in meter readings and communication. Some early movers found that the business case disappeared with the costs of the field work required to fix inaccuracies and improve the system efficiency. Also the low-voltage network documentation must be accurate and detailed enough for efficient implementation of AMI.

Almost every network company chose to buy complete meter-system solutions under turnkey contracts with long term functionality guaranties. Some of the contracts also included full service for several years, all in the attempt to minimize the risk to the network company and the customer. This shifted the risk to the manufacturer, which had an effect on the meter market. Overall the meter market changed in many ways during the roll-out: several meter manufacturers and suppliers filed for bankruptcy and a few folded their local operations. Some local manufacturers were bought-out in the early wave of consolidations and some players restructured their local business models.

Despite the attempt to mitigate risk, some concern remained over the decision of many network companies to install propriety AMI systems. This was perceived as a risk to technical support and service should the supplier go into bankruptcy. There are some persistent concerns that this might result in many systems being exchanged long before their estimated end of life. This issue is being addressed in part through developing minimum standardized functionality for meters which improves their likelihood of interoperability with other technologies and proper functioning throughout their lifespan. This initiative is discussed later in the Proactive Forum section.

Not fully accounted for in the original business case, the improved understanding of the grid behaviour and load pattern has allowed network companies to make more strategic decisions about infrastructure upgrades and has reduced the risk of over-sizing assets. As a platform for other smart grid technologies, many future services will be enabled by the data and the functionality of the AMI.

Communications Operability

A common problem with the roll-out reported by many network companies was the difficulty in getting the communication with the meters to function properly. In general it was found that meter data sent on the electricity grid (PLC-technology) was more problematic compared to for instance radio communication through GPRS which experienced fewer problems.[10] Furthermore, network companies reported situations where meters had to be serviced or replaced because the communication technology was not durable enough.

During the roll-out a few manufacturers delivered batches of meters with faults. This necessitated a replacement of several hundred thousand meters.

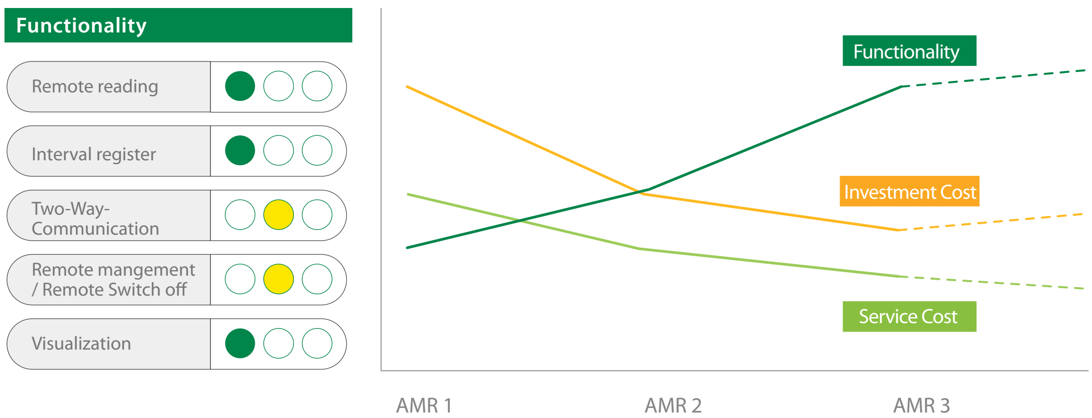
Vattenfall, 10 Years of Experience with Smart Meters

Vattenfall Distribution, Sweden's largest network operators, began its smart meter roll-out in 2003. The roll-out occurred over three phases that each focused on different geographic regions in the country. From 2003 – 2008 Vattenfall installed 860,000 meters for residential and commercial customers. The Smarter Meter development in the market during the roll-out, as well as an increased experience of new meters for each new phase was reflected in an increasing functionality and lower incremental investment and service cost as deployment moved forward. Figure 12 shows the functionality of the meters and metering costs over the roll-out phases (AMR1, AMR2 and AMR3), and the degree to which to the overall system is completely (green) or partially (yellow) functional in the areas of remote reading, interval registering, two-way communication, remote management/remote switch off and visualization.

The initial business case for Vattenfall was primarily based on decreased reading and service costs when manual reading could be automated and done remotely. Besides the savings in regular reading for billing, the AMI/AMR also provided operational savings when customers moved in and out, as well as when customers switched from one supplier to another. During the roll-out it also became clear that it was very important to not underestimate the effort needed to reach the expected system performance. Only a slight increase in the number of errors in comparison to the expected level caused much manual work which had large impact on the business case.

[10] Smarta elnät I Sverige - http://www.utn.uu.se/sts/cms/filarea/1205_johan_simm.pdf

Figure 12 : The increasing functionality and decreasing costs of Vattenfall's AMR deployment through each phase, and overall system funcitonality. The level of functionality for different AMI capabilities in relation to common European Comission minimal requirements is indicated by the traffic light images where green indicates total, yellow partial, and red no system functionality.



The reduction of non-technical losses turned out to bring large additional indirect benefits that weren't accounted for in the initial business case. The AMI/AMR system improved Vattenfall's control of non-technical network losses caused by broken meters, thefts, faults in data quality, faults and missing meter values, etc.

With the steady state operation of the AMI/AMR system, Vattenfall found that it delivers more network benefits than expected. Some major examples include:

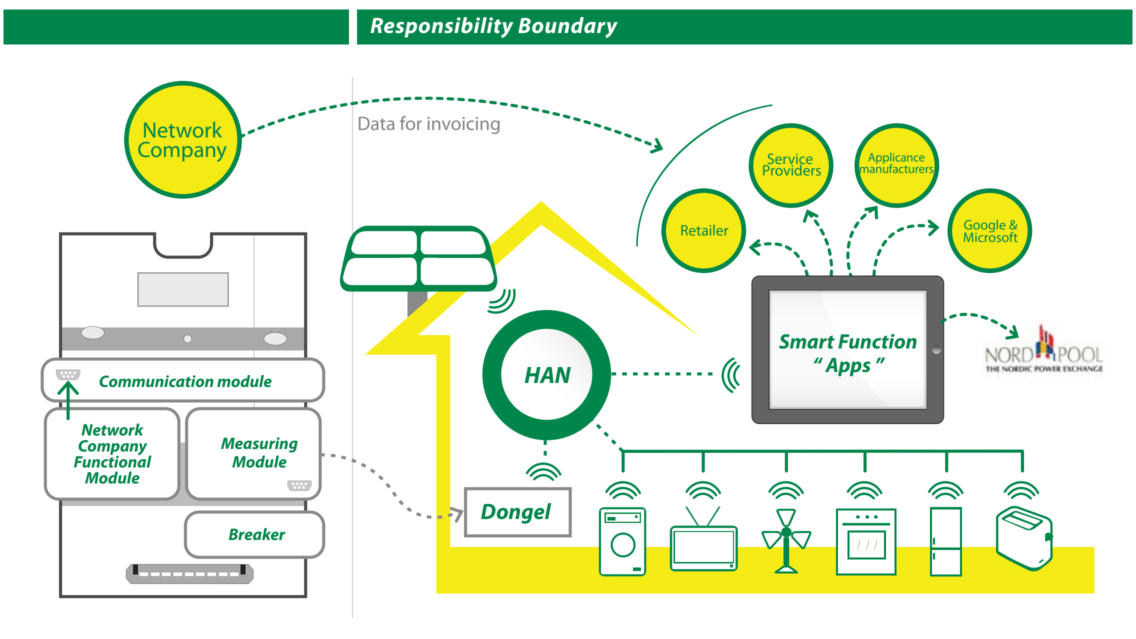
- Detection of zero ground faults. The AMI can detect a loss of ground connection, and resulting higher voltages in the network, which increases safety for customers and personnel.
- Reduced customer complaints. The presentation of daily or hourly consumption data to customers has improved the customer service experience with increased transparency
- Reduced costs from remote connect/disconnect switching. Sites without electricity ontracts, such as empty apartments or overdue accounts, can be disconnected efficiently to minimize risk and customer costs.
- Power outage compensation. Customers no longer need to call in to report an outage, meter data also ensures that customers are compensated correctly.
- Low Voltage (LV) network quality monitoring. Quality monitoring ensures that customer power quality aligns with the regulation. This increased customer service commitment relies heavily on accurate network documentation.

Next Steps – The Proactive Forum

Swedenergy, the power industry and special interest organisation for companies involved in the supply of electricity in Sweden, has worked out recommendations for requirements on AMI. The work is a result of a working group named Proactive Forum. In brief, the recommendation is to keep the meter simple. This means, for example, that utility signals or communication with the customer will not rely on specific meter functionality. Instead, internet or other protocols through various media such as wireless networks may be used as input for customer participation in demand response.

In order to enable the customer to receive high resolution data at or near real time, it is recommended that customers connect data output from the meter locally using a standard port. This design along with customer data access supports will strengthen the customer position while at the same time avoiding unnecessary investments in data processing and transfer between the network company and the network user. A schematic presentation is given in Figure 13.network company and the network user. A schematic presentation is given in Figure 13.

Figure 13 : Schematic presentation of Swedish recommended division of responsibilities for services related to smart metering and customer participation in demand flexibility



Key Directives, Legislation and Further Resources

Directive 2009/28/EG of the European Parliament and of the Council, on the promotion of the use of energy from renewable sources

Directive 2009/28/EG of the European Parliament and of the Council, concerning common rules for the internal market in electricity

Swedish government bill 2009/10 : 113, Effektreserven i framtiden

Proactive Forum website :
http://www.svenskenergi.se/sv/Kompetens/webbshop/Gratisprodukter/Elaret/Proaktivt-forum-for-Elmatare/

Technical codes and standards work:
IEC 62056-21 ELECTRICITY METERING - DATA EXCHANGE FOR METER READING, TARIFF AND LOAD CONTROL - Part 21: Direct local data exchange; Amendment A
: Mode D DFI interface with OBIS codes
http://www.iec.ch/cgi-bin/restricted/getfile.pl/13_1518e_NP.pdf?dir=13&format=pdf&type=_NP&file=1518e.pdf

Sweden's Electricity Grid Policy

Swedish Electricity Grid Policy has been formed out of a combination of regulation and government targets. The European Union's 20-20-20 targets in 2008 became part of that policy and set targets for decreased GHGs, increased renewable generation and energy efficiency that guided the larger policy objectives for AMM systems in Sweden. There are four general goals for the Swedish energy system pushing the development in the electricity grid:

- Objective to Reach at Least 50 % Renewable Energy as a Share of Total Energy Use by 2020
- Objective to Reach 20 % more Efficient Energy Use by 2020 requiring Increased Consumer- Engagement
- Spatial Planning Target for Increased Wind Power from 4.5 TWh (2010) to 30 TWh by 2020
- By 2030, Sweden should have a vehicle stock that is independent of fossil fuels

In 2012 the government launched a Smart Grid Council made up of representatives from agencies, government, utilities and the private sector, who are currently investigating different strategies for smart grid in Sweden.

※ Information in this case was provided by the Swedish Energy Agency, the Association of Swedish Electric Utilities, Swedenergy and from Vattenfall.

California

Market structure	ISO operates but does not own the grid • Runs transmission market • Acquires ancillary services • Runs an 'imbalance' energy (spot) market • Locational Marginal Pricing
Number of retail customers (2011)	14.9 million
Electricity consumed (2011)	285 TWh
consumed (2011)	(70% in-state, 30% import)
Peak Demand for Power (2011)	58,000 MW
Total Revenue to Distribution Companies (2011)	> $29 billion USD (Net Revenues not available)
Distribution Network	51,499km transmission lines 75 utilities or load-serving entities (including retailers) 77% of these customers are served by 3 large investor owned utilities.
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4 California AMI deployments

Overall AMI deployment across the USA is expanding, many with pilots in behind the meter technologies such as in-home displays and customer web portals, and many with dynamic pricing schemes. In 2011 the US Energy Information Administration reported over 37 million AMI meters, and over 45 million AMR meters in operation. Over 10.5 million of those AMI meters were in California, with another 0.5 million AMR meters in operation. California in particular has accelerated efforts through policy and programming since 2006, for smart grid investments supportive of conservation and renewable energy integration. As a result, a lot of regulatory and implementation issues have been dealt with in California first, before other states. Most notably, California has developed best practices for managing data and privacy issues in particular, and also managing deployment with alternative options such as opt-out availability. Four California utility experiences are presented in this case to illustrate the deployment of AMI under different smart grid drivers, and with different approaches: Sacramento Municipal Utility District (SMUD), Glendale Water and Power (GWP), Burbank Water and Power (BWP) and San Diego Gas and Electric (SDG&E). These four utilities serve about 2.2 million of the 15 million customers in California.

Each of these deployments includes smart meters and the associated communications networks, remote reading and control, data management systems, web portal customer interaction, and some form of dynamic pricing. They differ in size or scale, pricing scheme and in behind-the-meter capabilities such as in-home displays. A summary of the project descriptions are shown in Table 4 under Current Status & Results.

Objectives & Benefits

California smart grid policy is enacted in part through the California Public Utilities Commission (CPUC) which regulates the three large investor-owned utilities (IOUs). San Diego Gas & Electric is one of them with almost 1.4 million customers. While the CPUC does not have regulatory authority over the municipal utilities, such as the three outlined in this case, its regulation does set the tone across California for smart grid approaches and serves to identify best practices. When authorizing rate recovery from 77% of the California customers for AMI, the CPUC recognized the following benefits[11] to customers, the electricity system and the state from smart meters:

- Allows for faster outage detection and restoration of service
- Provides customers with greater control over their electricity use when coupled with time-based rates
- Allows customer to make informed decisions by providing highly detailed information
- Helps the environment by reducing the need to build power plants, or avoiding the use of older, less efficient power plants as customers lower their electric demand

[11] CPUC website, Benefits of Smart Meters: http://www.cpuc.ca.gov/PUC/energy/Demand+Response/benefits.htm

• Increases privacy because electricity usage information can be relayed automatically to the utility for billing purposes without on-site visits by a utility

While each of these benefits are written more from the perspective of the customer, AMI systems also generate significant operational benefits as described below. Together these customer and system benefits served to create the business case for AMI investment.

Looking at the four utilities presented in this case, each had a unique set of objectives. For example, BWP, responsible for water and power services, wanted a mesh network across the whole city. SMUD and SDG&E were driven more by demand for the integration of renewable generation. That notwithstanding, drivers common to each of their AMI deployments can be summarized as:

1. Operational efficiency and reliability
2. Customer satisfaction and engagement with more services

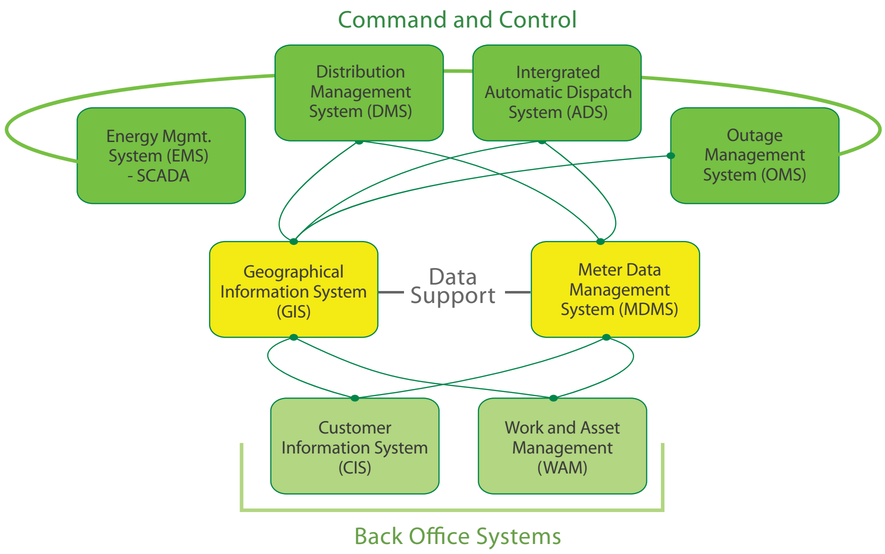
The initial focus was primarily on achieving system functionality. As will be discussed later in this case, however, the utility experience with AMI implementation in each of these deployments led to greater focus on customer satisfaction and engagement.

Building the Business Case & Measuring Success

The CPUC recognized smart meters as a key step toward creating a smart grid in California. By enabling greater visibility of grid performance, AMI is seen to contribute to greater reliability and resilience to outages and other problems on the grid. AMI can also allow utilities to meet various operational and customer satisfaction objectives, including conservation, customer control, environmental performance, customer service and privacy.

The technical systems underlying an exemplary AMI implementation are illustrated in Figure 14, which shows the BWP integration schematic. In the BWP deployment, the Meter Data Management System (MDMS) interconnects to 5 other operation and information systems. This tight integration supports a wide range of applications, which in turn supports the business case for the project. As BWP, SMUD, and GWP are municipal utilities, their respective city councils reviewed and approved their smart grid deployments, while the CPUC performed this role in the case of SDG&E.

Figure 14 : **BWP Smart Grid Key Operations and Information Systems**



Burbank Water & Power's Meter Data Management System (MDMS) is interconnected with its other operation and information systems. (Image source: B. Hamer, BWP)

The intended functionalities enabled by AMI are evident in the metrics designed to measure AMI functionality and progress toward achieving the stated benefits. The CPUC mandated in April 2012 that AMI metrics be reported by the IOUs each year, including:

- Number of smart meter malfunctions where customer electric service is disrupted;
- Number of utility owned smart meters supporting consumer devices with Home Area Network (HAN) or comparable consumer energy monitoring or measurement devices registered with the utility;
- Number of escalated customer complaints related to the accuracy, functioning, or installation of smart meters or the functioning of a utility administered HAN with registered consumer devices;
- Number of utility owned smart meters replaced annually before the end of their expected useful life;
- Number and percentage of customers with smart meters using a utility administered Internet or a web-based portal to access energy usage information or to enrol in utility energy information programs;
- Number of customers enrolled in time-variant electric vehicle tariffs;
- System-wide and total number of minutes per year of sustained outage per customer served; and,
- Total annual electricity deliveries from customer-owned or operated, grid-connected distributed generation facilities.

Half of these metrics focus on the delivery of services to customers, while the other half measure customer response to the delivery of services. This speaks to the challenge of making a business case centred only on customer value. While customer benefits are an important aspect to make the business case, these need to be coupled with operational benefits. Because a business case dependent on customer behaviour is not entirely predictable, the command and control and data management functionalities shown in Figure 14 bolster the value proposition for utilities. Thus, outside of these customer-focused metrics, operational savings are measured against the cost of deploying AMI such as reduced number of truck-rolls from AMR and outage management, and deferred asset investment based on more detailed information about demand profiles.

Current Status & Results

A summary of the drivers, current status and results of each of the four utility deployments of AMI are presented here. They are also outlined in Table 4.

Table 4 : California AMI Project Details

	Sacramento Municipal Utility District (SMUD*)	Glendale Water and Power (GWP)*	Burbank Water and Power (BWP)*	San Diego Gas & Electric (SDG&E)**
Customers Served	672,860	84,343	51,858	1,377,197
AMI meters	617,502	85,349	52,163	1,093,312
Web portal	Yes	Yes	Yes	Yes
Pricing	TOU; TOU + CPP; Tiered + CPP	TOU	TOU	TOU; CPP
IHD	4,079	15 (120 planned)	n/a	n/a
Remote Service	Yes	Yes	Yes	Yes
Approximate AMI cost	~$131 M	~$23 M	~$13 M	~$572 M***

*as of Feb 2013 **as of Dec 2010 *** includes non-meter communications infrastructure
Tier + CPP = Tiered Rate + Critical Peak Pricing; TOU = Time of Use Pricing; TOU + CPP = Time of Use + Critical Peak Pricing.

CASE 6. USA_California

Sacramento Municipal Utility District (SMUD)

As the second largest deployment presented in this case, SMUD's experience with AMI is interesting in that it includes the largest of the US Department of Energy funded consumer behaviour studies, with approximately 57,000 customers participating. In a randomized control trial SMUD is studying the effect of different rate combinations, in-home displays and mandatory, opt-in and opt-out deployment approaches on overall demand reduction. It is expected that these will be the largest most rigorous tests on how different technologies affect consumer behaviour, with results available in late 2013 or early 2014.

SMUD's AMI deployment is also part of a solar neighbourhood pilot, demonstrating some of the best communications between solar PV inverters and the meters. The PV integration project is described in the Future Steps section.

Drivers

- Operational efficiencies (reduced truck rolls and O&M costs, meter reading, deferred investment)
- Improved reliability and reduced line losses
- Solar PV integration

Current Status

- ~670,000 meters deployed with the network and billing systems in full operation
- Opt-out: $127 initial fee, and $14 per month recurring fee.

Complementary Technologies, Systems, and Processes

- Majority of Distribution Automation Systems installed, and will be fully operational summer 2014
- Solar PV and energy storage for smart grids with inverter – meter communication

Glendale Water and Power (GWP)

When GWP was planning for its AMI roll-out they realized that it would be the beginning of a much greater transition for the utility and the customers they serve. GWP embraced the opportunity with two years of internal preparation before launch. As one executive remarked, "For 100 years the utility worked in silos – customer service, technical, etc. It took 6 months to get people from different silos to come to meetings." During this time they paid careful attention to the impacts of an AMI program on unionized staff, and developed a plan where some work duties were changed, some were phased out and others were phased in. When it finally came time to launch, GWP adopted a "down home" approach to engaging their customers. Staff from the utility became a fixture in the park or in places around the community every week for citizens to come out and learn about smart meters prior to roll-out. They experienced virtually no push-back as a result (only about 0.25%), which is notable because there had already been a fair amount of negative response in other California service territories around that time.

Drivers

- Operational efficiency and loss prevention
- New customer services
- Planning for future systems

Current Status

- ~85,000 meters installed
- Out of 40,000 residential customers, ~100 on delay list

Complementary Technologies, Systems, and Processes

- Energy storage for peak shifting (162 thermal storage units ≈ 1.27 MW capacity)

Burbank Water and Power (BWP)

As was illustrated in Figure 14, BWP developed a plan that integrated its AMI within a plan for the administration, data management and control systems. Theirs is one of the few deployments with a mesh network backbone that covers the entire city. The resilience of this network will be compared with the hub and spoke type communications backbones adopted by other utilities.

Committed to their second driver of customer empowerment, BWP partnered with Opower, a company focused on customer-facing solutions and products, to engage customers in conservation and demand management programs. BWP's "Smart Choice" program tests varying ways to present energy use information to customers on their bills (and via a web portal) in order to encourage demand shifting or conservation.

Drivers

- Modernizing the business, communications systems, and delivery systems
- Empowering customers

CASE 6. USA_California

Current Status

- Cisco powered fiber optic network with a Trilliant / General Electric AMI meter system and eMeter Meter Data Management System
- Opt-out: $175 initial fee, and recurring $10 per month. Opt-out meters are digital meters with the radio modules removed

Complementary Technologies, Systems, and Processes

- Tropos city-wide wireless mesh network
- Thermal energy storage for peak shifting (19 Ice Bear rooftop thermal storage units at city and commercial and industrial sites); goal of 285 units ≈ 2MW of controllable demand
- 11 controllable plug-in hybrid electric vehicle (PHEV) charging points

San Diego Gas & Electric (SDG&E)

SDG&E stands out as having an outstanding AMI outreach and deployment methodology. Its "90/60/30" day communications plan prior to each community deployment now serves as a best practice adopted by many other utilities across the USA.

One of the early implementers, SDG&E had almost all of their meters deployed before federal stimulus funding was offered for smart meter deployment. This made them the first utility in the USA to cover their entire service territory with gas and electric smart meters. Taking the lead can also mean running into a lot of unanticipated challenges, but SDG&E also did two years of deep design work prior to doing any deployment. Customers were even involved in a co-design process prior to the first AMI deployment in 2009. Consistent with their commitment to customer engagement, SDG&E has also fully implemented the Green Button data platform, which is described later in the Future Steps section. Unsurprisingly, in California and the broader USA, SDG&E is known as a leader in AMI and smart grid for customer engagement.

Drivers

- Early drivers (pre-2009): safety, reliability and efficiency
- Current drivers: leveraging AMI for distributed generation and customer energy efficiency

Current Status

- Fully implemented Green Button data platform
- High satisfaction: 0.016% claims & complaints rate; 0.05% of customers joined the "delay list"

- Opt-out program in place (initial $75 fee + monthly $10 charge. Low-income customers may opt out at reduced rates: initial $10 fee + monthly $5 charge.)

Complementary Technologies, Systems, and Processes

- 57,000 programmable controllable thermostats

Lessons Learned & Best Practices

Customer Engagement

A lot of the early messaging with smart meter deployment was around conservation and savings. Since then, the messaging has become more tempered to allow for fluctuations in customer bills for unrelated reasons. For example, weather-related billing spikes following the installation of smart meters, can incorrectly lead customers to attribute the billing spike to smart meters. This serves as a reminder that unrelated (e.g. weather) events can impact customer perception of AMI benefits.

In this light, one lesson learned is the relationship between customer engagement and operational benefits. Specifically, utilities that aim to achieve operational benefits that are evident the consumer, such as faster restoration times, find better value in their investments.

Customer communication has also become more sophisticated by using different methods appropriate to reaching different customer segments. SDG&E's 90/60/30 plan is a good example of how to employ frequent messaging with different channels to facilitate a positive customer experience. The language has become more direct, avoiding jargon, to help customers understand new systems and realize their benefits. Addressing customer privacy concerns early, with fair, transparent and progressive privacy principles, is an example of how to avoid potential customer opposition. The intended customer benefits become even more transparent when they're measured and reported on by the utility to their customers.

Finally, for those customers with concerns that can't be resolved through outreach and engagement, opt-out provisions within the AMI deployment plan are increasingly a standard component adopted by utilities. Regulatory authorities have recognized the value of customer choice in this regard.

Organizational Change

Utilities have recognized that AMI deployment is not simply about installing new technologies. It marks a shift in the function of the grid, the services the utilities provide, and a shift in the customer-utility relationship. All of this stimulates organizational change for the utility. The most successful utilities in this respect created a strategy for internal utility change management. This strategy included details such as investing in staff training for customer service and field personnel to be well informed about the full range of smart grid and AMI issues and benefits.

System Integration

Utilities have recognized that AMI deployment is not simply about installing new technologies. It marks a shift in the function of the grid, the services the utilities provide, and a shift in the customer-utility relationship. All of this stimulates organizational change for the utility. The most successful utilities in this respect created a strategy for internal utility change management. This strategy included details such as investing in staff training for customer service and field personnel to be well informed about the full range of smart grid and AMI issues and benefits.

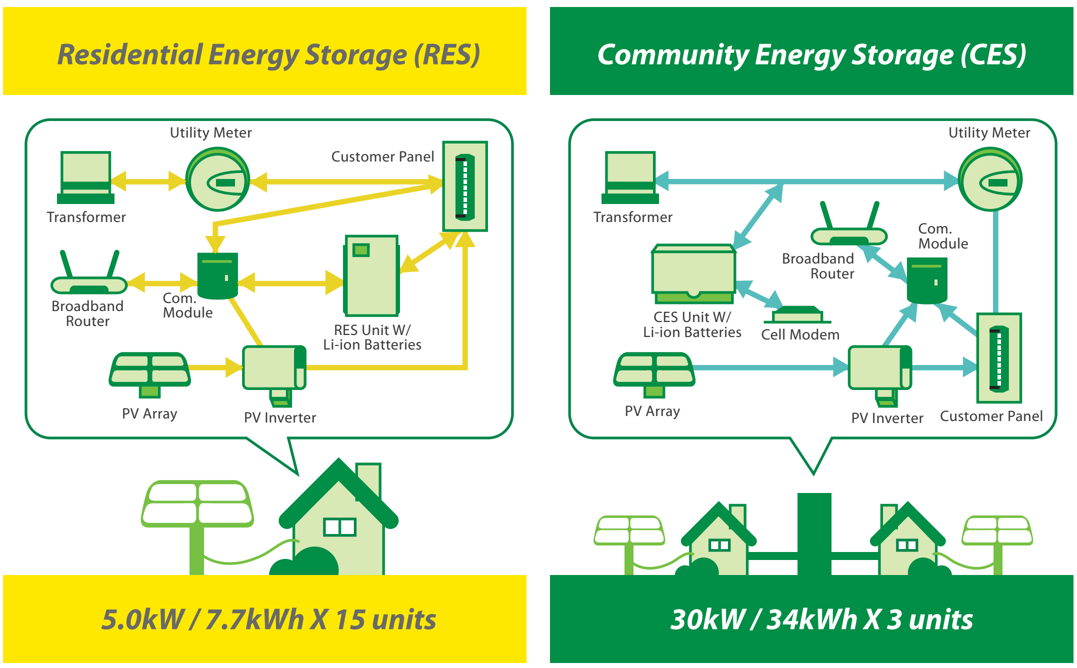
Business Case

The impact of AMI goes far beyond the direct customer benefits of billing. While these benefits are important to measure, it is also important for utilities to recognize the value of complementary technologies, systems and processes that leverage the value of AMI. For example, AMI provides cost effective outage management, grid visibility and solar PV integration capabilities. This is important to consider because while the AMI business model pays for itself in many cases with direct benefits, standing issues of declining utility revenue margins may require a new regulatory paradigm to support ongoing smart grid integration. Performance-based regulation would assign value to the added capabilities that investment in AMI coupled with other smart grid technologies can offer.

Future Steps

Looking ahead to emerging technologies enabled by AMI, California utilities are participating in some exciting initiatives. The Green Button initiative and solar neighbourhood pilot are examples of ways that AMI is stimulating innovation for customers to participate with both demand-side and supply-side technologies on smart grids.

Figure 15 : **PV and Energy Storage Demonstration at Anatolia Subdivision**



Sacramento Municipal Utility District solar PV and Storage with AMI pilot in partnership with the National Renewable Energy Laboratory

The solar neighbourhood in SMUD's network showcases one of the best communications between solar PV inverters and customer smart meters. When a meter gets a signal from the transformer that there is network congestion, it tells the inverter to start feeding the solar electricity into a battery so as to reduce distribution voltage violation. With this capability, smart integration of solar PV can defer overall distribution system upgrades.

CASE 6. USA_California

The Green Button Initiative, already available for all SGD&E customers, grants customers transparent, timely access to their energy usage data. Customers can download up to 13 months of their personal electricity data in an XML file from the utility website. Customers then can choose to share this data with third parties of their choice, which opens the door for entrepreneurs and customer service companies to offer competitive solutions for customers to manage their energy use.

Key Directives, Legislation and Further Resources

CPUC rulings: http://www.cpuc.ca.gov/PUC/energy/smartgrid.htm

July 2006: California Public Utility Commission (CPUC) approves first major IOU AMI deployment (PG&E)

April 2007: CPUC approves SDG&E smart meter proposal

September 10, 2009: CPUC expedites review process for smart grid funding under Recovery Act

July 2011: CPUC adopts privacy and security rules aligned with "Fair Information Practice" principles

Sept 2011: CPUC mandates a "delay list" for IOUs to allow customers to temporarily delay installation

April 2012: CPUC mandates an "opt-out" provision for SDG&E and Southern California Edison

Oct 2012: CPUC mandates HAN data be made available to consumers

The Green Button Initiative: *http://www.greenbuttondata.org/*

California's Electricity Grid Policy

California's policy and regulation has been supportive of smart meter deployment, with a provision for handling customer cases for delaying or opting-out of smart meter installation. The California Public Utilities Commission (CPUC) was the first state regulator to adopt privacy rules for customer smart meter data. The privacy rules are centred on the Fair Information Practice Principles adopted by the Department of Homeland Security. Other states are now following California's lead.

Furthermore, the CPUC required the 3 major investor-owned utilities in California to create a roadmap for modernizing their infrastructure. Since 2011, these utilities have been submitting 10 year smart grid deployment plans outlining their vision for 1) Smart Customer, 2) Smart Market, and 3) Smart Utility under the California policy framework for smart grid.

California also has aggressive renewable energy goals which drive some of the direction of smart grid strategy. With a goal of 20 GW of renewable energy capacity by 2020 (12 GW DG, 8 GW utility-scale), California has targeted to have renewable energy make up 20% of the supply capacity by 2010, 25% by 2013, and 33% by 2020.

CASE 6. USA_California

While the drivers for smart grid policy and planning vary from state to state and by utility, investment in smart grid technology throughout the US has been bolstered by national funding. The Smart Grid Investment Grant program, which began in 2009, has funded 50% of projects in the US, 62 of which are AMI projects with smart meters, communications networks, hardware and systems related deployment.

※ Sections of this case taken from California Public Utility Commission documents, DOE sponsored Peer-to-Peer workshop findings, and presentations by each of the 4 utilities.

Conclusion

This first ISGAN Case Book focused on AMI technologies, and featured cases in pilot, partial and full deployment stages. In this way, the range of cases are representative of the current global experience with AMI as part of a smart grid strategy. The Key Findings highlighted lessons learned common to the cases presented, and best practices that are beginning to emerge in regions of the world. All of the key findings relate to issues around the evolving customer role in smart grids and the business case based on system functionality and creating value.

Best practices around customer engagement and AMI deployment will continue to emerge as other aspects of smart grid develop and leverage AMI capabilities. These cases will provide an important comparison to other regions with less existing infrastructure that are approaching smart grid development differently. ISGAN will continue to publish AMI and other smart grid case studies, to be published in future Case Books and made available online at www.iea-isgan.org.

Further reading and resources

Readers are encouraged to explore the following resources for AMI experiences and studies, and national approaches smart grid policy :

ISGAN Annex 1: Smart Grid Drivers and Technologies by Country, Economies, and Continent : *www.iea-isgan.org*

European Commission October 2011 Report on: Set of common functional requirements of the smart meter:
http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/2011_10_smart_meter_funtionalities_report_full.pdf

International Confederation of Energy Regulators April 2012 Report on Experiences on the Regulatory Approaches to the Implementation of Smart Meters :
http://www.iern.net/portal/page/portal/IERN_HOME/ICER_HOME/ABOUT_ICER/ICER_at_WFERV/Reports/ICER%20Report%20on%20Smart%20Metering

The Global Smart Grid Federation 2012 Report :
http://www.globalsmartgridfederation.org/documents/GSGFreport_stateofworldsmartgrid_4_26_12_000.pdf

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