The Study of Addressing Challenges of AMI Deployment in APEC

APEC Energy Working Group
Expert Group on New and Renewable Energy Technologies

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Executive Summary

The purpose of this research is to investigate the major challenges of AMI deployment in all APEC economies and identify effective AMI polices and best practices. Two dimensions are put forward including: (1) A questionnaire survey and analysis of AMI development in APEC region; (2) A review of AMI development experience of Ireland, America and Australia as the case studies. Based on the above, we have provided guidelines and suggestions for rational foundation of deploying AMI policy as a reference for APEC members on developing relevant policies.

Survey Findings

The content of questionnaire consists of five aspects including basic background, policy, economy, technology and society. The questionnaire was designed to identify the key success factors of AMI deployment in APEC economies. There are in total 27 questionnaires distributed, and a total number of 6 respondents completed and returned the questionnaires.

From the survey, most of APEC economies have the similar policies for reducing meter reading costs. In addition, the effect of reducing electricity theft and introduction of dynamic pricing systems are positive effects from AMI deployment. To promote AMI installation, Japan emphasizes the policy of enhancing customer service, for example, the privacy issue is relatively important. Most APEC members have implemented dynamic pricing programs after smart meter roll-out. From our survey results, AMI financial issue is the most common challenge among APEC members in smart meter roll-out. For example, China, Hong Kong and New Zealand specifically point out that they all face this problem; however, Australia points out that the technical issue of deploying AMI is one of the critical challenges. On the other hand, New Zealand points out that the challenge of satisfying distribution and retailer needs is prominent.

There are some basic types of smart meter costs: capital cost of meters, inspection cost of meters, meter installation cost, meter operation and maintenance cost and communication set-up cost. In our survey, we found that the average capital costs of smart meters from six respondents run about US$250 per meter, with ongoing costs range roughly from US$10 to US$20 per meter per year. The benefits of installing AMI include reducing the theft of electricity, avoiding costs of routine manual reading and energy saving. For example, benefits of load detection and outage detection in China, Chinese Taipei and Australia are emphasized. While reducing the cost of manual disconnections and mitigating CO_2 emission are the costs to be avoided in Japan and Chinese Taipei.

In the technical aspect, six respondents all reflect that the two-way communications to the metering system and remote disconnection and connection are the basic and essential functions for AMI. Other required functions are interval metering data measurement, supporting load management (e.g. time-of-use rates) and loss of load detection and outage location identification. The most common communication technologies applied to smart meter communication network are GPRS and Zigbee, WiMax and RF Mesh as the secondary common technologies.

From our survey results, we know that safety and privacy issues are also the main concerns of the customers. Almost every respondent stresses these two concerns. These are the key social challenges for AMI deployment.

Case Analysis

We choose America, Australia and Ireland as our case studies. As of May 2012, U.S. utilities had installed roughly 36 million smart meters nationwide, and approximately 65 million smart meters will be deployed by 2015. But there are several problems such as installation errors, data storage and privacy of advanced metering data, radio frequencies on health and smart meters hacked in California are drawing a lot of attentions. On February 1, 2012, California Public Utilities Commission (CPUC) announced a new policy which allowed PG&E customers to retain their analog meters or have 'smart' meters replaced with analog meters by paying a one-time fee of $75 and a monthly fee of US$10 (US$10 up front and US$5 per month for low income California residents). This decision also authorizes PG&E to establish a new two-way electric and gas Modified Smart Meter Memorandum Accounts to track revenues and costs associated with providing the opt-out option until a final decision on recoverable costs and cost allocation is adopted.

In Australia, Victoria is the earliest jurisdiction that rollouts the biggest scale of AMI program in nation. Furthermore, there is a national AMI cost-benefit report identifying a positive net benefit for Victoria; however, the cost-benefit analysis behind the AMI decision was not comprehensive enough to provide all aspects of the economic dimensions of the AMI program. The Victoria case study, therefore, highlights some lessons for APEC economies that a comprehensive cost-benefit analysis including risk management and consumer protection should be considered.

Ireland emphasizes technology trial and demand response management during the beginning stage of AMI deployment plan. The statistical evidence from the Residential Customer Behaviour Trial is that the deployment of Time of Use tariffs in combination with other Demand Side Management stimuli results in a change in energy consumption. Specifically, the residential trial participants achieved reductions in electricity consumption, both overall and at times of peak usage. After the case analyses, several key success factors are presented for AMI roll-out from these economies.

Challenges for AMI deployment

One of the most important challenges for making a decision on AMI deployment program is to conduct a thorough cost-benefit analysis (CBA) based on the feasible alternatives. There are a couple of key components must be clearly evaluated before a CBA can be made. In order to carry out a more complete CBA, detailed information on all possible costs and benefits is needed as input data. As the result of a CBA can be strongly influenced by the selection, definition and specification of the input data, this step is crucial in avoiding bias in favor or against AMI deployment program.

In summary, the challenges facing AMI deployment include the followings:

- High cost of deploying smart meters. Deploying smart meters requires huge capital investment and hence it is crucial that the utility company is confident of successful implementation.
- Large scale of deployment of Smart Meters. The deployment of smart meters in such a huge volume demands a very highly organized system with properly managed inventory control.
-Data privacy. There are many concerns related to privacy of consumption data being raised as Smart Meters are installed at more and more locations. The meters' data can be mined to reveal details about customers' habits like when they eat, how much television they watch and what time they go to sleep.
- Dynamic adaptation and flexibility of roll-out plan. As is the case with any large transformation program, the carefully crafted requirements document, which is signed off and approved after much deliberation, becomes obsolete from the day the project begins. Dynamic adaption and flexibility of roll-out plan are always a big challenge for massive deployment of AMI.
- Cost-Benefit Analysis. One of the most important challenges for making a decision on AMI deployment program is to conduct a thorough cost and benefit analysis, based on the feasible alternatives. The scope and the items of cost and benefit associated with AMI are sometimes not easy to be identified.
-Healthy and privacy of consumers. Health and Privacy concerns surrounding smart meter technology arise from the meters' essential functions.

Principles for AMI Deployment Policy

Planning stage:

(1) Economic efficiency – the roll-out plan as elaborated in the previous chapter should be cost effective or benefit cost analysis justifiable.

(2) Societal equity – although the large customer with more electricity consumption should be more appropriate for installing AMI and smart meter, a comprehensive roll-out plan should cover all kinds of customers in order to full-fill the empowerment and choices of every consumer without social prejudice.
(3) Sustainable development - AMI is essential to encouraging renewable energy deployment transiting industries to low-carbon and clean-energy patterns, creating new "green jobs" for more employment, and building an infrastructure for long-term sustainable economic development.
(4) Security, privacy and health concerns – although AMI provides greater visibility of and control over the energy usage empowering customers to reduce their energy costs, the issues of cyber security, privacy and health concerns must be treated deliberate allow the consumers to opt-out from choosing smart meters.

Implementation stage:

(1) Standardization - There are a couple of AMI standards in this area. The government should considering an AMI standard format for themselves and power companies to analyze justifiable benefit/ cost.
(2) Interoperability – Standards of AMI must allow for interoperability. Ensuring systems and devices are fully interoperable from day one holds the key to the success of the smart metering program.
(3) Timing - Each AMI standard has different product maturity. In order to cost-down learning curve, the decisions must be continually adjusted, and quality stabilization must be enhanced.
(4) Cost-Benefit Analysis – One of the key challenges for making a decision on AMI deployment program is to conduct a thorough cost and benefit analysis, based on the feasible alternatives.

Guidelines for APEC Economies of Smart Metering Deployment

- *Public awareness and education:* Before deploying AMI, education and dissemination for public awareness of the benefits of AMI is very important.

- *Comprehensive plan:* It includes the target number of installed smart meter, reasonable timetable and a feasible financial plan.

- *Demand response program:* As power delivery becomes more flexible, variable tariffs should be adopted to reflect immediate supply and demand

- *Proper policy for important stakeholders:* Obligation and the rights of each stakeholder should be clearly defined. Provide opportunities for communication and mutual understanding.

- *Concerns on privacy and cyber security:* MDM including data warehouse maintenance and accessibility, also data security and network security of the grid, should be carefully addressed and dealt with.
- *Cost-benefit analysis:* It is important to estimate benefit cost ratio and net present value from the consumer side, who installs the smart meter or AMI. The perspective from electric utility or the administrator is equally important. Particularly from the view point of societal as a whole, policy makers may ultimately care for.

Acronyms and Abbreviations

ACMA	Australian Communication and Media Authority
AER	Australian Energy Regulator
AEMC	Australian Energy Market Commission
APEC	Asia-Pacific Economic Cooperation
AMI	advanced metering infrastructure
ANEEL	Agência Nacional de Energia Elétrica
BPL	broadband over power lines
CAISO	California Independent System Operator
CBA	cost benefit analysis
CBT	Customer Behavior Trials
CEC	California Energy Commission
CER	Commission for Energy Regulation
COAG	Council of Australian Governments
CO_2	carbon dioxide
CPA	California Power Authority
CPUC	California Public Utilities Commission
C&LM	Conservation and load management
DCENR	Department of Communications, Energy and Natural Resources
DER	distributed energy resources
DOE	Department of Energy
DOI	Department of Infrastructure
DPI	Department of Primary Industries
DSM	demand side management
DTF	Department of Treasury and Finance
EAP	Energy Action Plan
EEI	Edison Electric Institute
EMFs	electromagnetic fields
EnC	Energy Community
EPACT	Energy Policy Act
ERGEG	European Regulators' Group for Electricity and Gas
ESC	Victorian Essential Services Commission
ESRI	Economic and Social Research Institute
EU	European Union
FEA	Free Electricity Allowance
FERC	Federal Energy Regulatory Commission
GGP	Guidelines of Good Practice

HAN	Home Area Networks
IEPR	Integrated Energy Policy Report
IHD	in-home display
IT	information technology
IOUs	investor owned utilities
ISG	AMI Industry Strategy
KEMA	Keuring Van Elektrotechnische Materialen
KEPCO	Kansai Electric Power Company
MCE	Ministerial Council on Energy
MDMS	meter data management systems
MID	Measuring Instruments Directive
MPRs	market price referents
NEEAP	National Energy Efficiency Action Plan
NEL	National Electricity Law
NEM	National Electricity Market
NER	National Electricity Rules
NIAUR	Northern Ireland Authority for Utility Regulation
NIB	Nordic Investment Bank
NPV	net present value
NRAs	National Regulatory Authorities
OIC	Orders-in-Council
OLR	Overall Load Reduction
PG&E	Pacific Gas and Electric Company
PLC	Power Line Carrier
RF	Radio Frequency
RPS	Renewable Portfolio Standard
SDG&E	San Diego Gas and Electric Company
SEAI	Sustainable Energy Authority of Ireland
SEM	Single Electricity Market
SMEs	small and medium enterprises
TOU	Time of Use
TEPCO	Technical Projects Company
WAN	Wide Area Network

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1.0 Introduction

1.1 Background

The traditional method of changing electric energy consumption is termed as Demand-Side Management (DSM), transferring the electricity consumption from peak load period to off-peak period by electric customers. However, under the development of Advanced Metering Infrastructure (AMI), Demand Response (DR) can ease the integration of renewable generation and central power supply from the utility generation, by curtailing consumers' electricity use to cope with instability of renewable power. In addition, storage technologies can be applied on the transmission and distribution system to regulate intermittency from renewable power output and maintain system voltages at reliable levels. Architecture of AMI is the key to integrate different aspects of the smart grid, including demand response and distributed power supply from renewable energy as well as battery energy storage system. A collaborative effort among all the stakeholders is needed to develop a smart grid vision.

The application of AMI technology promises to provide benefit to electricity consumers and our economies by better utilizing electric system assets to securely satisfy consumer energy demands at a lower monetary and environmental cost. This report reviews the status of the deployment of AMI technologies within APEC economies, and in particular, discusses the potential application of this technology to enhance the integration of renewable energy and energy storage, and to advance greater levels of energy efficiency.

The global market for AMI is supported by various different economies, whose governments are gradually increasing their interest in energy efficiency. Increasingly, individual homeowners are being looked for independent efficient energy use. Smart meters and associated accessories enable consumers to be aware of their energy usage in real-time, and take appropriate action to cut down. Those economies which are implementing smart meters have formulated new legislation that supports the deployment of the technology. Governments and utilities, such as the US government and Korea's utility KEPCO, have introduced grants and funding for smart meter deployment, and these are expected to drive the market in the future.

AMI technology uses digital technology and communication to coordinate the actions of intelligent devices and systems throughout the electricity system: from large scale generation networked with transmission infrastructure, to the distribution of power to consumers (factories, commercial buildings, and residences), and down into the equipment and systems that use electricity in these facilities. Through automation, better information, and coordination, AMI technology helps to provide the flexibility to integrate variable generation that is a characteristic of some renewable resources such as wind and solar generators. AMI technology can also enhance efficiencies in the transmission and distribution delivery infrastructure, generation, and end-use systems by optimizing system performance and increasing asset utilization.

The key geographies of AMI include the Australia; Canada; China; Japan; Korea; US; Italy; Spain; UK; Ireland; France. ,The US currently accounts for around 56% of the global AMI market, followed by China with roughly a 23.9% share. China is expected to lead the global AMI market after 2014, as most of the US smart meter deployment is expected to be completed by then. Grants from the State Grid Corporation of China, the large consumer base, and policy initiatives promoting grid modernization and smart metering are major drivers behind the 2012 national growth rate of 30% in the smart meter market.

1.2 Purpose of Research

The purpose of this research is to investigate and confer the development strategies and current status of AMI in all APEC economies and identify effective AMI polices and best practices. Based on the analysis in the research, we find out some challenges for AMI deployment including AMI cost and benefit analysis. Guidelines to economies and industry for AMI deployment are offered in this research. We hope these guidelines and suggestions can provide well information in implementing AMI.

AMI saves energy and AMI technology has great potential, in many ways, the AMI is about reducing wasted energy. That's not just good policy; it's also good business. The smart meter in AMI is such a massive infrastructure project with lots practical applications that we offer some outlook of the areas for further study at the end of this research.

1.3 Research Methodology

This research provides information for APEC members to better understand the potential of AMI to increase the usage of renewable energy and energy efficiency in their economies in a manner appropriate for their populations and development needs. The approach is taken to create the document first and gather information from two sources:

- **A questionnaire survey and analysis of advanced metering infrastructure development in APEC region.**

- **A review of advanced metering infrastructure development in Ireland, American and Australia as case studies.**

The first item is used to assess APEC member implementation AMI statue. The second item assesses how these economies roll-out AMI and practices are being used. The case studies also identify key success factors or lessons we learned from these economies.

The findings from these sources are then combined to develop guidance on how AMI can be best used to enhance the use of renewable energy and energy efficiency across the APEC region.

1.4 Definition of AMI

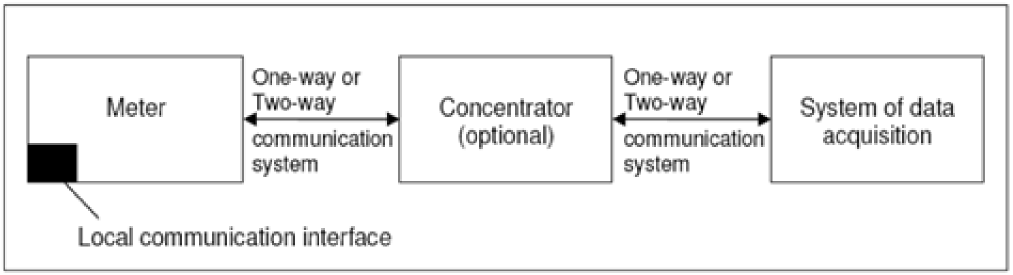
1.4.1 What is Smart Metering?

"An intelligent metering system or 'smart meter' is an electronic device that can measure the consumption of energy, adding more information than a conventional meter, and can transmit data using a form of electronic communication. A key feature of a smart meter is the ability to provide bidirectional communication between the consumer and supplier/operator. It should also promote services that facilitate energy efficiency within the home. The move from old, isolated and static metering devices towards new smart/active devices is an important issue for competition in energy markets. The implementation of smart meters is an essential first step towards the implementation of smart grids."

It is important to note that 'smart metering' encompasses more than just the meter itself. Smart metering should be viewed as a system rather than a single device. It is essentially a hybrid technology consisting of three high level layers:

- Physical meters and associated devices
- Communications layer covering data transport and communications network management
- IT systems which manage the data, applications and services

The following diagram (Figure 1.1) illustrates the general structure of a smart metering system.



(Source: Figure 6, ERGEG Status Review of Regulatory Aspects of Smart Metering)

Figure 1.1 General structure of a smart metering system

Smart meters are the next generation of meters, which can replace existing electro-mechanical meters and offer a range of benefits for both the individual electricity and gas consumer and for the electricity and gas systems in general. The existing standard mechanical meter records the total amount of electricity/gas used over time. These meters are read manually and the information is sent to the network company and then used to calculate customer bills. If a meter reader does not have access to the customer's meter, estimated consumption information (or a reading provided by the customer) is used to calculate the bill. If the estimated consumption is higher or lower than the actual meter read, this is corrected for when the meter is next read by the customer or the meter reader.

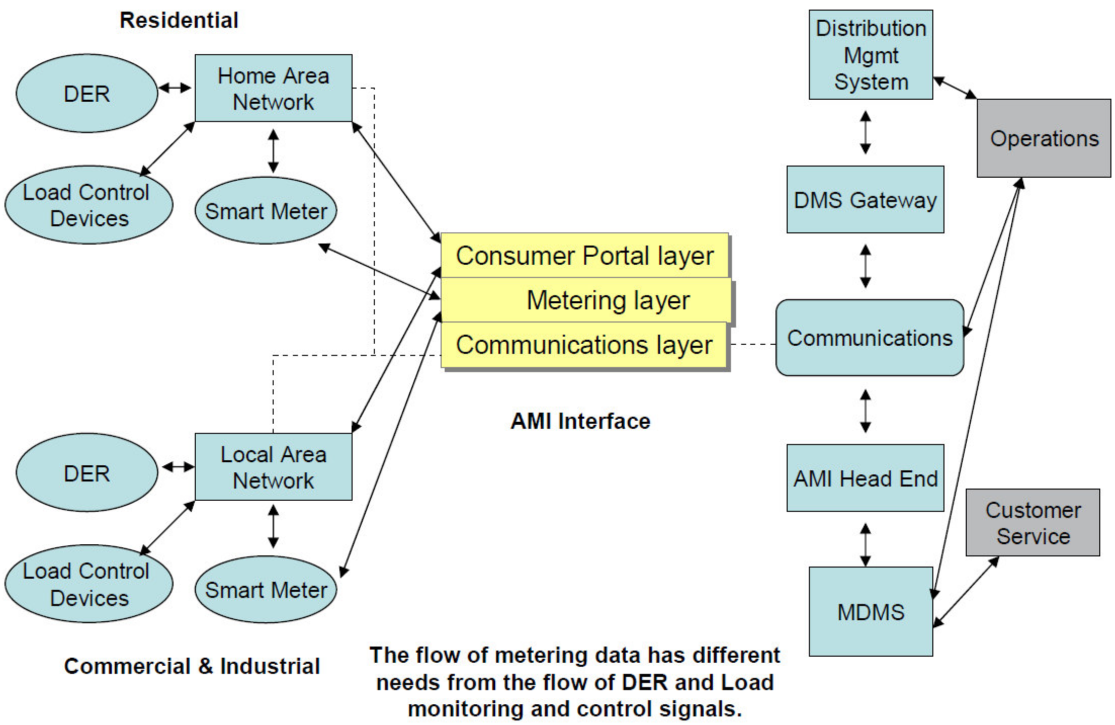
A smart meter is much more sophisticated. It records customers' actual use of electricity/gas over short intervals (e.g. every 30 minutes). These meters are connected by a communications system to the network company / meter data collector providing the operator with automated, up-to-date information on the amounts of electricity/gas used by customers. Access to this information provides opportunities to reduce network operation costs, including reduced costs of visiting customer premises to manually read the meter and carrying out any necessary connections and disconnections. There are also savings due to reductions in technical losses and theft.

The data collected from smart meters can be used by electricity and gas suppliers, subject to data protection requirements, to deliver useful information to their customers regarding their electricity and gas consumption and costs. In particular, the installation of smart metering will allow electricity suppliers to create innovative pricing arrangements that can be offered to customers to support the efficient use of electricity, such as time-of-use electricity tariffs. This is where the price of electricity varies at different times of the day to reflect the changes in the costs of producing electricity. This will allow customers to manage their consumption of electricity in line with price movements and demand patterns.

Smart meters can facilitate improving 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.

1.4.2 System Structure

AMI infrastructure includes home network systems, including communicating thermostats and other in-home controls, smart meters, communication networks from the meters to local data concentrators, back-haul communications networks to corporate data centers, meter data management systems (MDMS) and, finally, data integration into existing and new software application platforms. Additionally, AMI provides a very “intelligent” step toward modernizing the entire power system. Figure 1.2 below graphically describes the AMI technologies and how they interface:



(Source: Figure 4, NETL Modern Grid Strategy Powering our 21st-Century Economy, Advanced Metering Infrastructure 2008)

Figure 1.2 Overview of AMI

At the consumer level, smart meters communicate consumption data to both the user and the service provider. Smart meters communicate with in-home displays to make consumers more aware of their energy usage. Going further, electric pricing information supplied by the service provider enables load control devices like smart thermostats to modulate electric demand, based on pre-established consumer price preferences. More advanced customers deploy distributed energy resources (DER) based on these economic signals. And consumer portals process the AMI data in ways that enable more intelligent energy consumption decisions, even providing interactive services like prepayment.

The service provider (utility) employs existing, enhanced or new back office systems that collect and analyze AMI data to help optimize operations, economies and consumer service. For example, AMI provides immediate feedback on consumer outages and power quality, enabling the service provider to rapidly address grid deficiencies. And AMI's bidirectional communications infrastructure also supports grid automation at the station and circuit level. The vast amount of new data flowing from AMI allows improved management of utility assets as well as better planning of asset maintenance, additions and replacements. The resulting more efficient and reliable grid is one of AMI's many benefits.

1.4.3 Functions

We make the definition of AMI by basic and advanced, as the following table:

Table 1.1 Definition of AMI

	Basic	Advanced
Functions	AMI is a metering and information technology (IT) system.	AMI is an integration of technologies that provides an intelligent connection between consumers and system operators.
Benefits	1. Establishes communications with the consumer 2. Provides time stamped system information	1. Integrated Communications 2. Sensing and Measurement 3. Advanced Control Methods 4. Advanced Grid Components 5. Improved Interfaces & Decision Support

(Source: Figure 3 and p14, NETL ADVANCED METERING INFRASTRUCTURE 2008)

AMI is also known as "smart meters" - is a metering and information technology (IT) system. It is not a single technology implementation, but rather a fully configured infrastructure that must be integrated into existing and new utility processes and applications.

Then we focus on the information of smart meter, AMI communications infrastructure and home area networks to introduce the functions of AMI.

Conventional electromechanical meters served as the utility cash register for most of its history. At the residential level, these meters simply recorded the total energy consumed over a period of time – typically a month. Smart meters are solid state programmable devices that perform many more functions, including most or all of the following:

1. Time-based pricing
2. Consumption data for consumer and utility
3. Net metering
4. Loss of power (and restoration) notification
5. Remote turn on / turn off operations
6. Load limiting for "bad pay" or demand response purposes
7. Energy prepayment
8. Power quality monitoring
9. Tamper and energy theft detection
10. Communications with other intelligent devices in the home

And a smart meter is a green meter because it enables the demand response that can lead to emissions and carbon reductions. It facilitates greater energy efficiency since information feedback alone has been shown to cause consumers to reduce usage.

AMI Communications Infrastructure

About the AMI communications infrastructure, it supports continuous interaction between the utility, the consumer and the controllable electrical load.

It must employ open bi-directional communication standards, yet be highly secure. It has the potential to also serve as the foundation for a multitude of modern grid functions beyond AMI. Various architectures can be employed, with one of the most common being local concentrators that collect data from groups of meters and transmit that data to a central server via a backhaul channel. Various media can be considered to provide part or all of this architecture:

1. Power Line Carrier (PLC)
2. Broadband over power lines (BPL)
3. Copper or optical fiber
4. Wireless (Radio frequency), either centralized or a distributed mesh
5. Internet
6. Combinations of the above

Power Line Communication (PLC) and Radio Frequency (RF) are the most commonly used communication technologies for AMI networks in Europe and North America. However, most of the utilities in these regions rely on cellular communication technology for the Wide Area Network (WAN) communication. In Europe, economies such as Italy and Sweden, who are pioneering the deployment of AMI, have opted for PLC communication technology as the most economical solution in areas with a high population density.

Future inclusion of smart grid applications and potential consumer services should be considered when determining communication bandwidth requirements.

Home Area Networks (HAN)

A HAN with a consumer portal to link smart meters to controllable electrical devices. Its energy management functions may include:

1. In-home displays so the consumer always knows what energy is being used and what it is costing
2. Responsiveness to price signals based on consumer-entered preferences
3. Set points that limit utility or local control actions to a consumer specified band
4. Control of loads without continuing consumer involvement
5. Consumer over-ride capability

The HAN/consumer portal provides a smart interface to the market by acting as the consumer's "agent." It can also support new value added services such as security monitoring. A HAN may be implemented in a number of ways, with the consumer portal located in any of several possible devices including the meter itself, the neighborhood collector, a stand-alone utility-supplied gateway or even within customer-supplied equipment.

1.4.4 Benefits

AMI provides benefits to consumers, utilities and society as a whole.

Consumer Benefits

For the consumer, this means more choices about price and service, less intrusion and more information with which to manage consumption, cost and other decisions.
It also means higher reliability, better power quality, and more prompt, more accurate billing. In addition, AMI will help keep down utility costs, and therefore electricity prices. And, as members of society, consumers also reap all the benefits that accrue to society in general, as described below.

Utility Benefits

Utility benefits fall into two major categories, billing and operations.
AMI helps the utility avoid estimated readings, provide accurate and timely bills, operate more efficiently and reliably, and offer significantly better consumer service. AMI eliminates the vehicle, training, health insurance, and other overhead expenses of manual meter reading, while the shorter read-to-pay time advances the utility's cash flow, creating a one-time benefit. And consumers' concerns about meter readers

on their premises are eliminated.

Operationally, with AMI the utility knows immediately when and where an outage occurs so it can dispatch repair crews in a more timely and efficient way. Meter-level outage and restoration information accelerates the outage restoration process, which includes notifying consumers about when power is likely to return.

Using AMI, the utility can receive significant benefits from being able to manage customer accounts more promptly and efficiently, starting with the ability to remotely connect and disconnect service without having to send personnel to the customer site. Similarly, many maintenance and customer service issues can be resolved more quickly and cost-effectively through the use of remote diagnostics. And AMI enables new programs and methods for creating and recovering revenue such as distributed generation and prepayment programs.

AMI also provides vast amounts of energy usage and grid status information that can be used by consumers to make more informed consumption decisions and by utilities to make better decisions about system improvements and service offerings.

Instead of relying on rough estimates, engineers armed with AMI's detailed knowledge of distribution loads and electrical quality can accurately size equipment and protection devices, and better understand distribution system behavior. This huge increase in valuable information helps the utility:

1. Assess equipment health
2. Maximize asset utilization and life
3. Optimize maintenance, capital and O&M spending
4. Pinpoint grid problems
5. Improve grid planning
6. Locate/ identify power quality issues
7. Detect/reduce energy theft

Societal Benefits

Society, in general, benefits from AMI in many ways. One way is through improved efficiency in energy delivery and use, producing a favorable environmental impact. It can accelerate the use of distributed generation, which can in turn encourage the use of green energy sources. And it is likely that emissions trading will be enabled by AMI's detailed measurement and recording capabilities.

A major benefit of AMI is its facilitation of demand response and innovative energy tariffs. During periods of high energy demand, a small reduction in demand produces a relatively large reduction in the market price of electricity. And reduced demand can avoid rolling blackouts. According to Edison Electric Institute (EEI), the direct costs (e.g. power costs) of rolling blackouts in California have been estimated at tens of millions of dollars. Business and consumer losses may be many times higher. Hence, a modest demand response capability could produce a societal benefit worth billions of dollars.

The benefits accrued may vary depending on the type of demand response programs initiated. For instance, demand response distributed to the individual premise in forms like thermostat and pool pump control allows load to be reduced without sacrificing consumer satisfaction. However, even just shifting demand away from peak hours through time-of-use tariffs can have major benefits, including the reduced cost to both utilities and consumers by deferring building new, expensive peak generation facilities.

There is also a societal fairness issue that AMI addresses. Modern AMI meters maintain their accuracy over time, resulting in a more equitable situation for all consumers. In addition, modern meters are self monitoring, making it easier to identify inaccurate measurements, incorrect installations and, especially, electric energy theft.

As reported by Edison Electric Institute (EEI), price and demand reductions during high-demand periods lead to:

1. Reduced

(1) peak capacity requirements

(2) congestion costs

(3) T&D costs

(4) electrical losses

(5) generation costs

(6) market influence by any one supplier

2. Improved

(1) electric system efficiency (lower operating costs)

(2) electric system reliability (lower maintenance costs)

(3) settlement data management

1.5 About this document

The smart grid area is undergoing rapid change. The concepts themselves are being reconsidered as they adapt to address economic, geographical, climate, cultural, and political differences within APEC and the world. This situation, together with the fast changing nature of AMI technologies, creates a dynamic landscape. As such, this report is intended to provide guidance to assist APEC members in determining rational paths forward.

Chapter 1 of the report provides the overall introduction and purpose of this project. Chapter 2 includes a survey and an overall review of AMI implementation activities of

AMI programs in APEC economies. The survey is designed to study the key successful factors of AMI development in APEC. Although the landscape of AMI programs and technology is changing rapidly, the chapter attempts to describe the present situation and challenges of AMI deployment within APEC.

Three case studies are given in Chapter 3 which identifies key successful factors and key challenges of AMI deployment. Chapter 4 of the report presents the APEC workshop on Addressing Challenges in AMI Deployment and Smart Grids in APEC.

The details of challenges of AMI deployment are given in Chapter 5 including cost-benefit analysis, key challenges and mitigation strategies from different perspectives. Each APEC economy will face unique challenges in deploying AMI, depending on many factors such as market structure, degree of industrialization, urbanization, population density, status of installed electric power system, environmental and economic drivers, along with many other factors. Some challenges must be addressed at the local, regional, or national level, while others can be addressed in part by global efforts such as the APEC Smart Initiative or the International Smart Grid Action Network being established as an activity of the Clean Energy Ministerial.

Overall conclusions and recommendations are provided in Chapter 6 of the report. To provide a starting point for addressing AMI challenges, Chapter 6 describes impactful, principles for the deployment of AMI policies, guidelines, recommendations for APEC economies of smart metering development, and some areas ripe for further study. Based upon the presentation of the results of this work, follow-on activities, such as a workshop, may be arranged to further examine findings of the study and establish a path forward for future progress in these areas.

2.0 Situation within APEC

2.1 APEC AMI Overview

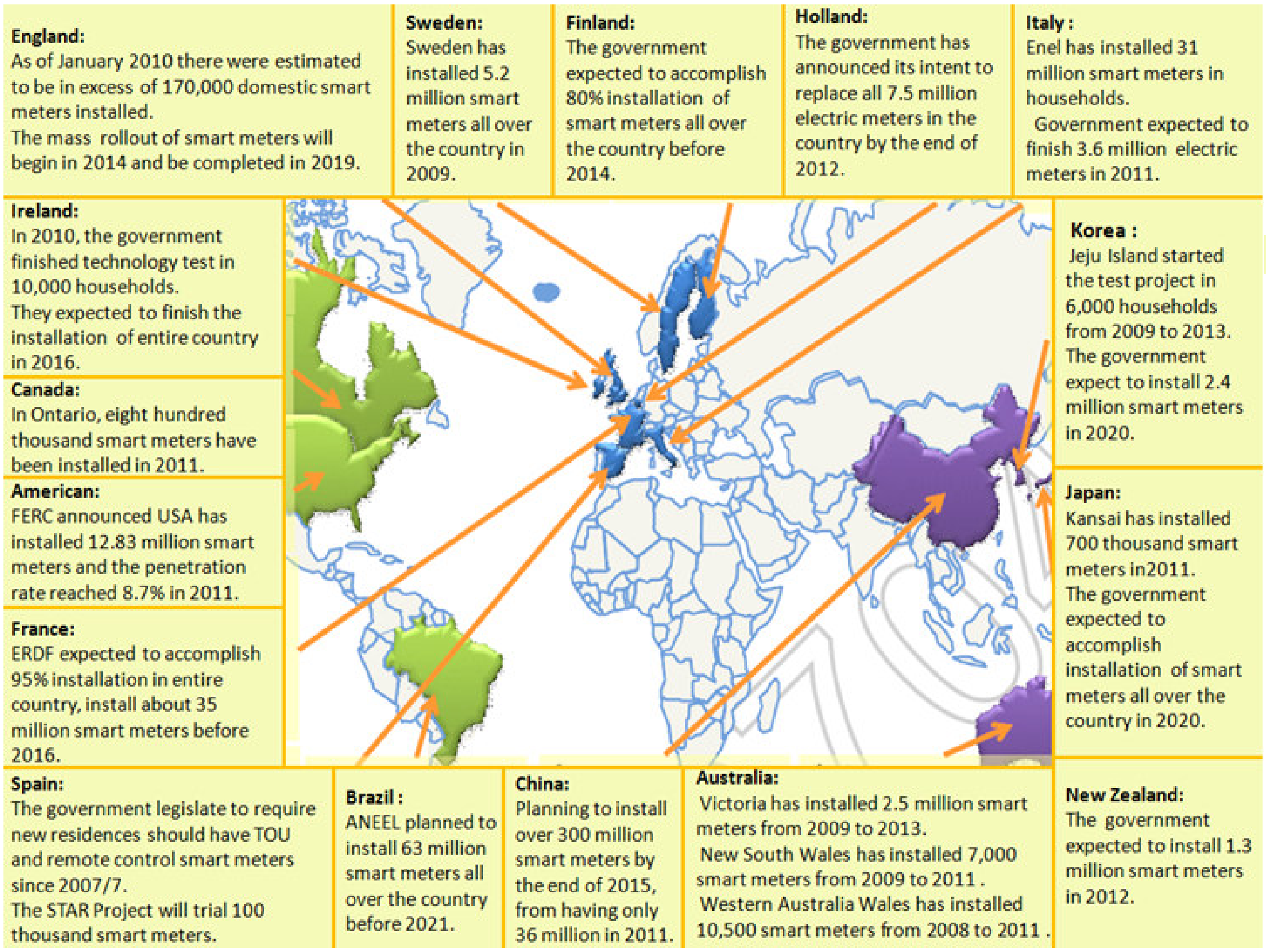


Figure 2.1 World AMI overview

The picture of electrification across the world is complex. The economies are in various states of smart grid development, ranging from no activity, to conducting demonstrations, and engaged in joint projects with other economies. Each member economy has unique attributes that influence the benefits of smart grid capabilities and affect the priorities given to deployment strategies. The following is an overview of APEC AMI deployment status.

England

The official start date of rollout is 2012, involving visits to more than 27 million homes to replace meters for both gas and electricity. As of January 2010 there were estimated to be in excess of 170,000 domestic smart meters installed. In October 2010, First Utility became the first energy supplier to offer smart meters to all new and existing customers across the U.K.

British Gas have committed to providing Smart Meters in all homes by 2019. They are starting this rollout now, with 160,000 homes in the UK already having a Smart Meter.

Sweden

Sweden is in the midst of replacing its existing metering infrastructure to comply with government regulations designed to promote an open and efficient energy market. Sweden has installed 5.2 million smart meters all over the economy in 2009.

Finland

The Nordic Investment Bank (NIB) and Kymenlaakson Sähköverkko Oy have signed a 10-year-maturity loan total EUR 15 million for the implementation of a remote reading system of electricity metering in South-East Finland. The aim of the project is to improve customers' means to control and optimize electricity usage. Approximately 100,000 consumption sites will be included in the remote reading system by the finalisation of the project in 2013.

Holland

The Netherlands government has announced its intent to replace all 7.5 million electric meters in the economy by the end of 2012.

Italy

Enel has installed 31 million smart meters in households. The government expected to finish 3.6 million electric meters in 2011.

Korea

Korea announced a roadmap in November 2009 to develop the grids. The private sector may invest 24.8 trillion won ($22 billion) by 2030 for the grids, with the state contributing 2.7 trillion won, according to government estimates in January 2010.

Korea plans to replace all analogue meters at households with the new devices by 2020. The government on Feb. 28 said it plans a 14-fold increase in the number of meters to 10 million units by 2016.

Japan

At the end of February 2012, TEPCO will reveal requirements of power meter to potential suppliers after exchanging non-disclosure agreement. First tender for 3 million units is scheduled in October 2012. Meanwhile, the government is planning to replace 80% of the economy conventional meters with smart meters within five years.

New Zealand

Approximately 1.3 million smart meters are due to be rolled out to New Zealand households by 2012. However, the economy appears to be unusual in the developed world in that the rollout is being undertaken by the market, with no government control, going on to recommend that the government takes a more hands-on approach.

Australia

In 2010, the government finished technology test in 10,000 households. By 2013 Victoria's electricity distribution businesses will have installed 2.5 million Smart Meters in homes and businesses across the state. They expected to finish the installation of entire economy in 2016.

China

China is reportedly planning to install over 300 million smart meters by the end of 2015, from having only 36 million in 2011.

Brazil

The Brazilian Electricity Regulatory Agency (in Portuguese, Agência Nacional de Energia Elétrica, ANEEL) planned to install 63 million smart meters all over the economy before 2021.

Spain

Endesa (Enel group) has installed 22,000 meters in Andalusia (within the framework of the "smart city" project) with a target to install 13 million meters by the end of 2015.

France

By the 20th of September 2010 over 47.000 AMM meters have been commissioned. The government expects to install 35,000 thousand electric meters before 2016 and accomplish 95% installation in entire economy.

USA

As of May 2012, U.S. utilities had installed roughly 36 million smart meters nationwide, and approximately 65 million smart meters will be deployed by 2015.

Canada

The Government of Ontario set a target of deploying smart meters to 800,000 homes and small businesses by the end of 2007, which was surpassed, and throughout the province by the end of 2010. BC Hydro in British Columbia, Canada is implementing Itron smart meters to all customers by the end of 2012.

Ireland

From 1st January 2010, around 5,500 household electricity customers nationwide began using smart meters.

Initiation of the Gas CBT for residential customers is due to complete in June 2011. This encompassed a roll out of circa 2,000 smart meters to trial participants testing a range of smart metering enabled stimuli.

2.2 Survey Results

2.2.1 Questionnaire Design

The questionnaire was designed to study the key success factors of AMI development in APEC. There are totally 27 questionnaires distributed and a total number of 6 respondents completed the survey.

To fully understand AMI deployment in APEC, five aspects were taken into account including basic background, policy, economy, technology and society.

The first aspect was designed to study the background information in each economy. This was not the part of core research but it is helpful in understanding respondent's economy power background. The second aspect concerns the smart meter roll-out plan and status. In this section, we are trying to find out what role should the government or regulator play in the roll-out process. And what are the most critical challenges they faced. The third part concerns about the cost and benefit of AMI deployment. The fourth part, we consider the technical aspect to find out the necessary functions and communication technologies for smart meter, and how to deal with technical challenges of AMI deployment in APEC. Finally, the major concerns of the customers are presented in the society aspect. And we hope to get some suggestions for the social challenges from the respondents. The survey questions are listed in Appendix A.

2.2.2 Status of AMI from Survey Results

Basic background

Table 2.1 basic background of APEC economies

	Energy consumption (per year)	Number of households (Units)	Number of installed electricity meters (Units)	Number of installed smart meters (Units)	Mandatory frequency for electricity meter reading for households	Electricity Meter standard
Australia	Total: 30,000GWh Households: 18,000GWh Commercial: 12,000GWh	1.6 million	1.6 million	12,000	4 times per year	American National Standards Institute
New Zealand	Total: 38,091GWh Households: 12,879GWh Commercial: Unknown	1.68 million	2.28 million	70,000	3 times per year	International Electricity Commission

Hong Kong	Total: 42,065GWh Households: 11,076GWh Commercial: 20,751GWh	2.64 million	3.0 million	14,428	6 times per year	International Electricity Commission
Japan	Total: 906,417GWh Households: 304,229GWh Commercial: 47,452GWh	51.8 million	79 million	1,300,000	12 times per year	International Electricity Commission
Chinese Taipei	Total: 198,640GWh Households: 41,714GWh Commercial: 31,782GWh	745 million	12.97 million	746	6 times per year	American National Standards Institute
China	-	-	-	-	6 times per year	China National Standards

Political Aspect

From the survey results, we can know that Australia, China, Chinese Taipei and New Zealand now are on roll-out underway. Japan is still planning. And Hong Kong is at discussing stage.

There are 1.6 million meters needed to be replaced in Australia's smart meter roll-out plan. New Zealand is expected to displace 2.25 million meters or 1.5M of 1.99M of connection point. There are 80% of total demand million units meters needed to be reinstalled into smart meters in Japan. There are 6 million existed electricity meters need to be replaced in Chinese Taipei. Hong Kong is not yet defined.

From the result, Australia starts to install smart meter for householders in 2012 and their target is 20,000 units. China starting form 2010, wants to reach 33million smart meters. Then China started to install 36M smart meters in 2011, and also plan to install 300 million in the economy. New Zealand expects to install 1.5 M on April 1 2015. During 2011 to 2012, 10,000 units have been replaced. Chinese Taipei, expects to reach 1 million meters in 2015 and to 6 million in 2016. Japan started to install in 2011.Japan expect to install 80% of total demand in 5 years.

There are some main policies for each economy to encourage metering roll-out plan. From the survey we can see that most of APEC economies have the same policies of reducing meter reading costs. The second common is the policy of reducing electricity theft, and introduction of more complex tariff systems. To encourage smart meters installation, Japan especially regulates the policy of enhancing customer service for encouraging smart meters installation.

There are some roles that government or regulatory play in the roll-out process. From the results, we can see from the result. Most common choices are the definition of minimal technical requirements and monitoring and reviewing. China has to do also definition of targeting roll-out units, organizing the target roll-out units, developing the privacy policy framework and definition of the level of ROI expected. Comparing to China, Japan only has to do the definition of roll-out timetable.

The result shows that electric power company needs to do installation, maintenance, meter reading and data management in Hong Kong, China, Chinese Taipei and Japan. However, New Zealand separated the duties into three part; Energy Service Company (ESCO) for installation, smart metering system integrator for maintenance and meter reading, and independent data management company to do data management.

Most APEC members have implemented dynamic pricing programs before meter roll-out. Hong Kong, Australia, Chinese Taipei and China have adopted Time-of-Use pricing. Australia and China have adopted critical peak pricing. New Zealand has adopted days and night pricing. From the questionnaire, there are no dynamic pricing programs being adopted in Japan.

From the survey, most APEC members have developed dynamic pricing programs after smart meter roll-out. Australia has different kinds of pricing programs; time-of use, critical peak pricing, real-time pricing and extreme day CPP. Hong Kong and New Zealand now are in progress trials underway. China has time-of-use pricing and critical peak pricing. China also has a multi-step electricity price programs. But Japan doesn’t have any programs. Chinese Taipei is still in progress.

From the result, financial issue is the most common challenges in applying roll-out smart meters. Hong Kong, China and New Zealand all face this problem. Hong Kong also has potential tariff impact. However, Australia faces technical issue in applying the plan. New Zealand has the challenge of satisfying distribution and retailer need. Japan has the privacy issue to solve.

Economic Aspect

Table 2.2 Survey result of economic aspect

Who pays for the roll-out of smart meters?	Australia	New Zeland	Hong Kong	Japan	Chinese Taipei	China
Government	✓					
Electric power company			✓	✓	✓	✓
Distribution system operator(DSO)						
Customer	✓					
Others(please specify)		Lndepended nedea owners				
Has the government, the regulator or the DSO conducted a cost & benefit analysis of the roll-out plan?	Yes	No	No	-	Yes	Yes
Please point out the <u>three major</u> cost elements for the roll-out of smart meters.						
Capital cost of meters	✓				✓	✓
Meter installation cost	✓					✓
Meter operation and maintenance cost						✓
Information technology cost						
Communication set-up cost	✓				✓	
Communication operation and maintenance cost						
Others(please specify)					Inspection cost of meters	
Please point out <u>five major</u> benefits from						

your smart metering project.						
Reducing the theft of electricity		-	✓			✓
Avoided cost of routine manual reading	✓	-	✓	✓		✓
Loss of load detection and outage detection	✓	-			✓	✓
Avoided cost of manual disconnections and reconnections		-		✓	✓	
Avoided generation capacity costs		-				
Avoided transmission and distribution costs		-				
Energy saving		-	✓	✓	✓	
Avoided CO_2 costs		-		✓	✓	
Others(please specify)		-			Reducing healthy cost	

The business environment of Smart Metering is currently emerging while the rules of the game have not yet been determined up to now. Nowadays, the third industrial revolution is on the way, with Smart Metering being an inconspicuous, but the benefits brought by the Smart Metering should not be underestimated. Next, we analyze the implementation effects of smart metering systems by economic aspect. The roll-out is being led by different stakeholders in different economies, like electric power company in China; Hong Kong, China; Japan and Chinese Taipei government and customers in Australia; and others in New Zealand.

In an earlier survey, we found that the capital costs run about US$250 per meter, with ongoing costs range roughly US$10-20 per meter per year. There are some basic types of smart meter costs: capital cost of meters, inspection cost of meters, meter installation cost, meter operation and maintenance cost and communication set-up cost. We also found the energy consumption (per year), Japan totally 906,417GWh is the highest one and Australia totally 30,000GWh is the lowest one of these countries being investigated.

Fortunately, policymakers in over 30 states and economies have already identified that the benefits of smart meters have exceeded the costs. Smart meter benefits include reducing the theft of electricity, avoiding cost of routine manual reading and energy saving. Benefits are so much as loss of load detection and outage detection in China, Chinese Taipei and Australia. The cost of manual disconnections and CO_2 are also avoided in Japan and Chinese Taipei. And the progress of the deployment project of smart meters is quite smooth in Japan, where the number of total households is 51.8 million and the number of installed electricity meters is 79 million. In Japan, the mandatory frequency for electricity meter reading for each household is 12 times per year. It is expected that the deployment project will be completed on schedule.

Smart meters should benefit consumers. To face the least standards of consumer trust, utility regulators and other government have a credible plan to keep the cost of the roll-out tightly under control. And they rely on credible expert utilities to provide number analysis before deciding whether to approve smart meter rollouts.

Technical Aspect

In the technical aspect, APEC members believe that the functions such as two-way communications to the meter system and remote disconnection and connection are basic and essential functions for smart meter. Secondly required functions are interval metering data measurement, supporting load management (e.g. time-of-use rates) and loss of load detection and outage location identification.

The most common communication technologies applied to smart meter communication network are GPRS and Zigbee, WiMax and RF Mesh as the secondary common technologies.

The primary technical challenge is that integration of different type of meters and system secondly is how to make sure the meter system is compatible for smart grid development in the future and ensuring security and privacy protection.

APEC members propose different solutions for the technical challenges. Hong Kong needs a pilot test on field; Australia will choose proven solutions from vendors, and New Zealand wants to put competitive or commercial pressure on making some regulation and guidelines to address technical challenges that they are facing.

Society Aspect

From the survey results, we know that safety and privacy issues are the main concerns of the customers. Almost every respondent stresses these two concerns. These are the key social challenges of AMI deployment. On the other hand, some suggestions are provided for these challenges, for example education campaign for the consumers, communication with relevant stakeholders, regulations on security and data access.

3.0 Case Analysis

In this part, we choose America, Australia and Ireland as our case studies. The reasons are these economies have their own unique deployment plans, schedules or some challenges we can learn from. For example, Ireland emphasis on technology trial and demand response management during the beginning stage of deployment plan, and America provides an "opt-out option" for the smart meter against.

3.1 America

3.1.1 Introduction

As of May 2012, U.S. utilities had installed roughly 36 million smart meters nationwide, and approximately 65 million smart meters will be deployed by 2015.

Sections 1252(e) and (f) of the U.S. Energy Policy Act of 2005 (EPACT) state that it is the policy of the United States to encourage “time-based pricing and other forms of demand response, whereby electricity customers are provided with electricity price signals and the ability to benefit by responding to them.” It further states that “deployment of such technology and devices that enable electricity customers to participate in such pricing and demand response systems shall be facilitated, and unnecessary barriers to demand response participation in energy, capacity and ancillary services markets shall be eliminated.” To help implement this new policy on demand response, the Act creates new requirements for electric utilities and states with respect to demand response. States are charged with conducting investigations to determine how those new requirements should be applied and whether to adopt widespread time-based pricing and advanced metering for utility retail customers.

EPACT provides specific guidance to Department of Energy (DOE) in encouraging demand response. Specifically, the Secretary of Energy is authorized to:

- educate consumers on the availability, advantages, and benefits of advanced metering and communications technologies, including the funding of demonstration or pilot projects; and
- work with States, utilities, other energy providers, and advanced metering and communications experts to identify and address barriers to the adoption of demand response programs (EPACT, Sec. 1252(d)).

The law also requires DOE to provide a report to Congress, not later than 180 days after its enactment, that “identifies and quantifies the national benefits of demand response and makes a recommendation on achieving specific levels of such benefits by January 1, 2007” (EPACT, Sec. 1252(d)).

The Federal Energy Regulatory Commission (FERC) Identifies Smart Grid-Enabled Demand Response as Key Priority for Standards Development to Achieve Smart Grid Interoperability

On July 16, 2009, the Commission issued a Final Smart Grid Policy to guide and prioritize the development of smart grid devices and systems, and to adopt an Interim Rate Policy to encourage investment in smart grid technologies. The Commission stated that smart grid enabled demand response is a key priority because of its potential to help address several bulk power system challenges, including reliably integrating unprecedented amounts of variable generation resources into the electric grid. To further this goal, the final policy explains that a key priority should be development of standards to enhance interoperability and communications between system operators, demand response resources, and the systems that support them. Emphasis should be put on further development of use cases and scenarios for demand response, particularly with regard to dispatchable demand response and various forms of dynamic pricing. Further, the Commission encourages the National Institute of Standards and Technology and its industry collaborators to continue investigating potential national interoperability standards for advanced metering systems.

Defining and Characterizing Demand Response

Demand response, defined broadly, refers to active participation by retail customers in electricity markets, seeing and responding to prices as they change over time. Currently, most customers see only flat, average-cost based electric rates that give them no indication that electricity values change over time, nor any incentive to vary their electric use in response to prices.

Why is Demand Response Important?

Demand response offers a variety of financial and operational benefits for electricity customers, load-serving entities (whether integrated utilities or competitive retail providers) and grid operators. Electric power systems have three important characteristics. First, because electricity cannot be stored economically, the supply of and demand for electricity must be maintained in balance in real time. Second, grid conditions can change significantly from day-to-day, hour-to-hour, and even within moments. Demand levels also can change quite rapidly and unexpectedly, and resulting mismatches in supply and demand can threaten the integrity of the grid over very large areas within seconds. Third, the electric system is highly capital-intensive, and generation and transmission system investments have long lead times and multi-decade economic lifetimes.

The types of time-based rate schedules include:

I. **Time-of-use pricing** whereby electricity prices are set for a specific time period on an advance or forward basis, typically not changing more often than twice a year, based on the utility's cost of generating and/or purchasing such electricity at the wholesale level for the benefit of the consumer. Prices paid for energy consumed during these periods shall be pre-established and known to consumers in advance of such consumption, allowing them to vary their demand and usage in response to such prices and manage their energy costs by shifting usage to a lower cost period or reducing their consumption overall.

II. **Critical peak pricing** whereby time-of-use prices are in effect except for certain peak days, when prices may reflect the costs of generating and/or purchasing electricity at the wholesale level and when consumers may receive additional discounts for reducing peak period energy consumption.

III. **Real-time pricing** whereby electricity prices are set for a specific time period on an advanced or forward basis, reflecting the utility's cost of generating and/or purchasing electricity at the wholesale level, and may change as often as hourly.

IV. **Credits for consumers with large loads** who enter into pre-established peak load reduction agreements that reduce a utility's planned capacity obligations.

California

Since the 1970s, conservation and load management programs have been promoted by the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC) as alternatives to power plant construction and gas supply options. Conservation and load management (C&LM) programs have been implemented in California by the major utilities through the use of ratepayer money and by the CEC pursuant to the CEC legislative mandate to establish energy efficiency standards for new buildings and appliances.

In 2001, California suffered from rolling blackouts due to a failed opening of the electricity wholesale market – caused largely by poor regulation and the greed and market manipulation by the generators/Enron. The mechanisms of how the wholesale market failed are beyond the scope of this report, however the outcome was a loss of faith in deregulation and competition and a decision to increase the power of demand as one mechanism for controlling the power of the generators - a conclusion was reached that a factor in the California crisis was the lack of demand response to mitigate market power.

The CPUC began a rulemaking in June 2002 which it concluded in November 2005 with the aim of "developing demand response as a resource to enhance electric system reliability, reduce power purchase and individual consumer costs, and protect the environment. The desired outcome of this effort was that a broad spectrum of demand response programs and tariff options would be available to customers who make their demand-responsive resources available to the electric system." Subsequently the CPUC and the utilities have developed an integrated package of smart metering plus demand response measures of direct load control and time differentiated pricing tariffs.

In 2003, the three key energy agencies in California – the CEC, the California Power Authority (CPA), and the CPUC – came together in a spirit of unprecedented cooperation to adopt an "Energy Action Plan" (EAP) that listed joint goals for California's energy future and set forth a commitment to achieve these goals through specific actions

The EAP was a living document meant to change with time, experience, and need. The CPUC and the CEC have jointly prepared this Energy Action Plan II to identify the further actions necessary to meet California's future energy needs. EAP II supports and expands the commitment to cooperation among state agencies embodied in the original EAP and reflected in the State's coordinated actions over the past two years. The development of EAP II has benefited from the active participation of the Business, Transportation, and Housing Agency, the Resources Agency, the State and Consumer Services Agency, the California Independent System Operator (CAISO), the California Environmental Protection Agency (Cal EPA), and other agencies with energy-related responsibilities.

EAP II describes a coordinated implementation plan for state energy policies that have been articulated through the Governor's Executive Orders, instructions to agencies, public positions, and appointees' statements; the CEC's Integrated Energy Policy Report (IEPR); CPUC and CEC processes; the agencies' policy forums; and legislative direction. This document also is intended to be consistent with the energy policies embodied in the Governor's August 23, 2005, response to the 2003 and 2004 IEPRs. We expect to update or revise this action plan to reflect any changes needed to further implement the Governor's 2004 IEPR response, future energy policies, and decisions related to the forthcoming 2005 IEPR, as well as other relevant events that may arise in the future.

All of the utilities in California have now received permission to rollout smart meters as part of a larger efficiency plans – the main demand response programs in use are critical peak pricing, critical peak rebates, time of use and automated AC thermostats. Customer feedback and education will also be used but sometimes as a support to the pricing programs only.

On top of this, each utility has asked for extra funds to provide services which go beyond the minimal requirements of the smart metering regulation. There is good evidence that private industry as well as the utilities now have a substantial financial stake in the success of these programs creating green jobs and business opportunities.

Also, in 2002, the Governor signed the Renewable Portfolio Standard (RPS), SB 1078. This standard requires an annual increase in renewable generation equivalent to at least 1% of sales, with an aggregate goal of 20% by 2017. The state is aggressively implementing this policy, with the intention of accelerating the completion date to 2010, and will:

- Add a net average of up to 600 MW of new renewable generation sources annually to the investor-owned utility resource portfolio.
- Establish by June 30, 2003, key RPS implementation rules, including market price benchmarks, standard contract terms, flexible compliance and penalty mechanisms, and bid ranking criteria under the "least cost-best fit" rubric. Other key RPS rules will be developed and refined throughout 2003.
- Facilitate an orderly and cost-effective expansion of the transmission system to connect potential renewable resources to load.
- Initiate the development of RPS compliance rules for energy service providers and community choice aggregators.
- Coordinate implementation with all relevant state agencies and with municipal utilities to facilitate their achievement of the standard.

Established in 2002 under Senate Bill 1078, accelerated in 2006 under Senate Bill 107 and expanded in 2011 under Senate Bill 2, California's Renewables Portfolio Standard (RPS) is one of the most ambitious renewable energy standards in the economy. The RPS program requires investor-owned utilities, electric service providers, and community choice aggregators to increase procurement from eligible renewable energy resources to 33% of total procurement by 2020.

The CPUC and the CEC jointly implement the RPS program. The CPUC's responsibilities include:

1. Determining annual procurement targets and enforcing compliance.
2. Reviewing and approving each investor owned utilities (IOUs) renewable energy procurement plan.
3. Reviewing IOU contracts for RPS-eligible energy.
4. Establishing the standard terms and conditions used by IOUs in their contracts for eligible renewable energy.
5. Calculating market price referents (MPRs) for non-renewable energy that serve as benchmarks for the price of renewable energy.

The CPUC has authorized the state's investor owned utilities to replace conventional customer meters with Smart Meters in order to give consumers greater control over their energy use. Smart Meters enable a utility to provide customers with detailed information about their energy usage at different times of the day, which in turn enables customers to manage their energy use more proactively.

In California, Smart Meter is integrated into a larger package to help control consumption as a direct method of improving security of supply for the State. California is the USA's most populous State with about 37 million people. The State counts 14.8 million retail energy customers which were provided with 91 TWh of electricity in 2008. Household consumption is one of the lowest in the economy with an average of 6,150 kWh per year. State-wide sales amounted to 268.1 TWh while generation was only at about 208 TWh which makes California the largest electricity importer in the USA.

Smart Meters are being rolled out nationwide and internationally. According to the Edison Foundation, more than 36 million Smart Meters have been deployed by electric utilities in the U.S. and nearly 65 million should be in place by 2015. In California, the CPUC authorized Southern California Edison to install approximately 5.3 million new Smart Meters, San Diego Gas and Electric Company (SDG&E) 1.4 million electric Smart Meters and 900,000 natural gas meters, and Pacific Gas and Electric Company (PG&E) approximately 5.2 million electric meters and 4.4 million natural gas meters.

The positive cost/benefit for the utilities is directly related to how successful they are with their demand response programmes (due to the regulatory framework in place). The overall success of the meter rollout will now be dependent on the ability of the utilities and private companies involved to educate and interest consumers. Rollout is due to be completed in 2012 for most utilities and the full impact of the programmes may take a couple of years after this to be fully realized.

Pacific Gas and Electric Company

PG&E and Wellington Energy, an authorized, independent contractor for PG&E, began upgrading gas and electric meters in 2006. The SmartMeter™ program is already the largest in the nation, and by mid-2012, will be available to all of the millions of gas and electric customers we serve.

The SmartMeter™ system provides new features for you: More convenience and better, faster service; New rate choices and more control over your energy bills.The SmartMeter™ system collects electric and natural gas usage data from your home or business. SmartMeter™ electric meters record residential electric usage hourly and commercial electric usage in 15 minute increments. SmartMeter™ natural gas modules attached to gas meters record gas usage daily. This data is periodically transmitted to us via a secure wireless communication network.

Time-based rates are available to PG&E's residential, agricultural, and commercial and industrial customers with a Smart Meter.

On February 25, 2010, the CPUC adopted new rate structures for commercial, industrial, and agricultural customers of PG&E as part of an effort to implement dynamic electricity prices for all California consumers. These rates are designed to reflect the cost of electricity production during periods of high demand. When combined with PG&E's Smart Meters, these rates will provide an opportunity for customers to lower their bills while improving system reliability and reducing greenhouse gas emissions.

Beginning on May 1, 2010, large commercial and industrial customers will be placed on new Peak Day Pricing rates. Customers on these rates will pay different prices for electricity depending on the time of day. On the few hottest days of the year, prices for electricity used between 2 p.m. and 6 p.m. will increase further. However, PG&E will notify customers about these peak days one day in advance, so customers can plan accordingly. Beginning on November 1, 2011, medium and small commercial and industrial customers will begin moving to new Peak Day Pricing rates.

Residential customers may elect to enroll in PG&E's Smart Rate program, which is designed to encourage customers to reduce their electricity usage at during peak periods. Participants in Smart Rate may also elect a bill protection option for the first full summer of participation.

Residential and small business customers can also enroll in PG&E's Smart AC program, where they can reduce or shift their air conditioning in response to signals from the utility. In the near future, residential customers will have the option of enrolling in a Peak Time Rebate program, where they can receive a rebate for reducing their electricity consumption in response to demand response signals from the utility.

3.1.2 Specific Action Areas

I. Energy Efficiency

As stated in EAP I and reiterated here, cost effective energy efficiency is the resource of first choice for meeting California's energy needs. Energy efficiency is the least cost, most reliable, and most environmentally-sensitive resource, and minimizes our contribution to climate change. California's energy efficiency programs are the most successful in the nation.

However, to achieve the full energy efficiency potential that exists in California, we must continue to ratchet up our efforts. We need to focus not only on developing and supporting programs, but also on increasing public outreach and education; promoting research, development, and demonstration; and improving the evaluation, measurement, and verification of efficiency programs.

KEY ACTIONS:

1. Require that all cost-effective energy efficiency is integrated into utilities' resource plans on an equal basis with supply-side resource options.
2. Adopt 2006-2008 energy efficiency program portfolios and funding by late 2005.
3. Expand efforts to improve public awareness and adoption of energy efficiency measures.
4. Promote a balanced portfolio of baseload energy, demand, and peak demand reductions to obtain both reliability and long-term resource benefits of energy efficiency for both electricity and natural gas.
5. Integrate demand response programs with energy efficiency programs.
6. Implement actions outlined in the Governor's Green Buildings Action Plan to improve building performance and reduce grid-based electrical energy purchases in all State and commercial buildings by 20 percent by 2015.
7. Work with customer-owned utilities in the implementation of all cost-effective energy efficiency programs so that they treat energy efficiency savings as a resource and help California reach its goal of a reduction in per capita electricity use.
8. Adopt new appliance standards by 2006, supplementing those adopted in December 2004.
9. Adopt new building standards for implementation in 2008 that include, among other measures, cost effective demand response technologies and integrated photovoltaic systems.
10. Increase the availability of State-sponsored low-interest loans for energy efficiency and clean distributed generation projects.
11. Improve energy efficiency programs for low income, non-English speaking, and other hard-to-reach communities.
12. Adopt verifiable performance-based incentives in 2006 for IOU energy efficiency investments, with risks and rewards based on performance that will align the utility incentives with customer interests.
13. Update and augment, as necessary, utility evaluation, measurement and verification protocols to assure that energy efficiency continues to be fully

integrated into resource planning, emission reduction benefits are quantified, and compliance goals are verified.

14. Identify opportunities and support programs to reduce electricity demand related to the water supply system during peak hours and opportunities to reduce the energy needed to operate water conveyance and treatment systems.
15. Adopt a report on improving efficiency in existing buildings, as required by Assembly Bill 549, and pursue legislation and regulations to implement its recommendations.

II. Demand Response

California is in the process of transforming its electric utility distribution network from a system using 1960s era technology to an intelligent, integrated network enabled by modern information and control system technologies. This transformation can decrease the costs of operating and maintaining the electrical system, while also providing customers with accurate information on energy use, time of use, and cost. With the implementation of well-designed dynamic pricing tariffs and demand response programs for all customer classes, California can lower consumer costs and increase electricity system reliability. To achieve this transformation, state agencies will ensure that appropriate, cost-effective technologies are chosen, emphasize public education regarding the benefits of such technologies, and develop tariffs and programs that result in cost-effective savings and inducements for customers to achieve those savings.

KEY ACTIONS:

1. Issue decisions on the proposals for statewide installation of advanced metering infrastructure for all small commercial and residential IOU customers by mid-2006 and expedite adoption of concomitant tariffs for any approved meter deployment.

2. Expedite decisions on dynamic pricing tariffs to allow increased participation for summer 2006 for customers with installed advanced metering systems and encourage load shifting that does not result in increases in overall consumption.

3. Identify and adopt new programs and revise current programs as necessary to achieve the goal to meet five percent demand response by 2007 and to make dynamic pricing tariffs available for all customers.

4. Educate Californians about the time sensitivity of energy use and the ways to take advantage of dynamic pricing tariffs and other demand response programs.

5. Create standardized measurement and evaluation mechanisms to ensure that demand response savings are verifiable.
6. Provide that the utilities' demand response investment opportunities offer returns commensurate with investments in traditional plant.
7. Integrate demand response into retail sellers' electricity resource procurement efforts so that these programs are considered equally with supply options.
8. Provide customer access to their energy use information and allow participation in demand response programs, regardless of retail provider.
9. Evaluate and, if appropriate, incorporate demand response technologies such as programmable communicating thermostats into the 2008 building standards.
10. Incorporate demand response appropriately and consistently into the planning protocols of the CPUC, the CEC, and the CAISO.
11. Encourage the integration of demand response programs into a capacity market or other mechanisms.
12. Coordinate IOU demand-response programs with customer-owned utility demand-response efforts to provide a comprehensive, statewide contribution to California's resource adequacy portfolio.

III. Renewables Portfolio Standard

California can reduce its greenhouse gas emissions, moderate its increasing dependence on natural gas, and mitigate the associated risks of electricity price volatility by aggressively developing renewable energy resources to meet the RPS requirements. As originally established, the RPS requires 20 percent of electricity sales to come from renewable sources by 2017. In the first EAP, we set a goal of accelerating the 20 percent target from 2017 to 2010. We are now identifying the steps necessary to achieve that target, as well as higher goals beyond 2010, such as Governor Schwarzenegger's proposed goal of 33 percent of electricity sales by 2020. California governor Jerry Brown described his state's plans to deploy 20 GW of new renewable energy capacity in accordance with his Clean Energy Clean Jobs Plan. The recently announced energy targets are a substantial increase from current levels and depend highly on distributed solar power. 60 percent (12 GW) of the 20 GW target is intended to come from "localized generation," or distributed projects less than 20 MW in size. Such projects offer a number of benefits like streamlined grid integration and reduced siting challenges.

The 12 GW target is made up of three main components:

- Behind the meter: 5.2 GW of rooftop solar developed on customer roofs and used to offset retail power purchases.
- Wholesale generation: 3.4 GW of distributed generation fed into the utility system through feed-in-tariffs or other utility procurement approaches.
- Distribution Grid Interconnection Capacity: An additional 3.4 GW of capacity that can be deployed without major upgrades to the distribution system.

IV. Electricity Adequacy, Reliability and Infrastructure

Significant capital investments are needed to augment existing facilities, replace aging infrastructure, and ensure that California's electrical supplies will meet current and future needs at reasonable prices and without over-reliance on a single fuel source. Even with the emphasis on energy efficiency, demand response, renewable resources, and distributed generation, investments in conventional power plants will be needed. The State will work to establish a regulatory climate that encourages investment in environmentally-sound conventional electricity generation resources.

An expanded, robust electric transmission system is required to access cleaner and more competitively priced energy, mitigate grid congestion, increase grid reliability, permit the retirement of aging plants, and bring new renewable and conventional power plants on line. Streamlined, open and fair transmission planning and permitting processes must move projects through planning and into construction in a timely manner. The state agencies must work closely with the CAISO to achieve these objectives and to benefit from its expertise in grid operation and planning. Finally, the distribution system, which has the most direct effect on reliable service for consumers, must be continually upgraded and reinforced.

KEY ACTIONS:

1. Ensure that all load serving entities meet the state's adopted reserve and resource adequacy requirements of a 15-17 percent planning reserve no later than June 2006, through a reasonable mix of short-, medium- and long-term resource commitments.

2. Provide for the continued operation of cost-effective and environmentally-sound existing generation needed to meet current reliability needs, including combined heat and power generation.

3. After incorporating higher loading order resources, encourage the development of cost-effective, highly-efficient, and environmentally-sound supply resources to provide reliability and consistency with the State's energy priorities.

4. Establish appropriate incentives for the development and operation of new generation to replace the least efficient and least environmentally sound of California's aging power plants.

5. Evaluate the potential for California's access to clean coal energy resources and recommend a California clean coal policy in the 2005 IEPR.

6. Manage California's aging electricity infrastructure to coordinate maintenance and outages and to provide orderly retirements.

7. Adopt a long-term policy for existing and new qualifying facility resources, including better integration of these resources into CAISO tariffs and deliverability standards.

8. Promote adequate investment in the utility distribution system, with an emphasis on translating those expenditures into higher levels of reliability.

9. Develop tariffs and remove barriers to encourage the development of environmentally-sound combined heat and power resources and distributed generation projects.

10. The CEC supports legislation to consolidate the permitting process for all new bulk transmission lines within the CEC, while the CPUC believes existing permitting authority should remain in place. Irrespective of the status of legislative efforts, the two Commissions agree to continue to work together to improve the transmission planning and permitting processes under existing authorities.

11. Improve the State's transmission line planning and permitting processes by integrating the CAISO's transmission planning and modeling capabilities, the CEC's power plant licensing, environmental and planning expertise, and the CPUC's ratemaking function and by ensuring that the processes are adaptable, flexible and representative of broad stakeholder input.

12. Adapt the state's transmission planning process to better evaluate strategic benefits, as well as economic costs and benefits, of proposed projects over multiple decades, including recommending a range of discount rates to be used to evaluate transmission lines.

13. Support legislation to expand the CEC's transmission corridor planning process, coordinated with applicable federal and state agencies, local governments and other stakeholders, to designate and preserve critical corridors for potential development in the future.

14. Coordinate the state's transmission planning process with regional efforts in the interconnected western states and identify and recommend means to increase California's participation in the broader western regional energy planning efforts.
15. Apply the GHG adder as a resource selection criterion in IOU procurement decisions to more appropriately value the risk of future environmental regulation in long-term investment decisions made now.
16. Acknowledge the interdependent nature of the energy needs among all the Western states, Canadian provinces, and Mexico by collaborating with our regional partners on regional resource and transmission planning, in particular by addressing overall resource adequacy and deliverability in the West, including cost allocation, planning, and routing of inter-regional transmission projects.

3.1.3 Problems

Pacific Gas and Electric Co. has found a number of reasons why almost 45,000 of its Smart Meters haven't worked as planned.

Since mid of 2009, California's largest utility has faced a customer uprising over the meters, which were designed to measure power use with precision and wirelessly transmit their data to PG&E. Angry homeowners have accused the meters of gross inaccuracy, blaming them for monthly bills that in some cases doubled without warning.

PG&E insists that most of the soaring bills blamed on Smart Meters were actually caused by high electricity rates and heat waves. However, the company's internal investigation has found several recurring problems with the meters and their installation. PG&E's findings so far don't explain every customer complaint about Smart Meters, and there remain a handful of meters spotted by PG&E that failed for reasons the utility doesn't yet understand. All of the problems identified to date can be easily fixed, says PG&E.

I. Problem: installation errors

The most common Smart Meter problem boils down to human error. Or rather, several different errors, most involving meters that measure natural gas usage.

PG&E Smart Meters that record electricity use are entirely new devices that replace old, analog predecessors. Gas Smart Meters, in contrast, are small modules that installers attach to existing gas meters to record and relay data.

Smart Meters for homes record electricity use once an hour, while those for businesses record once every 15 minutes. But in roughly 2,900 cases, workers installed the wrong kind, giving homeowners meters meant for businesses or vice versa. Putting the wrong meter on an account can confuse PG&E's computer system.

Burt said that problem could affect customer bills, although she wasn't aware of any specific cases in which that happened.

II. Problem: data storage and privacy of advanced metering data

In some meters, a software glitch causes the component that stores energy-use data to reboot itself occasionally, losing some but not all of the data in the process. Not every customer who experiences this problem will notice it.

EFF and other privacy groups filed comments with the California Public Utilities Commission Tuesday, asking for the adoption of strong rules to protect the privacy and security of customers' energy-usage information. Without strong protections, this information can and will be repurposed by interested parties.

Security researchers worry that today’s smart meters and their communications networks are vulnerable to a variety of attacks. There are also questions of reliability, as PG&E faces criticism from California customers who have seen bills skyrocket after the installation of the new "smart meters." Unsurprisingly, California legislators are questioning the rapid rollout. Texas customers are also complaining.

The need for safeguards and standards to protect the privacy and security of customer usage data continues to be a key issue associated with advanced metering systems. While one of the potential benefits associated with advanced metering is the ability to measure and communicate customer usage at a much greater level of detail than traditional electro-mechanical meters, various stakeholder groups have raised concerns at the state and national levels regarding the use, privacy and security of the vast amount of detailed usage data produced by advanced meters. In response to these concerns, states and the federal government are working on privacy standards and policies. Policies under consideration include procedures and rules governing customer ownership, consent, access and use, delineation of responsibilities, security, as well as the sale and transfer of data.

At the federal level, the Obama Administration examined privacy issues in depth in its June 2011 smart grid policy framework report. The report recommends that “State and Federal regulators should consider, as a starting point, methods to ensure that consumers’ detailed energy usage data are protected in a manner consistent with federal Fair Information Practice Principles and develop, as appropriate, approaches to address particular issues unique to energy usage.”

A number of states also took action in the past year to protect consumer data privacy. For example, as a result of legislation enacted in 2010 (SB 1476), the California PUC adopted privacy rules for the three investor-owned utilities addressing disclosure and protection of customer energy usage data generated by advanced metering, and the investor-owned utilities must file tariff changes that will provide third parties with access to a customer's usage and billing information (e.g., 15-minute or hourly price, usage and cost data) when authorized by the customer. The decision adopts the Fair Information Practice Principles. In addition to the privacy rules for the three investor-owned utilities, the California PUC also ruled that if specific electric utilities file applications to deploy advanced metering systems, these utilities must also address how the privacy rules should apply to their operations.

III. Problem: Radio frequencies and health

Another publicly noted concern regarding the deployment of advanced metering is the possible linkage between the radio frequencies used to transmit meter data wirelessly and human health. The radio frequency emissions associated with advanced metering have not been proven to present a risk to human health, but concerns about a possible linkage continue.

In response to customer concerns, several states examined the health concerns raised by some customers and developed policies to address these concerns. For example, in December 2010, the California Public Utilities Commission dismissed a motion to consider the potential danger of advanced metering, concluded that RF emissions are under the purview of the FCC, and the RF emissions from advanced meters are "one/six thousandth of the Federal health standard at a distance of 10 feet from the Smart Meter and far below the RF emissions of many commonly used devices." Nevertheless, in March 2011, California Public Utilities Commission President Peevey asked Pacific Gas & Electric to develop a customer opt-out proposal to address customer concerns. PG&E's initial proposal identified two options as economic and technically feasible: turning off the radio transmitter in the customers' meters or relocating the meter to a different location on the property at the customer's expense.

IV. Problem: Smart meters hacked

In 2009, the Federal Bureau of Investigation investigated widespread incidents of power thefts in Puerto Rico believed to be related to smart meter deployment. The FBI believed that former employees of the meter manufacturer and employees of the utility company were tampering with the meters charging between $300 to $1,000 to reprogram residential meters and $3,000 to reprogram commercial meters.

The perpetrators were said to have hacked into the smart meters using an optical converter device connected to a laptop, allowing smart meters to connect with the computer. The hackers were able to change the settings for recording power consumptions using software available on the internet after making a connection. This method does not require the removal, alteration or disassembly of the meter.

3.1.4 Lesson

Decision Modifying PG&E Company's Smart Meter Program to Include An Opt-Out Option

This decision modifies Pacific Gas and Electric Company's Smart Meter Program to include an option for residential customers who do not wish to have a wireless Smart Meter installed at their location. The opt-out option shall be an analog electric and/or gas meter.

This new opt-out option is a service that we are adopting with this decision. This opt-out option is a service because the standard for metering has been transitioned throughout the economy and for the most part the world from the older technology, analog meters, to today's technology, Smart Meters. In this decision we are not reversing that transition, however, we do approve an option for those customers who, for whatever reason, would prefer an analog meter. This option to move away from the standard will require PG&E to incur costs such as purchasing a new meter, going back to the customer location to install and service the meter, and monthly cost of reading the meter. These are some of the examples of the additional costs required to opt-out of the standard wireless Smart Meters. As a result, this decision further finds that customers electing the opt-option shall be responsible for costs associated with providing the option. Issues concerning the actual costs associated with offering the analog opt-out option and whether some portion of these costs should also be allocated to all ratepayers or PG&E shareholders will be addressed in a separate phase of this proceeding.

To allow residential customers to begin selecting the opt-out option immediately, this decision adopts interim fees and charges, which will be subject to adjustment upon conclusion of the second phase of this proceeding. A Non-CARE customer electing the opt-out option shall be assessed an initial fee of $90.00 and a monthly charge of $10.00. A CARE customer electing the opt-out option shall be assessed an initial fee of $10.00 and a monthly charge of $5.00.

This decision also authorizes PG&E to establish new two-way electric and gas Modified Smart Meter Memorandum Accounts to track revenues and costs associated with providing the opt-out option until a final decision on recoverable costs and cost allocation is adopted.

This decision further directs PG&E to file a Tier 1 Advice Letter implementing the opt-out option and to establish a Smart Meter Opt-Out Tariff within 15 days of the effective date of this decision. Finally, the September 21, 2011 Assigned Commissioner's Ruling directing PG&E to establish a delay list shall no longer be in effect and all customers currently on the delay list shall be transitioned to a wireless

Smart Meter unless they elect to participate in the opt-out option. This proceeding remains open to address cost issues associated with the opt-out option.

3.2 Australia

3.2.1 Introduction

The AMI Program has been developing and evolving since 2004, when it was first recognized by the Victorian Government that replacing the existing stock of basic accumulation meters with meters that can record electricity use in half hour intervals would enable more efficient pricing and assist Victorians to better manage their energy consumption.

To achieve energy efficiency, and hence a corresponding reduction in carbon emissions, consumers and the electricity industry both need to work together to:

I. reduce energy demand and waste where appropriate and possible
II. promote the efficient use of household appliances, and limit the inefficient use of appliances such as air conditioners and pool filters
III. shift consumption patterns to maximize the efficient use of power generating assets and smooth out peak consumption periods, which cause spikes in the cost of electricity and create inefficiencies in the allocation of capital to new generation capacity.

Mindful of these objectives, the Victorian government mandated the installation of smart meters for every household and small business in 2006, after consultation with power distributors, as part of the AMI program. Between 2009 and 2013 the AMI project will replace accumulation meters in 2.4 million homes and small businesses with smart meters.

The AMI project is a partnership with the electricity industry. Victorian electricity distribution businesses are responsible for installing smart meters and their infrastructure. The government has amended the electricity regulations so that consumers will directly pay for AMI installation costs.

Victoria is the earliest jurisdiction that rollouts the biggest scale of AMI program in Australia. Furthermore, there is a national AMI cost-benefit report released in mid-2008 and found a positive case for Victoria (and for most other jurisdictions). Despite the Council of Australian Governments' commitment to the development of a national smart meter legislative and regulatory framework, other jurisdictions have been more cautious than Victoria with its implementation.

Victoria AMI program working group

April 2006, Victorian Ministry of Infrastructure (DOI) established AMI industry Group (ISG) as the lead organization of AMI project. ISG is responsible for making strategies, providing conversation plat to several organizations, being the coordinating role through government, industry, management units, and households. ISG's main mission is to make relative laws, cost recovery method, schedules, service level requirements and to supervise the technical tests.

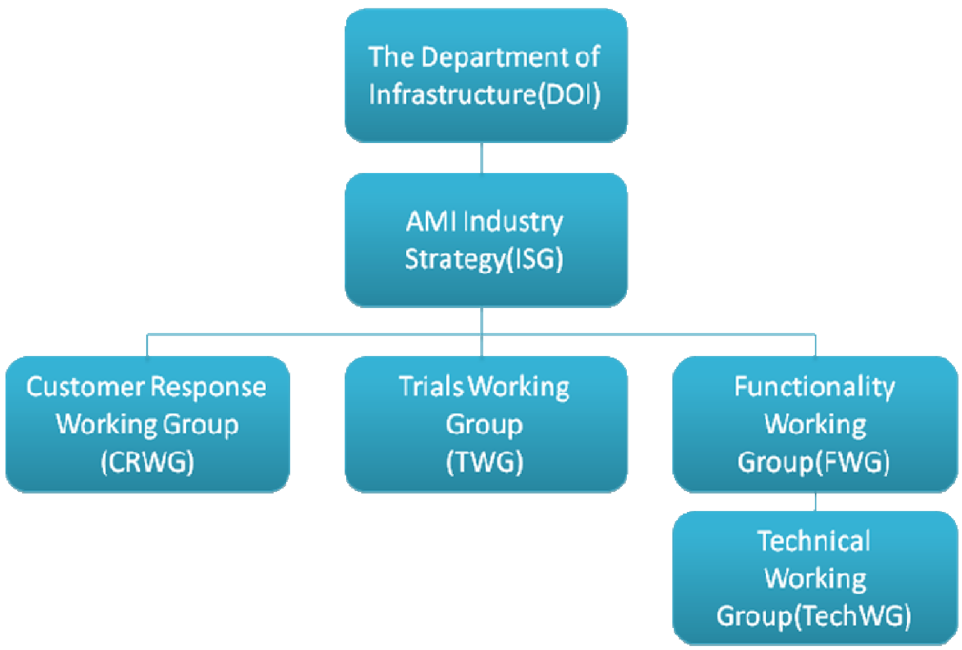
ISG has three work groups, Customer Response Working Group, Trials Working Group and Functionality Working Group. They are responsible for promote AMI.

I. CRWG urges electricity distributors make new power pricing systems and give new the information to consumers.

II. TWG assists ISG in making level requirements of the minimum function;

III. FWG has its technology work group, TechWG. TechWG provides technology suggestions to the other work groups. The suggestions contents are focus on the minimum functions from ISG.

Organizational structure is shown in the following figure 3.1.



(Source: P4, Department of Primary Industries, Advanced Metering Infrastructure (AMI) Project -Stakeholder Forum 2007)

Figure 3.1 Organizational structure

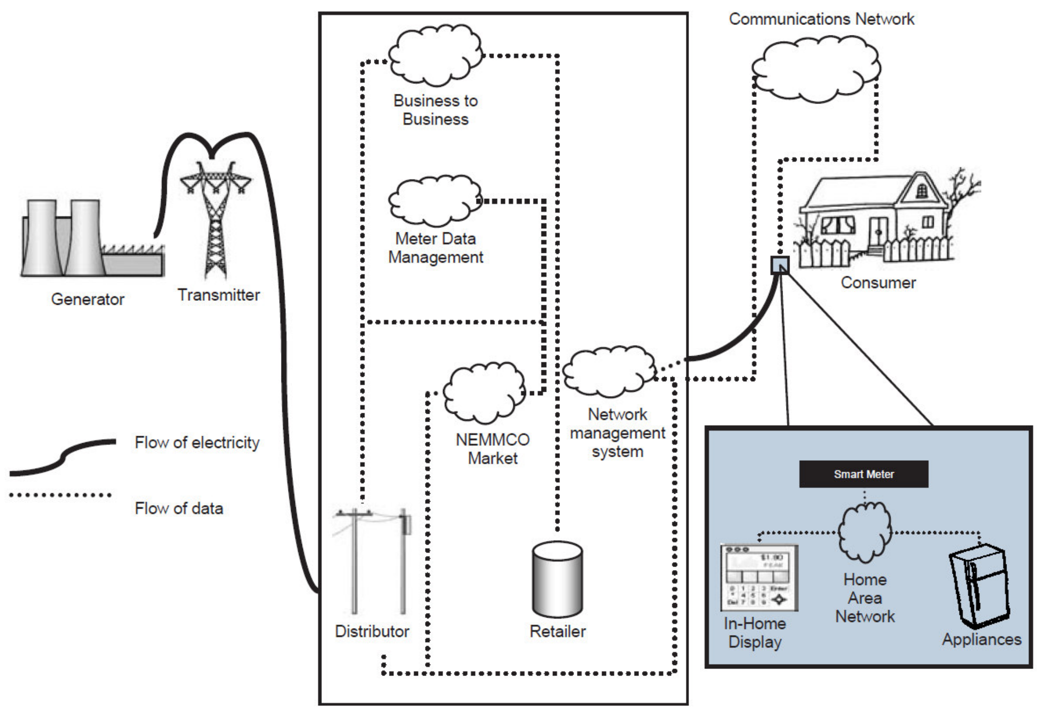
The former Department of Infrastructure (DOI) administered the AMI project until late 2006 when a 'machinery of government' change transferred administrative responsibility to the Department of Primary Industries (DPI).

Victoria electricity market

The Victorian electricity industry has been operating in a privatised and commercial environment since the early 1990s. As for-profit entities, the industry players bear commercial and technological risks within an appropriate regulatory framework.

The National Electricity Market (NEM) enables the flow of electricity from generators to the consumer, acting as a wholesale exchange for the trading of electricity between generators and bulk buyers. The generators compete to sell their power into the NEM where retailers can buy it in bulk and then on-sell this power to customers at retail rates.

The electricity distributors own and manage the network of 'poles and wires' that takes electricity to the consumer. In Victoria, distribution is a 'natural monopoly', as each distributor is responsible for one geographic zone. Due to this, an independent regulator determines the aggregate charges the distributors can recover from the retailers, who are not restricted by geographic zones.



Source: Victorian Auditor-General's Office.

(Source: Figure 1A, Victorian Auditor-General's Report, Towards a 'smart grid' – the roll-out of Advanced Metering Infrastructure 2009)

Figure 3.2 Victorian electricity industry

Key market characteristics

I. Recent energy market reform

a. The Victorian electricity sector was privatised in the 1990s.
b. The electricity industry was vertically (ensuring that there are no shared ownership interests between retailers and distribution businesses) and horizontally disaggregated.
c. Full retail competition for electricity was introduced in January 2001.
d. Retail price regulation of the standing offer was removed in January 2009.

II. Load and consumption issues

a. Victoria has the second highest peak load (in percentage terms) of all the Australian States (only South Australia has a more peaky load) caused by factors such as large businesses and industry having peak loads at coincident times, and the increasing penetration and use of air conditioning in homes.
b. Domestic electricity accounts for approximately 26% (12,638 GWh) of the state's total annual electricity consumption.
c. Approximately 70% of households have air conditioning.

III. Domestic consumers

a. There are approximately 2.1 million residential electricity connections.
b. Average electricity consumption per household is approximately 6000 kWh per annum.
c. In areas without access to reticulated gas, average electricity consumption per household is approximately 8246 kWh per annum.
d. Compared to other jurisdictions, a high proportion of households have access to reticulated gas. Approximately 66.5% of households use natural gas for heating purposes.
e. The average annual domestic electricity bill in 2007 was $973 (including GST).
f. The average annual domestic electricity supply charge in 2007 was $155.13
g. The annual gross switching rate among small electricity customers in 2007-08 was 23%.14
h. Approximately 60% of all domestic and small business customers have switched from a standing offer contract to a competitive market contract for the supply of electricity or gas (or a combination), since the start of full retail competition.15
i. The various cost components of a customer's bill are approximately:

- 40% regulated network tariffs (transmission and distribution)
- 45% generation costs

◆ 10% retail services
◆ 5% retail margins

IV. **Energy affordability and disconnections**

a. Approximately 38% of domestic electricity customers are concession cardholders.
b. 18% of households have used instalment plans to pay electricity bills.
c. The mean ranking of priority in bill paying shows that payment of rent/mortgage rank first and electricity bills second.20
d. In 2006-07, electricity retailers disconnected and reconnected (in the same name) 1.2% of domestic customers.
e. 2.9% of domestic electricity consumers experienced disconnection in 2007-08.

V. **Market participants and regulators**

a. There are currently 14 retailers operating in Victoria.
b. Victoria has five distribution businesses:
  ◆ Powercor (western suburbs and western Victoria)
  ◆ Citipower (city and inner suburbs)
  ◆ SP AusNet (outer northern and eastern suburbs and eastern Victoria)
  ◆ Jemena (northern and south-western suburbs)
  ◆ United Energy (southern suburbs and the Mornington peninsula).
c. The Australian Energy Market Commission (AEMC) administers the National Electricity Rules (NER) that governs the NEM in accordance with the National Electricity Law (NEL). The Ministerial Council on Energy (MCE), established by the Council of Australian Governments (COAG), is the national policy and governance body for the Australian energy market and sets the NEL.
d. The Australian Energy Regulator (AER) regulates the wholesale electricity market and is responsible for the economic regulation of electricity transmission and distribution networks in the NEM, as well as compliance with and enforcement of the NER. The AER took over responsibility for economic regulation of the Victorian electricity distributors from the Victorian Essential Services Commission (ESC) on 1 January 2009.
e. The ESC is the independent regulator of the retail energy industry in Victoria. It licenses the distribution and sale of energy in Victoria and ensures that licensees comply with its codes and guidelines.

Victorian Government AMI Policy

All residential and small business electricity consumers across Victoria have access to the benefits of smart meters and the full capabilities that AMI enable.

I. Consumer benefits: Increase options for consumers to better manage their energy use and understand greenhouse emissions;
II. Energy Market benefits: Encourage new and innovative products and prices, enable improvements to consumer service, competition and wholesale trading;
III. Distributor benefits: Deliver operational efficiencies, improve network management and utilization, defer augmentations and optimize investment.

Since the AMI project began in 2006 the government, in conjunction with industry and regulatory stakeholders, has:

I. established enabling legislation
II. formulated cost recovery methods
III. set a project schedule
IV. developed specifications and service level requirements
V. supervised technology trials
VI. confirmed its commitment to the AMI roll-out.

The current schedule for rolling out smart meters to Victorian households and small businesses is presented in table 2 below.

Table 3.1 AMI roll-out schedule

Rollout timelines for the Victorian smart meter project Date	Percentage of meters to be installed
30 June 2010	**5%**
31 December 2010	**10%**
30 June 2011	**25%**
30 June 2012	**60%**
30 June 2013	**95%**
31 December 2013	**100%**

(Source: Figure 1B, Department of Primary Industries, Towards a 'smart grid' – the roll-out of Advanced Metering Infrastructure 2009)

Legislation framework of AMI

The government's AMI policy and legislative framework made distributors responsible for the AMI project as this was considered to be the most cost effective option. As the National Electricity Rules hold retailers responsible for the interval data collected remotely, the government gained a waiver from these rules, which is applicable for a period covering the project implementation timeframe.

In August 2006, the Parliament passed an amendment to the *Electricity Industry Act* that gave government the authority to make 'Orders-in-Council' (OIC)—which are enforceable orders by the executive branch of government—to establish a range of requirements for the deployment of AMI.

In August 2007 the government issued an OIC, setting up the initial regulatory framework for cost recovery and installation targets for distributors. This OIC was subsequently amended in November 2008.

The OIC also establishes a regulated cost recovery framework to provide certainty for electricity distributors to commit to AMI deployment expenditure through to December 2013.

Orders in Council

The Victorian Government announced the rollout of AMI for all customers consuming less than 160MWh per annum in 2006. The Government subsequently decided that electricity distributors would be given an exclusive mandate to roll out the meters.

The regulatory arrangements relating to the rollout are set out in an August 2007 OIC made under sections 15A and 46D of the Electricity Industry Act 2000, and an amending order that mandate the initial minimum specifications for functionality, performance and service levels of the smart meters made on November 2008.

The OIC also establishes a regulated cost recovery framework to provide certainty for electricity distributors to commit to AMI deployment expenditure through to December 2013.

In summary, the Orders in Council:

I. establish a regulated cost recovery framework to provide certainty for electricity distributors to commit to AMI deployment expenditure through to December 2013

II. mandate the initial minimum specifications for functionality, performance and service levels of the smart meters; and

III. specify meter installation targets for distributors.

Cost recovery framework

Under the Cost Recovery Order, budgets for the AMI roll-out are established by the distributors and agreed with the AER at the beginning of the budget period (January 2009-December 2011, and January 2012-December 2015). Annual charges are then determined based on a combination of actual and forecast expenditure, assessed of program scope and prudence by the AER.

The regulatory cost recovery mechanism is essentially ’expenditure orientated’ based on prudent and competitive procurement practice. This is in contrast to a “forecast orientated” approach, whereby distributors benefit from spending less than forecast through improved and more efficient practices under an incentive based regulation approach.

Present situation of AMI in Victoria

A Ministerial Advisory Council for the Advanced Metering Infrastructure program has recently been formed in Victoria, focusing on the benefits of smart meters to consumers and giving people in Victoria a voice in the program. The Council aims to give the key stakeholders a collaborative framework, including consumer groups and industry representatives to bring forward the benefits of the smart meter program. It will monitor smart meter consumer information and engagement programs to ensure that the people of Victoria have the facts about smart meters.

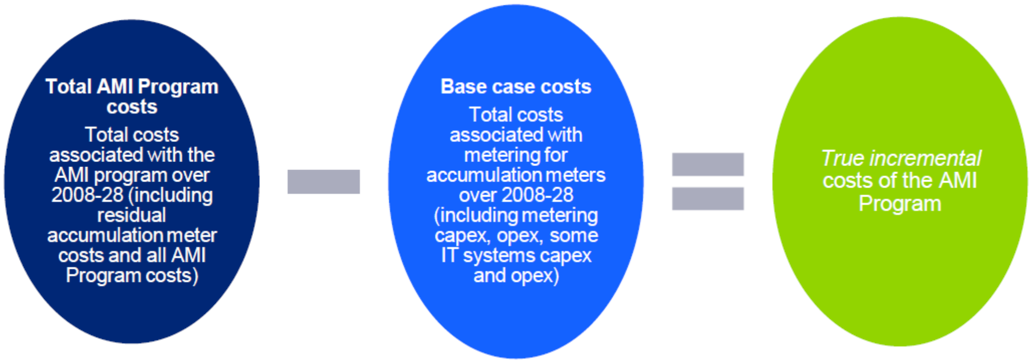
The AMI rollout was around 40% complete at the end of February 2012, with around 1 million meters installed, many of these already being remotely read. The rollout is expected to be complete by the end of 2013.

3.2.2 Finding

Benefits and Costs Analysis of the Victorian AMI Program

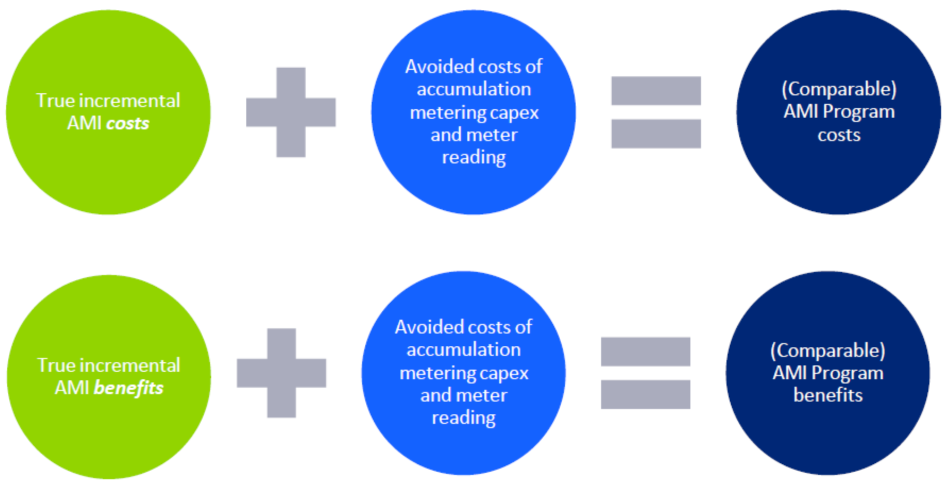
The analysis is from Deloitte‘s that is a UK private company. Deloitte‘s approach to cost benefit analysis is in a fully established accumulation meter base case for 2008-28 has been calculated separately to the full costs of the AMI Program over 2008-28. In order to determine the incremental costs of the AMI Program, the base case costs are subtracted from the AMI Program costs.

Part of Deloitte‘s brief in developing the cost benefit analysis of the AMI program was to make an assessment of the distributors‘ 2012-15 AMI budget applications that were submitted to the AER in February 2011.The following diagram demonstrates the approach to calculating the incremental costs of the AMI Program.



(Source: Figure 4.1, Deloitte, Department of Treasury and Finance Advanced metering infrastructure cost benefit analysis Final report 2011)

Figure 3.3 Calculating the true incremental costs of the AMI Program



(Source: Figure 4.2, Deloitte, Department of Treasury and Finance Advanced metering infrastructure cost benefit analysis Final report 2011)

Figure 3.4 Calculating the costs of the AMI Program for comparison to previous analyses

Cost prudency assessment

Deloitte‘s outlined in their analysis of the AMI Program costs some adjustments made to the distributors‘ 2012-15 proposed AMI program management costs to account for our view that they are unlikely to pass the prudency test in the AMI OIC and therefore will not be approved by the AER. While we consider the remainder of the 2012-15 proposed costs reflects the likely cost to be incurred by customers‘, there are areas of the distributors‘ proposed costs that may not be prudent. In estimating the

AMI Program costs from 2016-28, we have only included those costs we consider to be the efficient costs of the AMI Program.

Deloitte's approach to testing the prudency of the distributors' proposed budget expenditure relied on internal benchmarking of distributor costs against each other, and international benchmarking of broad capex and opex cost categories on a per customer basis. Drawing on a significant bank of international smart meter rollout experience, we make the following observations about the distributors' proposed budgets for 2012-15, as set out in table 3.2. The table provides the estimated impact that not approving the distributors' proposed costs would have on our estimate of total AMI Program costs over 2012-15.

Table 3.2 Assessment of the prudency of proposed costs over 2012-15

Cost category	Comments	Estimated impact on our total AMI Program costs over 2012-15 ($,2011)
Program Management	One distributor (SP AusNet) proposed program management costs of over 40% higher than the other distributors in 2012-13. Also, all distributors proposed significant program management costs for 2014 and 2015 (CitiPower and Powercor). It is our view that these costs are unnecessary.	$0 (these were adjusted within our estimate of the total costs of the AMI Program)
IT capex - Connection Point Management (CPM)	Two distributors (CitiPower and Powercor) proposed CPM costs significantly above the other distributors‘ costs over 2009-15. However, the majority of the costs were approved for 2009-11 and are therefore sunk. Recommend that further proposed CPM costs for 2012-15 be rejected.	$4.9 million
IT capex – Network Management System (NMS)	One distributor (SP AusNet) has proposed significantly higher NMS costs than the other distributors over 2009-15. Again, most of this difference was approved over 2009-11. Recommend that further proposed NMS costs for 2012-15 be rejected.	$3.8 million
Ongoing opex	As discussed in section 4.4.3.3 above, the distributors‘ metering operating costs for 2015 are approximately 21% higher than international benchmarks.	$33.2 million

(Source: Table 4.3, Deloitte, Department of Treasury and Finance Advanced metering infrastructure cost benefit analysis Final report 2011)

Avoided costs resulting from the AMI Program

Deloitte‘s have relied on publicly available information on the Victorian distributors‘ accumulation metering costs over 2001-09 to determine the avoided costs. This included data taken from regulatory decisions made by the ORG in 2001, the ESC in 2006 and the AER‘s decision on AMI costs over 2009-11 (noting that this latter decision incorporates metering costs over 2006-08).

Historical cost data on meter supply capex and meter reading were sourced from these decisions. Both accumulation meter replacement and manual meter reading costs were escalated by the projected growth in meter numbers over 2008-28.
Table 3.3 presents our estimates of the avoided costs resulting from the AMI Program, as compared to the previous analyses.

Table 3.3 Avoided costs resulting from the AMI Program (millions, NPV at 2008)

Benefit	Futura 2010	Oakley Greenwood	Deloitte
Avoided cost of replacing accumulation meters	492	492	649
Avoided cost of replacing time switches	75	75	Incorporated in avoided cost of replacing accumulation meters
Avoided cost of manual meter reading	288	288	154
TOTAL	**855**	**855**	**802**

(Source: Table 4.6, Deloitte, Department of Treasury and Finance Advanced metering infrastructure cost benefit analysis Final report 2011)

Total AMI Program Benefits

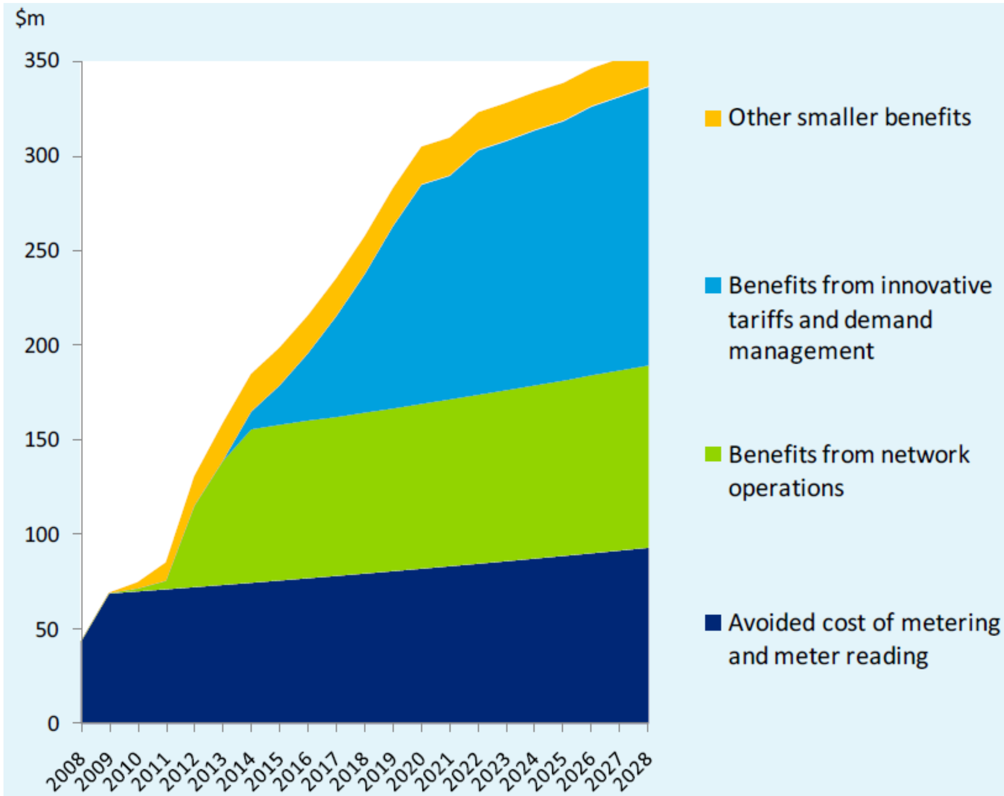
Table 3.4 compares our total benefit calculation to that calculated by Future and Oakley Greenwood, and Figure 3.5 demonstrates our estimated value of Total AMI Program benefits, and their expected realisation over 2008-28.

Table 3.4 Total AMI Program benefits (millions, NPV at 2008)

Benefit category	Futura	Oakley Greenwood	Deloitte
Avoided costs resulting from AMI Program	855	855	802
Benefits derived from efficiencies in network operations	1 029	956	587
Benefits generated from innovative tariffs and demand management	413	498	490
Other smaller benefits	343	280	151
Total	**2 640**	**2 588**	**2 030**

(Source: Table 4.20, Deloitte, Department of Treasury and Finance Advanced metering infrastructure cost benefit analysis Final report 2011)

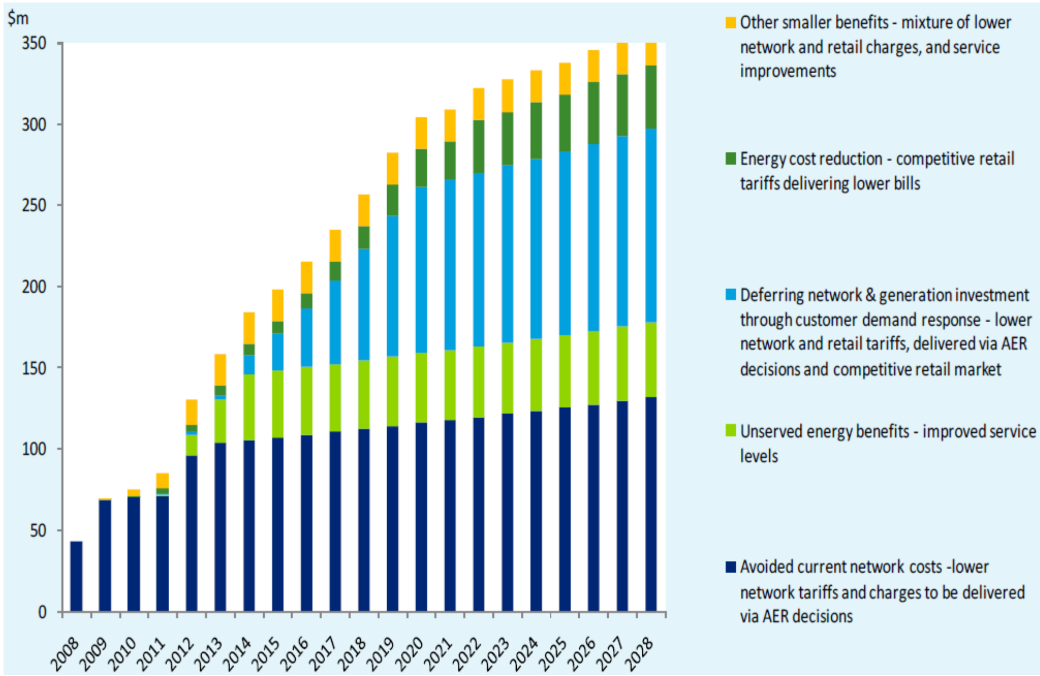
The figure below presents benefits over time. The key benefits derived from efficiencies in network operations and innovative tariffs start from 2014 (after the smart meter rollout is completed) and ramp up significantly over the next 14 years



(Source: Figure 4.10, Deloitte, Department of Treasury and Finance Advanced metering infrastructure cost benefit analysis Final report 2011)

Figure 3.5 Estimated value of Total AMI Program benefits over 2008-28

Figure 3.6 outlines the benefits according to how they are to be realised by customers.

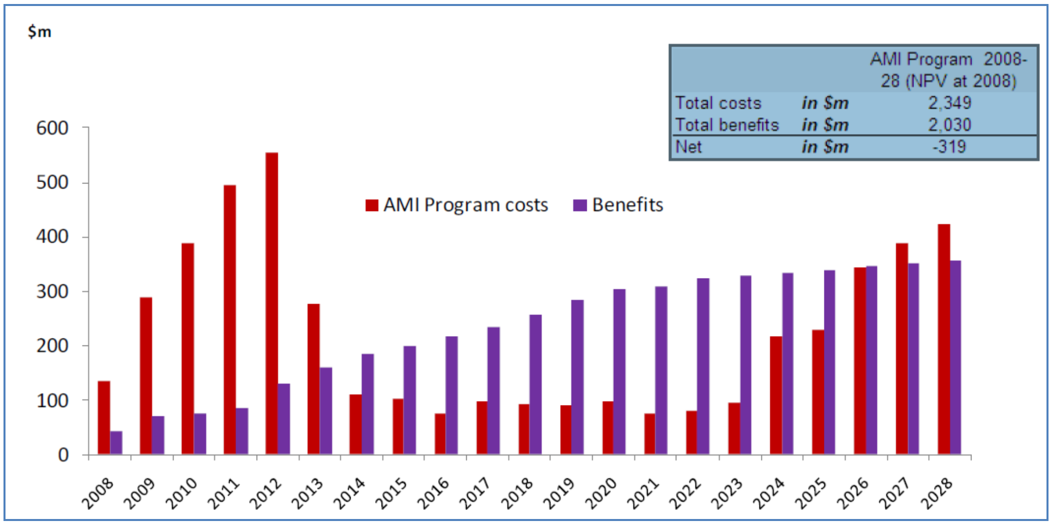


(Source: Figure 4.11, Deloitte, Department of Treasury and Finance Advanced metering infrastructure cost benefit analysis Final report 2011)

Figure 3.6 AMI Program benefits accrual to customers

Costs and benefits of the AMI Program 2008-28

The costs and benefits of the AMI Program from 2008-28 concludes that the Program will result in a net cost to Victorian customers of $319 million, as outlined in Figure 3.7 (NPV at 2008). This negative result is driven largely by the fact that the realisation of benefits has been delayed as compared to previous analyses of the AMI Program, and costs have increased.



(Source: Figure 4.12, Deloitte, Department of Treasury and Finance Advanced metering infrastructure cost benefit analysis Final report 2011)

Figure 3.7 Profile of AMI Program costs and benefits 2008-28

3.2.3 Problems

1. Time-of-Use (TOU) pricing

This allows power distributors to 'shape' customer demand, by imposing higher prices when power distributors want to reduce load. However, many low-income and disadvantaged people have limited discretionary energy consumption and are therefore unable to switch off unwanted appliances. TOU pricing also discriminates against others, such as parents with young children, bedridden people, and the elderly who remain at home during the day.

Questions have also been raised as to the actual effectiveness of time-of-use pricing as a tool to shape customer demand. The impact of TOU on consumers' energy loads waned overtime, with TOU tariffs eliciting only a 0.6% reduction in peak demand towards the end.

2. Billing Errors

The introduction of AMI technology has led to a surge in billing errors being reported. Errors reported by the media include overbilling due to what are believed to be serious systemic issues, bills soaring by many hundreds or even thousands of dollars due to faults, and moderate increases which are being blamed on either previous underestimation by analogue meters, or the ability of smart meters to detect wider parameters of electrical usage.

3. Additional costs being imposed on households without any apparent benefit

The Auditor-General concluded in November 2009 that it was unclear how consumers, in particular, would benefit from the smart meter program. Electricity retailers have also claimed the chief beneficiaries of the smart meter program are the power distributors.

However since 1st January 2010 electricity retailers have been required to pass on the advanced meter charge to consumers. This is regardless of whether or not a particular household has had a smart meter installed, or whether or not remote communications, which aren't due to have full functionality across Victoria until the end of 2013, are in place. This is also despite the fact that the power distributor owns the meter, not the consumer.

However, there is no compensation to cover "unused life" of current meters, nor any choice about installation of new smart meters, whether wanted or not. This current compulsory meter changeover is an unjustified financial imposition on the householders and small businesses of Victoria. The Consumer Action Law Centre wrote in its submission to DTF '*we do not see why consumers should bear the entire upfront cost of the rollout, particularly when there are many unfounded assumptions being made about the extent of the benefits being passed through to consumers*'.

4. Cost blow-outs

CitiPower, Powercor's sister company, stated in February 2009 in its Advanced Metering Infrastructure Budget Application 2009-11 that Victoria was to be a world 'trail blazer' with respect to the IT component of the AMI program, with the adoption of 'relatively immature technologies with attendant risk'.

Already, the Australian Communication and Media Authority (ACMA) has considered shifting the smart meter communications used by CitiPower, Powercor, Jemena and United Energy (between 915 MHz to 928 MHz) to the 928 MHz to 933MHz band due to overcrowding in the current segment, and the likelihood that smart meter communications will interfere with other users.

Jemena stated, if the move to the higher band is implemented, *'the change means that every meter deployed so far would require the internal radio to be re-tuned to the new frequency'*. They also went on to state that it is unclear whether this would involve a hardware or software change in the meter.

Who is going to pay for this? According to CitiPower and Powercor, ultimately it is customers that bear the burden of any redesign costs. ABC News reported on 18th May of 2010 that there had been a $500 million dollar blow-out in the cost of "smart" electricity meters, which the government had conceded individual consumers would have to pay for. Around $800 million was originally budgeted, with a report into the project now showing a cost of $2.3 billion. What will the final bill be for consumers?

5. Privacy concerns

It is reported that collected data, revealing consumer usage of electricity over each 30 minute interval, is to be on-sold for research purposes. This is of concern to a number of people as they believe this information should remain confidential. Other areas of concern centre on questions regarding the vulnerability of radiofrequencies carrying usage data to interception. DPI engaged Lockstep Consulting to undertake a Privacy Impact Assessment of AMI last year.

Lockstep's report largely sidestepped technical questions regarding the vulnerability of radiofrequencies to interception, relying on the fact that all meter to electricity distributors' communications and all HAN traffic is encrypted.

6. Fire risk

The proficiency of installers is only one part of the safety equation. There are also concerns that the high frequencies transmitted by smart meters may couple on to household wiring, given the close proximity to conductive wiring. In a paper that household wiring is simply not designed to carry the high frequency harmonics generated by 'very short, very high intensity wireless emissions'.

The government has not to-date commissioned testing of this possibility. The Metropolitan Fire Brigade announced in November that it was examining all fires at premises that had a smart meter installed, but findings from this have not yet been released.

7. Health concerns

DPI state in their Health fact sheet that 'health authorities around the world, including ARPANSA and the World Health Organization, have examined the scientific evidence regarding possible health effects and, using prescribed exposure limits, concluded that the weight of evidence does not demonstrate the existence of health effects'.

The World Health Organization on 31st May of 2011, pointing out that the evidence of the existence of health effects is still accumulating, classified 'radiofrequency electromagnetic fields (EMFs) as possibly carcinogenic to humans, based on an increased risk for glioma, a malignant type of brain cancer, associated with wireless phone use' (IARC, 2011). These frequencies are in the same bandwidth as that employed by smart meters.

8. No ‘opt-out’ provision available to customers

According to newspaper reports ten percent of Victorians have taken the unprecedented step of refusing to have a smart meter. It is not known how these consumers will be dealt with. The government maintains that every Victorian household will have a smart meter installed by the end of 2013. Consumer Action Law Centre pointed out last year that if consumers continue to prevent access to the distribution business’ asset, the law has not been tested in this respect and the consequences are unknown for consumers. It has already been reported that the government, whilst issuing platitudes assuring consumers that there are processes in place to attempt to come to an agreeable solution, have stated disconnection is a last resort.

3.2.4 Lesson

1. Economic merits

The cost-benefit study behind the AMI decision was flawed and failed to offer a comprehensive view of the economic case for the project. There are significant unexplained discrepancies between the industry’s economic estimates and the studies done in Victoria and at the national level. These discrepancies suggest a high degree of uncertainty about the economic case for the project.

2. Implementation risks

The AMI project has significant implementation risks that have been underestimated in advice to government. These risks, which relate to technology and relationships with national systems and processes, have started to materialise and are likely to erode the projected net benefits.

The advice to government that led to the AMI decision scarcely considered project risks. The risk management approach was to rely on the electricity industry to address and bear technology risks. However, the regulatory regime does not give the industry enough incentive to manage risks and associated costs that consumers are likely to pay. The project risks are therefore very likely to directly affect consumer prices.

The technology risks were underestimated when the government was recommended to commit to the project. Sufficient resources were not allocated to manage equipment trials. The trials did not offer reasonable assurance that the proposed technologies were viable. However, DPI persisted in advising government to proceed.

The department’s lack of adequate risk management comes from its belief that industry is responsible for managing technology risks. However, given the extent to which the department promoted the project, the nature of the regulatory intervention, and the implications for consumers, the department is accountable for effectively managing risks that have the potential to undermine the economic case.

3. Consumer implications

The cost-benefit analysis is unclear about how stakeholders, particularly consumers, will benefit and who should bear which costs. There is little evidence to show that when the project was designed, the resultant benefits and costs were adequately considered. It is therefore possible that there will be an inequitable, albeit unintended, transfer of economic benefits from consumers to industry.

3.3 Ireland

3.3.1 Introduction

The Commission for Energy Regulation

The Commission for Energy Regulation ('the CER') is the independent body responsible for overseeing the regulation of Ireland's electricity and gas sectors. The CER was initially established and granted regulatory powers over the electricity market under the *Electricity Regulation Act 1999*. The enactment of the *Gas (Interim) (Regulation) Act 2002* expanded the CER's jurisdiction to include regulation of the natural gas market, while the *Energy (Miscellaneous Provisions) Act 2006* granted the CER powers to regulate electrical contractors with respect to safety, to regulate natural gas undertakings involved in the transmission, distribution, storage, supply and shipping of gas and to regulate natural gas installers with respect to safety. The *Electricity Regulation Amendment (SEM) Act 2007* outlined the CER's functions in relation to the Single Electricity Market (SEM) for the island of Ireland. This market is regulated by the CER and the Northern Ireland Authority for Utility Regulation (NIAUR). The CER is working to ensure that consumers benefit from regulation and the introduction of competition in the energy sector.

EU Environment

I. EU Legislation

There are a number of key *European Union* ('EU') legislative instruments promoting smart metering, which include:

- **Third Legislative Package for Further Liberalization of the Electricity and Gas Markets**

The 3rd Package contains provisions regarding intelligent metering systems, with the aim of better informing customers of their consumption and helping to increase awareness of energy consumption. The implementation of those metering systems may be subject to an economic assessment of all the long-term costs and benefits to the market and the individual consumer or of which form of intelligent metering is economically reasonable and cost-effective and which timeframe is feasible for their installation.

The general principle is that consumers must have access to their consumption data. National Regulatory Authorities (NRAs) must ensure access to customer consumption data, and the existence of a nationwide harmonized format for consumption data and a process for suppliers and consumers to access the data must be defined.

Intelligent metering systems are promoted twice in the Directives: first, with the aim to promote energy efficiency and demand side management measures; second, with the aim to ensure active participation of consumers in the market. Different provisions apply for electricity and for gas. There are also a number of EU Interpretive Notes which cover smart metering published on these directives.

- **Directive 2006/32/EC - Energy End-use Efficiency and Energy Services**

It has been estimated that EU energy consumption is around 20% higher than can be justified on economic grounds. This has led to the view that there is a large potential for unrealized economic energy savings which can be realized through energy services and other end-use efficiency measures. In pursuit of this objective the European Commission adopted EU Directive EC 2006/32 on April 5, 2006. Article 13 of this Directive requires that:

> *"Member states shall ensure that, in so far as is technically possible, financially reasonable and proportionate in relation to the potential energy savings, final customers for electricity … are provided with competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use"*

> *"Appropriate information shall be made available with the bill to provide final customers with a comprehensive account of energy costs. Billing on the basis of actual energy consumption shall be performed frequently enough to enable customers to regulate their own energy consumption".*

II. EU Initiatives

There are currently a number of EU coordinated smart metering initiatives underway which include.

- On February 8, 2011, ERGEG (European Regulators' Group for Electricity and Gas) published its final Guidelines of Good Practice (GGP) on Regulatory Aspects of Smart Metering for Electricity and Gas (E10-RMF-23-03)12. These final recommendations aim to provide guidance regarding the European Commission's 3rd Energy Package provisions on the installation of intelligent metering systems for electricity and gas, focusing on customer services, roll-out of smart meters, cost benefit analysis and data security and integrity.
- European Standards organisations are progressing **Mandate M/44113** for the development of an open architecture for utility meters involving communication protocols and functionalities enabling interoperability. The Mandate has the general objective to highlight or to harmonise European standards that will enable Electricity Customer Behavior Trials (CBT) Findings Report (CER/11/080a) Introduction interoperability of utility meters (water, gas, electricity, heat). This can then improve the means by which customers' awareness of actual consumption can be raised in order to allow timely adaptation to their demands. According to Mandate M/441, the implementation of this provision requires the definition of new functionalities for smart meters – in addition to those in the Measuring Instruments Directive (MID) and as stated by the European Commission in the Mandate M/441.
- The **Open Meter Project** began in January 2009 with the main objective to specify a comprehensive set of open and public standards for AMI, supporting electricity, gas, water and heat metering. This project is due to conclude in June 2011.
- In January 2010 a **Task Force on Smart Grids** was launched whose mission is to advice the European Commission on policy and regulatory directions at European level and to coordinate the first steps towards the implementation of smart grids under the provision of the 3rd Package. The initial duration of the Task Force is 20 months to May 2011.

III. Smart Mertering Roll-out Status in Europe

The status of smart metering for electricity and gas in Europe is diverse and changing at a rapid pace.

The last publicly available official report on the status of each economy is the *ERGEG Summary of Member State experiences on cost benefit analysis* ('CBA') *of smart meters* published February 2, 2011, but this document focuses on smart metering cost benefit analysis development rather than specific meter rollout status. Table 3.5 below is an excerpt from this report and indicates that, out of the 24 member states that responded to the ERGEG survey, as of 1st January 2011 eleven had completed an electricity CBA & six had completed a gas CBA.

Table 3.5 Status of Smart Metering CBA Development in EU Member States

Status of CBA in CEER economies	Electricity	Gas
Economies have conducted a CBA	11[1]	2[6]
Positive result of CBA	7[3]	5[4]
Economies plan (or ongoing) to conduct a CBA (in some cases for the 2nd time - France, Hungary, Poland, Portugal)	12[5]	14[6]
Economies do not plan a CBA	2[7]	5[8]
Economies with no CBA, but no longer relevant (yes/no of roll-out already decided)	3[9]	0
1: Austria, Denmark, France, Hungary, the Netherlands, Norway, Poland, Portugal, Slovenia, Sweden, United Kingdom		
2: Austria, France, Hungary, Italy, the Netherlands, United Kingdom		
3: Austria, France, the Netherlands, Norway, Poland, Portugal, United Kingdom (Poland - study was TSO, not gov't authority. In Sweden, although result was negative, roll-out for electricity proceeded.)		
4: Austria, , France, the Netherlands, Italy, United Kingdom		
5: Belgium, Czech Republic, Germany, France, Greece, Hungary, Ireland, Luxembourg, Latvia, Poland, Portugal, Romania (Belgium - each region conducting its own, no federal one planned)(Portugal – to be decided by gov't)		
6: Belgium, Czech Republic, Germany, Spain, Finland, Greece, Hungary, Ireland, Latvia, Luxembourg, Lithuania, Portugal, Slovenia, Sweden (Portugal – to be decided by gov't)		
7: Lithuania, Slovak Republic		
8: Denmark, Norway, Poland, Romania, Slovak Republic (Norway has no gas)		
9: Spain, Finland, Italy,		

(Source: Page 2, ERGEG Summary of Member State experiences on cost benefit analysis (CBA) of smart meters published February 2, 2011)

The *ERGEG Status review on regulatory aspects of smart metering* report, published October 2009 is still the last publicly available official report on the status of each economy regarding trials and rollouts of smart metering. Because of the fast pace of development in the area of smart metering it should be noted that the national situations which are reflected in the status review may no longer provide a complete and accurate picture.

- Generally in electricity only two economies have undertaken a large scale meter installation programme for customers - these early adopters are Italy and Sweden with full roll-outs. In addition, some other economies have decided to undertake a large scale rollout of smart meters, such as Britain which mandated a national roll-out of smart electricity and gas meters. Other economies are considering roll-out plans with some undertaking smart metering trials to inform their decisions.

- In gas, there are fewer uptakes of smart meters, with Italy and Britain having planned roll-outs, while a small number of economies are discussing the possibility.

The *ERGEG Status review on regulatory aspects of smart metering* report also found that the most important policy objectives for supporting and encouraging a roll-out of smart meters in both electricity and gas are energy efficiency, peak load management and more frequent meter readings.

Smart Metering Progress in Ireland

I. Basic Market Situation of Electricity in Ireland

Ireland is operated by an electric company - Electricity Supply Board Networks (ESB Networks), power generation, transmission and distribution, total residential users of electric power reached 2,000,000. The basic description of electric power market is showed in Table 3.6.

Table 3.6 Basic Market Situation of Electricity in Irelands

Item	Content
Structure of power sources	Fossil fuel 70.5%（coal, gas, fuel oil）, nuclear 0%, hydro 3.8%, other renewables 25.7%
Number of DSO（2010）b	1
Total residential customers（2010）b	2 millions
Average electricity consumption of each residential customer in 2010b	4,600 kWh
Percentage of electricity meters installation of total residential customers in 2010c	96%
Percentage of residential electricity consumption vs. total electricity consumption in 2009a	-

Notes： Other renewables include solar power, wind power, geothermal, burnable renewables and waste generation (fired wood, waste wood and other solid waste, industrial and commercial waste, biogas and biomass etc.).

(Source: a、IEA Electricity Information 2010 (2010)；b、Berg Insight (2010/07)；c、ABS Energy Research (2009))

In 2010, Thermal power generation ratio has reached 70.5% that is the main electricity resource. Renewable energy ratio in total electricity generation reached 25.7% due to wind power promoted by government policy. Average electricity consumption of each residential customer reached 4,600 kWh/per year.

II. Government Policy and Legislation

The National Smart Metering Plan is a key Government priority in the context of enabling the development of a Smart Grid, facilitating more efficient use of energy and underpinning smart and sustainable economic growth.

The importance of Smart Metering within the Government's energy policy, and indeed within its wider economic strategy, reflects the fact that, at EU level, Smart Metering is seen as a critical tool in managing energy demand in the interests of consumers and businesses.

On December 22, 2009, the Energy Services Directive (Directive 2006/32/EC) was transposed into Irish law under the European Communities (Energy End Use Efficiency and Energy Services) Regulations 2009, **Statutory Instrument No. 542 of 2009**. These Regulations also amend the Electricity Regulation Act 1999 to allow the Commission for Energy Regulation to place requirements on energy undertakings in relation to informative billing.

"The Commission may, by direction under subsection, require an energy undertaking to do any or all of the following—

Provide bills to its final customers, based on actual energy use, at such frequency as may be specified by the Commission to enable those customers to regulate their own energy consumption in a timely manner,..."

In May 2009 the first **National Energy Efficiency Action Plan (NEEAP)** was adopted in line with EU requirements. The first NEEAP set out the key targets to met in order to achieve our 2020 commitments, including Action 33:

"We will encourage more energy efficient behaviour by householders through the introduction of smart meters".

The second NEEAP, due to be published in June 2011, will reiterate the importance of smart metering as a key tool for realizing long term energy demand management objectives.

III. CER Smart Metering Project

In March 2007 the CER issued a Demand Side Management and Smart Metering Consultation Paper (CER/07/038) in which the case for providing domestic and small business customers with time of day electricity prices and smart metering arrangements was made. This was followed in November 2007 with the publication by the CER of an information paper, Smart Metering - The Next Step in Implementation (CER/07/198) which outlined a proposed framework in which the future scope of smart metering arrangements can be established.

Following on from the conclusions reached in the smart metering information paper CER/07/198 the CER established the Smart Metering Project Phase 1 in late 2007 with the objective of setting up and running smart metering trials and assessing their costs and benefits, which will inform decisions relating to the full rollout of an optimally designed universal National Smart Metering Plan.

In order to draw on the experience and expertise of the electricity and gas market a Steering Group and a Working Group was established by the CER for the Smart Metering Project Phase 1. Both groups are chaired by the CER and consist 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, as figure 3.8.

(Source: Figure3, CER Cost-Benefit Analysis (CBA) for a National Electricity Smart Metering Rollout in Ireland 2011)

Figure 3.8 Smart Metering Project Phase 1 – Overview of Participants

To achieve its objectives the Smart Metering Working Group was divided into four Work Streams each focusing on separate aspects of the Smart Metering Project Phase 1:

- **Networks**: Technical design and rollout of Smart Metering infrastructure.
  Lead: ESB Networks (electricity) and Bord Gáis Networks (gas).
- **Customer Behaviour**: Mainly focusing on the design and implementation of all aspects of the customer behavioral trials, including participant selection, communications and analysis of results.
  Lead: Sustainable Energy Authority of Ireland (SEAI).
- **Tariffs**: Mainly focusing on design of Tariffs (Time of Use) and development of a Prepayment Market Model.
  Lead: Electric Ireland.
- **Billing / Data**: Mainly focusing on data flows from the Smart Metering infrastructure to Suppliers for customer behavior trial billing options.
  Lead: Bord Gáis Energy Supply.

The CER was responsible for undertaking a CBA, which is published alongside the CBT report, and worked with the Economic and Social Research Institute (ESRI) in this regard. As part of this work, the CER identified all information requirements for a CBA, the parties responsible for providing such information and coordinated the transfer of the required information to the ESRI for their modelling. The CER also arranged for an independent audit of the supplier and network operator cost and benefits included in the CBA, which was conducted by Frontier Economies. The Governance Structure is as below:

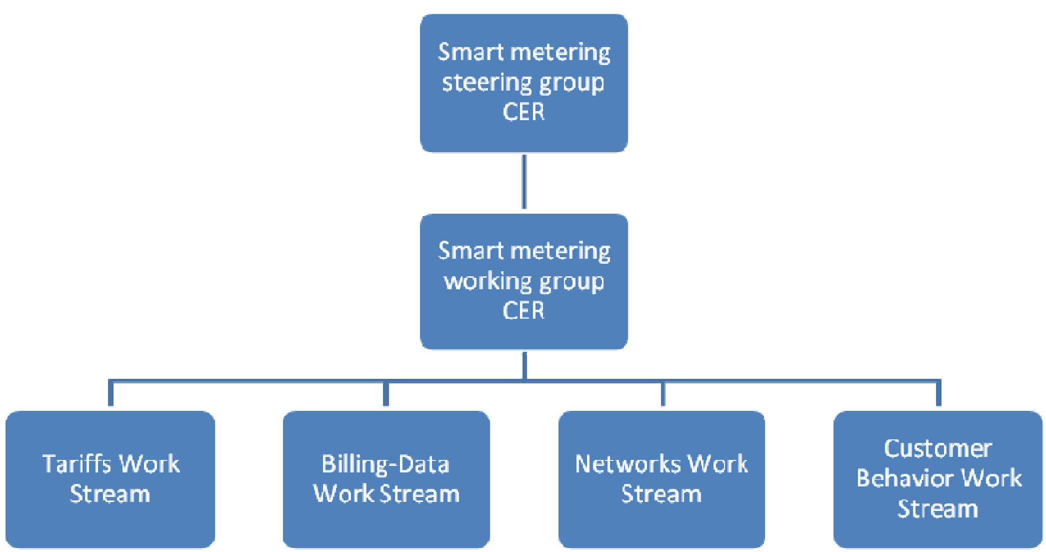
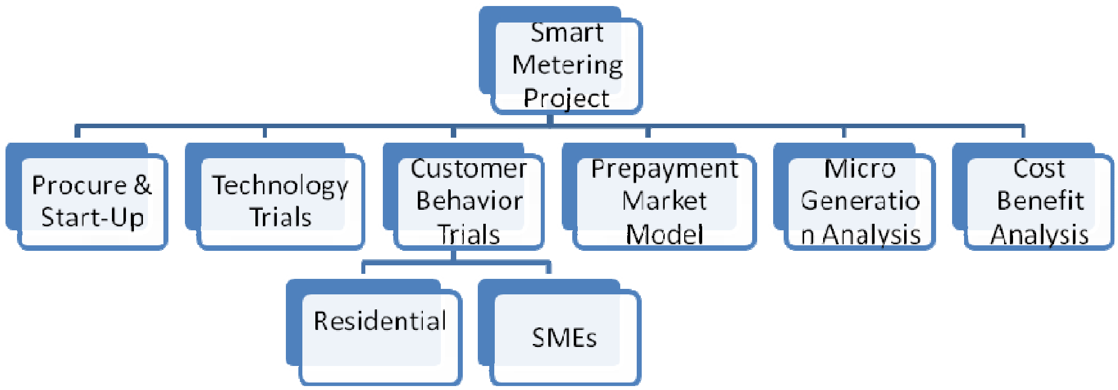


Figure 3.9 Smart Metering Project Phase 1 – Governance Structure

(Source: Figure 4, CER Cost-Benefit Analysis (CBA) for a National Electricity Smart Metering Rollout in Ireland 2011)

IV. The key milestone of smart metering project progress

The key deliverables of the Smart Metering Project Phase 1 are depicted below:



(Source: Figure 5, CER Cost-Benefit Analysis (CBA) for a National Electricity Smart Metering Rollout in Ireland 2011)

Figure 3.10 Smart Metering Project Phase 1 –High level Work Breakdown Structure

Overall, project progress has been very positive with all key milestones having been achieved. The main highlights to date have been the:

- Completion of the electricity technology trials in September 2010, the detailed report of which is published alongside this CBA report.
- Completion of the electricity customer behaviour trials (CBT) for residential and SME customers in December 2010 and completion of associated analysis and reporting in April 2011, the detailed report of which is published alongside this CBA report.
- Completion of the ‘smart prepayment’ trial in February 2011, the findings of which are included in the CBT report.
- Initiation of the gas customer behavior trials (CBT) for residential and SME customers which will complete in May 2011. Associated analysis and reporting is due to be completed by September 2011.
- Completion of the electricity cost-benefit analysis in April 2011. An addendum to the CBA for gas is due to be completed by September 2011.

3.3.2 Finding

Introduction

The National Smart Metering Plan was managed by the CER and consisted 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. There were three distinct strands to the work; technology trials, customer behaviour trials and a cost-benefit analysis for the rollout of smart meters.

The Irish CBT is one of the largest and most statistically robust smart metering behavioural trials conducted internationally to date and thus provides a wealth of insightful information on the impact of smart metering enabled initiatives on electricity consumers.

The statistical evidence from the Residential Customer Behaviour Trial is that the deployment of Time of Use tariffs in combination with other Demand Side Management stimuli results in a change in energy consumption. Specifically, the residential trial participants achieved reductions in electricity consumption, both overall and at times of peak usage.

The CER has worked with industry stakeholders to produce a detailed cost-benefit analysis (CBA) on a number of options for the national rollout of smart meters in the Irish electricity market. This CBA delivers a robust economic assessment of all the long-term costs and benefits to the market and the individual consumer (residential and SME) of a national electricity smart metering rollout. The analysis indicates that the rollout of smart metering has the potential to provide a positive net benefit to the Irish electricity market and consumers. The publication of this report is a major milestone in the CER's Smart Metering project, and a key deliverable in the completion of Phase 1. The findings from the CBA will provide a rich source of information which will be used to inform energy policy decisions in Ireland relating to smart metering enabled initiatives such as time of use tariffs, more detailed and frequent billing, in-home displays and prepayment metering.

I. The Customer Behaviour Trials

Pilot Objectives

The Customer Behaviour Trial included residential consumers and small and medium enterprises (SMEs). It was managed by the Commission for Energy Regulation in Ireland with support from the Department of Communications, Energy & Natural Resources, the Sustainable Energy Authority of Ireland, (formerly

Sustainable Energy Ireland), Electric Ireland (formerly ESB Customer Supply), Bord Gáis Energy, ESB Independent Energy (now part of Electric Ireland) and ESB Networks.

The overall objective of the Customer Behaviour Trial was to ascertain the potential for smart metering technology, when combined with time of use tariffs and different demand side management ('DSM') stimuli, to effect measurable change in consumer behaviour in terms of reductions in peak demand and overall electricity use.

The Residential Customer Behaviour Trial included the additional objective of seeking to identify a "Tipping Point" that is a point at which the price of electricity will significantly change usage.

The Trial had two distinct periods:

- **The Benchmark period** – 1st July to 31st December 2009. All meters were 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.

Also during the Benchmark, participants were allocated to either a test or control group, and were advised their bills would be issued on a calendar month basis ("calendarised"). These communications issued towards the end of the Benchmark period so as to minimise any impact such communications might cause. A pre-trial survey was also conducted in the Benchmark period.

- **The Test period** – 1st January to 31st December 2010. During the test period participants were in either a test group (i.e., each group tested a different Time of Use (ToU) tariff and selected Demand Side Management (DSM) stimuli) or the control group (billed on their existing flat rate, with no DSM stimuli). 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.

Test and Control Groups

At the end of the benchmark period participants in the Residential and SME Trials were divided into test and control groups. The test groups were asked to trial different time of use tariffs and DSM stimuli. The control group was billed on their normal electricity supplier (Electric Ireland) tariff and saw no changes to their bill. They received none of the DSM stimuli and were requested to continue using their electricity as normal.

Design of the Time of Use Tariffs

Time of use tariffs were trialled during the Customer Behaviour Trial. A weekend tariff was also included for Residential participants. The following principles were used in the design of the ToU tariffs to ensure that the key objectives of cost neutrality and cost reflectivity were achieved:

- The time of use tariff would be neutral in comparison with the standard Electric Ireland tariff to ensure that the "average" participant who did not alter their electricity consumption pattern was not penalized financially.
- The base ToU tariff would reflect the underlying cost of energy transmission, distribution, generation and supply as per standard tariffs.
- The time-of-use structure (time bands) would be based on system demand peaks.
- Tariffs would be based on the cost inputs used in the 2009/10 regulated tariffs.

Table 3.7 Time of Use Bands

	Day Rate	Peak Rate	Day Rate	Night Rate
Time band	8am-5pm	5pm-7pm	7pm-11pm	11pm-8am
Unit Rate(excel ,VAT)				

(Source: Figure 2, CER Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report 2011)

Customer Research

Research into electricity consumers and Trial participants represented a fundamental aspect of the Customer Behaviour Trial. This consisted of a series of surveys and consumer focus groups, summarised as follows:

- Pre-trial survey of participants in the Trial. Information gained from this survey provided insights which informed the participant allocation and provided a benchmark for any subsequent change in behaviour which might be measured at the end of the Trial.

- Post-trial survey of the same participants in January 2011, comparing change in attitude, equipment or electricity use to the pre-trial findings.

- Non-response survey of those who chose not to respond to the invitation letter and of those who left the Trial for various reasons before it had ended.

- Focus groups with non-Trial participants in order to assist in design of the ToU tariffs, DSM stimuli and some selected communications.

Participants in the Residential pre- and post-trial survey received a thank you payment of €25 for each survey (credited to their bill in December 2009 and January 2011).

Prepayment User Trial

The Prepayment User Trial aimed to conduct a proof of concept pilot to test whether a Smart Meter could be used as a Prepayment Meter without physical modification. A key requirement of the Trial was to test real prepayment as opposed to debt recovery and to test whether the meter could facilitate debits and credits, with the electronic purse resting with the supplier. It was initially proposed that the Trial would last six months. This was later extended by a number of months to allow for additional technical testing.

Once the consumer opted in to the Trial, ESB Networks installed the new smart meter. This meter returned daily readings similar to the Customer Behaviour Trial. The daily reads and daily payments were uploaded manually to the system and the account balance was calculated daily.

The daily balance was made available to participants by phone and by text message. The balance also incorporated any arrangement due for outstanding payment of arrears.

Participants could make payments to Electric Ireland through all the existing payment channels i.e., on-line and billpay.ie, at AIB or Bank of Ireland, by Laser card or an Ulster Bank visa debit card, through the National Contact Centre and at all Paypoint, Payzone, Postpoint and An Post outlets.

An off-line debt management process monitored account balances and compliance with any account arrangements. Accounts found to be in breach of agreed thresholds received a reminder by text message.

Multi-site User Trial

The Multi-site Trial was designed as a qualitative assessment. In all four organisations spread across 11 locations took part in the Trial. Participants ere provided with energy statements that consisted of detailed information on time of use energy consumption. Additionally, participants with internet connectivity had access to an on-line system providing further usage information.

While smart meter data was available, the reporting of potential reductions in overall or peak usage is not appropriate due to the relatively small number of organisations included. Organisations with multiple sites having at least two and, on occasion, three types of stakeholders were included within the research.

The research included up to three in-depth interviews of each stakeholder (one prior to the start of the Test period, potentially an additional one during the Test period and a final interview at the completion of the Trial).

Participants were provided with energy usage statements which provided additional information on time of use data. Participants with office internet connectivity also had access to an on-line system providing further usage information. In the research conducted during or after the completion of the Trial, the emphasis was on determining the degree to which processes and behaviours related to electricity usage were impacted by the stimuli.

II. The Residential Customer Behaviour Trial

The optimal sample size for the Trial was determined to be 4,300 participants. Allowing for attrition during the Trial, 5,375 were initially recruited with 5,028 still on the Trial when allocation commenced in November 2009.

Recruitment of Participants

In order to ensure that the outcome of the Trial would be robust and representative of the national population, the recruitment process was phased. After each phase the respondents who opted in were profiled to confirm that they representative of the national profile. Once recruitment was completed, the set of consumers who had accepted was compared to the set of those who had not (captured through a non-response survey) in order to check and confirm for representivity.

Participant selection and recruitment followed a voluntary "opt-in" model using a tear off slip and achieved an average response rate of 30%.

Time of Use Tariffs and Demand Side Management (DSM) Stimuli

Time of use tariffs and demand side management stimuli were specifically developed for use in the Customer Behaviour Trial. These may be summarized as follows:

- Four specific time of use tariffs A, B, C and D offering different unit prices for the night time, day time and peak times, in combination with;
- specific DSM initiatives, which included:

◦ bi-monthly electricity bill with detailed energy statement

◦ monthly electricity bill with detailed energy statement

◦ electricity monitor

◦ an Overall Load Reduction (OLR) incentive

- A weekend tariff

Supporting information

Participants also received supporting information in the form of a fridge magnet and sticker. The fridge magnet outlined the different time-bands and cost-per-band, customized for each tariff group. The sticker provided details of the time bands. At the end of the benchmark period participants were allocated to either a test or control group. These may be summarized as follows:

Table 3.8 Residential Matrix allocation as of 13 November 2009

Tariff	Bi-monthly bill and energy usage statement	Monthly Bill , and energy usage statement	Bi-monthly bill ,energy usage statement and	Bi-monthly bill ,energy usage statement	Total
Tariff A	342	342	342	342	1368
Tariff B	127	129	127	128	511
Tariff C	342	342	343	343	1370
Tariff D	127	129	126	127	509
Control					100
Group					1170
	938	942	938	940	5028

(Source: Table 1, CER Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report 2011)

Time of Use Tariffs

Four different time of use tariffs were developed for the Customer Behaviour Trial. A weekend tariff was also included. These may be summarized as in Table 3.9 and 3.10.

Table 3.9 Residential Time-of-Use tariffs 1st January to 31st December 2010

Domestic Time of Use Tariff				
		Night 23:00-08:00	**Day** 08:00-17:00 19:00-23:00 weekends 17:00-19:00 weekends and bank holidays	**Peak** 17:00-19:00(Monday to Friday), excluding bank holidays
Tariff A	Cents per kWh	12.00	14.00	20.00
Tariff B	Cents per kWh	11.00	13.00	26.00
Tariff C	Cents per kWh	10.00	13.00	32.00
Tariff D	Cents per kWh	9.00	12.50	38.00

(Source: Table 2, CER Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report 2011)

Table 3.10 Weekend tariff 1st January to 31st December 2010

Domestic Time of Use Tariff				
		Night 23:00-08:00 and all weekends	Day 08:00-17:00 19:00-23:00 excluding bank holidays	Peak 17:00-19:00 (Monday to Friday) excluding bank holidays
Monday to Friday	Cents per kWh	10.00	14.00	38.00
Saturday Sunday		10.00	10.00	10.00

(Source: Table 3, CER Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report 2011)

Balancing Credit

Throughout the Trial all participants testing time-of-use tariffs were guaranteed that they would not pay more for their electricity than if they had been on the normal Electric Ireland tariff (14.1c per unit ex VAT). Accordingly, all participants received a *balancing credit* at the end of the benchmark period and in January 2011. The small number of individuals who incurred costs above this average were recompensed on a case by case basis.

Table 3.11 Residential Balancing credits as of 1st January 2010

Residential	Total Amount	Paid December 2009	Paid January 2011
Tariff A	€ 30	€ 15	€ 15
Tariff B	€ 50	€ 25	€ 25
Tariff C	€ 70	€ 35	€ 35
Tariff D	€ 90	€ 45	€ 45

(Source: Table 4, CER Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report 2011)

Residential Customer Behaviour Trial Findings

The main findings of the Trial may be summarized as follows:

Response to tariffs and DSM stimuli

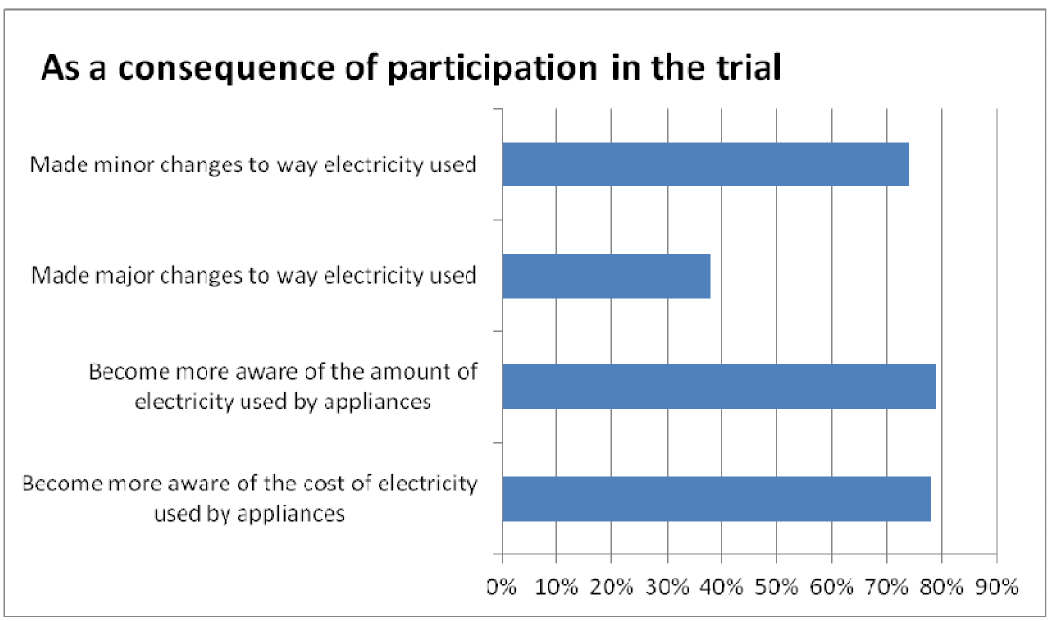
- The deployment of ToU tariffs and DSM stimuli are found to reduce overall electricity usage by 2.5% and peak usage by 8.8%;
- The combination of bi-monthly bill, energy usage statement and electricity monitor is found to be more effective than other DSM stimuli in reducing peak usage with a peak shift of 11.3%;
- Overall energy reduction is linked with the level of usage: Households with higher consumption tended to deliver greater reductions in usage;
- Analysis of the load distribution suggests shifting of load from peak to the post-peak period and in general to night usage from peak;
- Of the tariff groups tested, no single one in combination with DSM stimuli stands out as being more effective than the others;
- The peak and overall load reductions detected for all the stimuli tested proved to be statistically significant with the exception of the overall load reduction detected for the bi-monthly bill and detailed energy statement stimulus, although the peak load reduction for this stimulus was statistically significant;
- The data from the Trial provides no evidence of a tipping point, with demand for peak usage estimated as being highly inelastic relative to price.

Demographic, behavioural and experiential conclusions

- Participants adapted usage to realise the potentially positive impact of the tariffs on their bills. 82% of participants made some change to the way they use electricity due to the Trial with 74% stating major changes were made by their households;
- Simple information can also be effective: The fridge magnet and stickers achieved 80% recall with 75% finding the magnet useful and 63% finding the

sticker useful;

- The electricity monitor was deemed to be effective as a support to those achieving peak reduction (91% rated it as an important support) and shifting to night rates (87% deemed it an important support).
- Barriers to peak reduction relate to the difficulty of linking behavior change to bill reduction. These perceptions may have contributed to the current recorded reduction. This may be hard to address due to exaggerated expectations of savings and similar exaggerated expectations of consequences if reduction is not achieved;
- Barriers to shifting to night usage relate to safety and convenience.
- The OLR incentive was impacted by a low recall rate (58%). However, the scores for communications, reasonableness of the target and effectiveness of the OLR incentive in motivating change were all very good.
- The detected benefits of the Trial are focused on behaviour changes in response to the price signals and DSM stimuli applied. No secondary benefits were identified in increased awareness of general energy efficiency or investment in energy efficiency enhancements for the home;
- The Trial succeeded in making participants more aware of energy usage (54% agreed) which is in keeping with the reduction in usage recorded. Only 18% stated that there had been no impact on the way their household uses electricity;



(Source: Figure 3, CER Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report 2011)

Figure 3.11 Perceived impact of participation on usage and awareness

- Households headed by individuals with greater educational achievement or social grade achieved higher levels of reduction than those with lower levels. This was in part related to the typically higher level of usage associated with these households. Therefore, the impact of education or social grade on the ability to gain benefit from the tariffs is limited
- The impact of the time of use tariffs on recipients of FEA (Free Electricity Allowance) shows that these individuals exhibited the same level of change as other households and therefore do not appear to be disadvantaged over other groups;
- Fuel poor households (which lack financial means to adequately heat their homes) also benefit from the deployment of time of use tariffs.

III. The SME Customer Behaviour Trial

The overall sample size for the SME Customer Behaviour Trial was specified at 728 participants and was broadly representative of the population of electricity users eligible to participate in the Trial. Representivity was limited to that of the relative SME base, as reflected in the customer bases of the two participating suppliers. At the start of the benchmark the total number of SMEs still participating with meters installed was 723 with 650 remaining when allocation took place in November 2009.

Recruitment of Participants

The Trial focused on commercial organizations with a single site and reasonable payment history over the previous 12 months. The organizations with multiple sites were included within the separate multi-site study. Finally, participants were drawn from the customer bases of Electric Ireland and Bord Gáis Energy Supply. Recruitment was completed in a similar manner to the residential trial with an invitation letter which was then followed up by a phone call.

Time of Use Tariffs and Demand Side Management (DSM) Stimuli

Time of use tariffs and demand side management stimuli were specifically developed for use in the Customer Behaviour Trial. These may be summarised as follows:

- Time of use tariffs offering different unit prices for the night time, day time and peak times, in combination with;
- specific DSM initiatives, which included:
    - bi-monthly electricity bill with detailed energy statement

- monthly electricity bill with detailed energy statement
- electricity monitor
- web access to energy usage information

At the end of the benchmark period participants were allocated to test and control groups as in table 8:

Table 3.12 SME Matrix allocation as of 15 November 2009

	Bimonthly bill, energy use statement + Electricity Monitor	Bimonthly bill energy use Statement + Web access	Monthly bill energy use statement	Bimonthly bill energy use statement	Bimonthly bill energy use statement	Total
Sector	Electric Ireland	Electric Ireland	Electric Ireland	Electric Ireland	Bord Gáis Energy	
Retail	31	31	29	16	33	140
Small Industrial	13	17	19	8	19	76
Entertainment	19	19	17	8	18	81
Office/Professional	20	17	20	11	17	85
Total	**83**	**84**	**85**	**43**	**87**	**372**
Retail		67			33	103
		40				
		34				
		39				
		180				
Small Industrial					19	59
Entertainment					18	54
Office/Professional					18	62
Total					**88**	**268**
			475		**175**	**650**

(Source: Table 5, CER Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report 2011)

Time of Use Tariffs

Time of use tariffs were developed for the SME Behaviour Trial. Electric Ireland tested two different tariffs with two groups, Tariff A and Tariff B. Tariff B had a slightly higher unit charge during Day and Peak, but was almost half Tariff A for night use. Bord Gáis Energy continued to price participants on an individual basis and introduced a customized time of use tariff for each participant. The relativities developed for the Electric Ireland tariffs were maintained by Bord Gáis Energy in the development of their tariff. The final tariffs may be summarized as table 3.13:

Table 3.13 SME Time-of-Use tariffs as at 1st January 2010

Domestic Time of Use Tariff				
		Night 23.00 – 8.00	**Day** 8.00 – 17.00 19.00 – 23.00	**Peak** 17.00 – 19.00 (Monday to Friday), excluding bank holidays
Electric Ireland				
- Tariff A	Cents per kWh	14.00	15.00	22.00
- Tariff B	Cents per kWh	7.50	16.00	22.50
Bord Gáis Energy	Cents per kWh	Tariff applied varied by individual participant		

(Source: Table 6, CER Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report 2011)

Balancing Credit

Similar to the Residential Customer Behaviour Trial, participants also received a *balancing credit* one in December 2009 and the second in January 2011. The small number of individuals who incurred costs above this average was recompensed on a case by case basis.

Table 3.14 SME Balancing Credits as at 1st January 2010

SME	Total Amount	Paid December 2009	Paid January 2011
Tariff A	**€100**	**€50**	**€50**
Tariff B	**€100**	**€50**	**€50**
Bord Gáis Energy	**€100**	**€50**	**€50**

(Source: Table 7, CER Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report 2011)

SME Customer Behaviour Trial Findings

The main findings of the SME Trial may be summarised as follows:

Response to tariffs and DSM stimuli

- the deployment of ToU tariffs and DSM stimuli are found to reduce overall electricity usage by 0.3% and peak usage by 2.2%, although neither result is found to be statistically significant;
- there is no tariff, DSM stimulus or tariff/DSM stimulus group which reduced overall electricity usage or peak usage by a statistically significant amount;

Empirical, behavioural and experiential conclusions

- 41% of participants believed that they reduced overall usage with 59% stating they reduced peak usage. The tariffs were regarded as effective in supporting this reduction with 71% stating the peak cost forced their business to attempt to reduce usage at this time.
- Participants have an increased level of regular monitoring of their electricity usage with 13% reporting this to be the case compared to 8% among the control group with 45% stating that they reviewed usage to identify ways of reducing it;
- The main barrier to reduction was the perception that it was not possible to move the usage to other times. This was stated as a very important reason by 72% of businesses who stated they did not reduce peak usage and 61% of those who did not reduce overall usage;
- Among the participants who had an overall load reduction the level of reduction was on average 8.51% with an average peak reduction of 8.33%. Among the participants who had a peak load reduction the level of overall reduction was on

average 5.74% with an average peak reduction of 10.25%.

- Among participants who reduced either peak or overall usage, the electricity monitor was deemed to be effective with 93% of those reducing overall usage stating it was important and 85% of those reducing peak usage stating it was important;
- In contrast, the web-site information was rated as important to overall usage by 24% of reducing businesses with access to the stimulus. This reflects the low level of usage of the system (at 15% stating they logged in).

IV. The Cost-Benefit Analysis

This Cost-Benefit Analysis (CBA) is a key deliverable of Phase 1 of the CER Smart Metering Project. It draws information from other key Phase 1 deliverables which are published alongside it i.e. the Electricity Customer Behaviour Trials (CBT) Findings Report (CER/11/080a) and the Electricity Technology Trials Findings Report (CER/11/080b).

- The electricity customer behaviour trials are among the largest and most statistically robust smart metering behavioural trials conducted internationally to date and thus provide a wealth of insightful information on the impact of smart metering enabled initiatives on electricity consumers. The CBT looked at the measureable reduction in customer demand achievable through the use of smart meters in combination with time of use tariffs and a number of information stimuli (i.e. detailed billing on a bi-monthly and monthly frequency, in-home displays, an overall load reduction (OLR) incentive and Web access).
- The technology trials looked at a range of metering functionality and communications technology options in order to assess their performance, and enable learning and better understanding of the risks that would be associated with a national electricity smart metering rollout.

This suite of reports is intended to inform the Commission for Energy Regulation (CER), the Department of Communications, Energy and Natural Resources (DCENR), and stakeholders of the possible merits of providing smart electricity meters to residential and SME customers in Ireland. In addition, the CBA should help cast light on the relative attractiveness of various design options for implementation of smart meters and the main sources of risk associated with a rollout. The scope of the three reports covers all electricity residential consumers and all small-to-medium enterprises or SMEs (electricity non-profile meter businesses).

Approach to the CBA

For the purposes of compiling the CBA, ESB Networks and suppliers were requested by the CER to provide smart metering related costs and benefits in accordance with the national smart metering high level design and implementation assumptions, which had been developed by the CER via the Smart Metering project industry forums and a public consultation process. The CER reviewed and validated the submitted costs and benefits, including an audit by a contracted independent third party.

Some sources of costs and benefits are more amenable to quantification than others, so the analysis is divided between “quantifiable” and “qualitative” sources of costs and benefits. To place some structure on the analysis of the quantifiable elements, costs and benefits are also divided into rough categories by source: networks, suppliers, generation, and consumers (residential and SME). The validated network and supplier related costs and benefits were then inputted into a CBA model developed by the Economic and Social Research Institute (ESRI). Results from the customer behaviour trials (CER/11/080a) were also inputted into this CBA model in order to derive the usage-related benefits and to help derive the generation-related benefits.

The cost-benefit analysis assesses the broad societal costs and benefits of implementing smart metering rather than the private costs and benefits to any given subset of affected parties. The CBT Findings Report (CER/11/080a) does illustrate some distributional effects arising from a move to time of use charging for electricity. There may also be distributional effects along the value chain, for on the time required for this analysis such effects have not been modeled. The CER identified 12 high level smart metering national rollout options. The overall attractiveness of each option is identified for the quantifiable costs and benefits by computing the net present value (NPV) of the project in 2011, taking into account predicted cash flows from 2011-2032. However, these results make up only part of the assessment. Particularly on the benefits side, there are important possible future developments that might give rise to significant changes in the value of having smart meters in place but are difficult to quantify at this stage, including facilitation of increased renewable generation, electric vehicles and ‘smart grids’. These developments are discussed in a separate section on qualitative benefits and costs.

Key Findings of the CBA

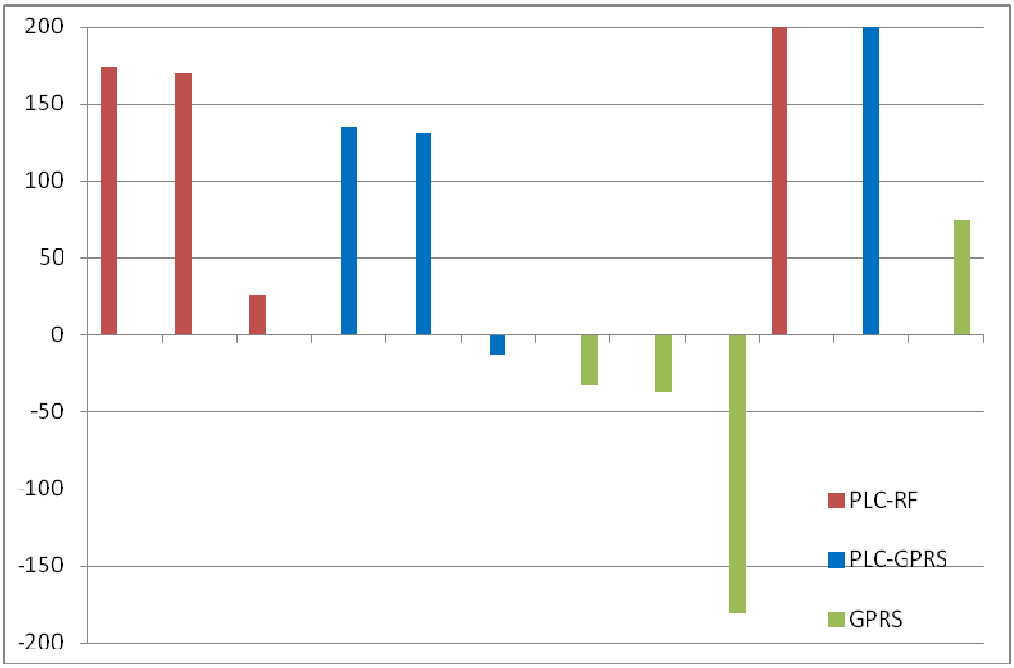
Overall Results from Quantifiable Analysis

- The estimated total net present values (NPVs) for the 12 main national electricity smart metering rollout options analyzed are generally positive, and often substantially so (see Table 3.15 and Figure 3.12 below):
- These positive NPVs remain strong under a range of sensitivity analyses carried out.
- If these results were 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.

Table 3.15 Total NPV by option

Option	Billing baseline	Billing scenario	Comm's	IHD	Total NPV (€m)
Option1	Bi-monthly	Bi-monthly	PLC-RF	N	174
Option2	Bi-monthly	Bi-monthly	PLC-RF	Y	170
Option3	Bi-monthly	Monthly	PLC-RF	N	26
Option4	Bi-monthly	Bi-monthly	PLC-GPRS	N	135
Option5	Bi-monthly	Bi-monthly	PLC-GPRS	Y	131
Option6	Bi-monthly	Monthly	PLC-GPRS	N	-13
Option7	Bi-monthly	Bi-monthly	GPRS	N	-33
Option8	Bi-monthly	Bi-monthly	GPRS	Y	-37
Option9	Bi-monthly	Monthly	GPRS	N	-181
Option10	Monthly	Monthly	PLC-RF	N	282
Option11	Monthly	Monthly	PLC-GPRS	N	242
Option12	Monthly	Monthly	GPRS	N	74

(Source: Table 10, CER Cost-Benefit Analysis (CBA) for a National Electricity Smart Metering Rollout in Ireland 2011)



(Source: Figure 9, CER Cost-Benefit Analysis (CBA) for a National Electricity Smart Metering Rollout in Ireland 2011)

Figure 3.12 Total NPV (€m) by options 1-12

Communications Technology (wide area network)

- Power line carrier (PLC) / Radio frequency (RF) communications shows higher net benefits than the other technologies examined, although the difference to PLC / GPRS may depend upon the value of key parameter assumptions.

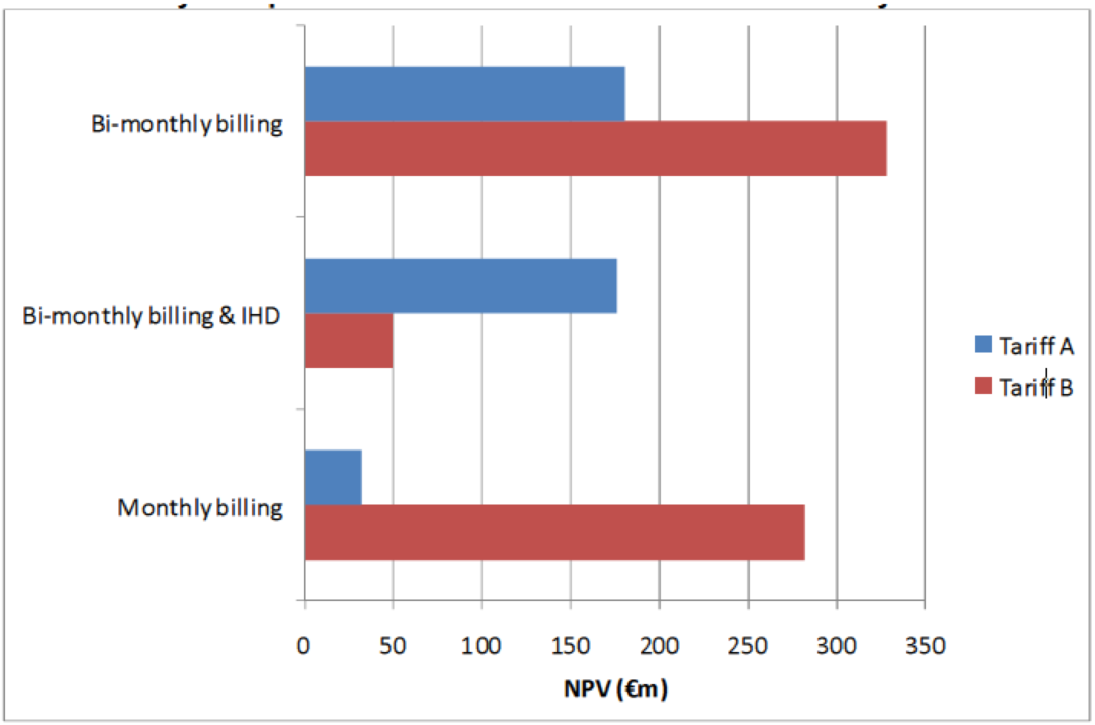
- The attractiveness of GPRS communications depends heavily on the assumed cost of network services. It also depends, to a lesser extent, on the perceived need to future-proof the communications technology in the meter to continue work on mobile operator general purpose commercial networks until 2032.

Informational Stimuli

- Bi-monthly billing with no in-home display (IHD) consistently exhibits the highest total NPV, but the margin is only €4m compared to the next best option (bi-monthly billing with an IHD) under Tariff A.

- The relative merits of different informational stimuli proved to be quite sensitive to the CBT tariff band chosen, with IHDs showing a substantial reduction in NPV under Tariff B and monthly billing showing a big increase (see Figure 7 below).

- This suggests that one should be cautious in basing decisions about the choice of stimulus in a rollout on the estimates of quantifiable benefits alone.

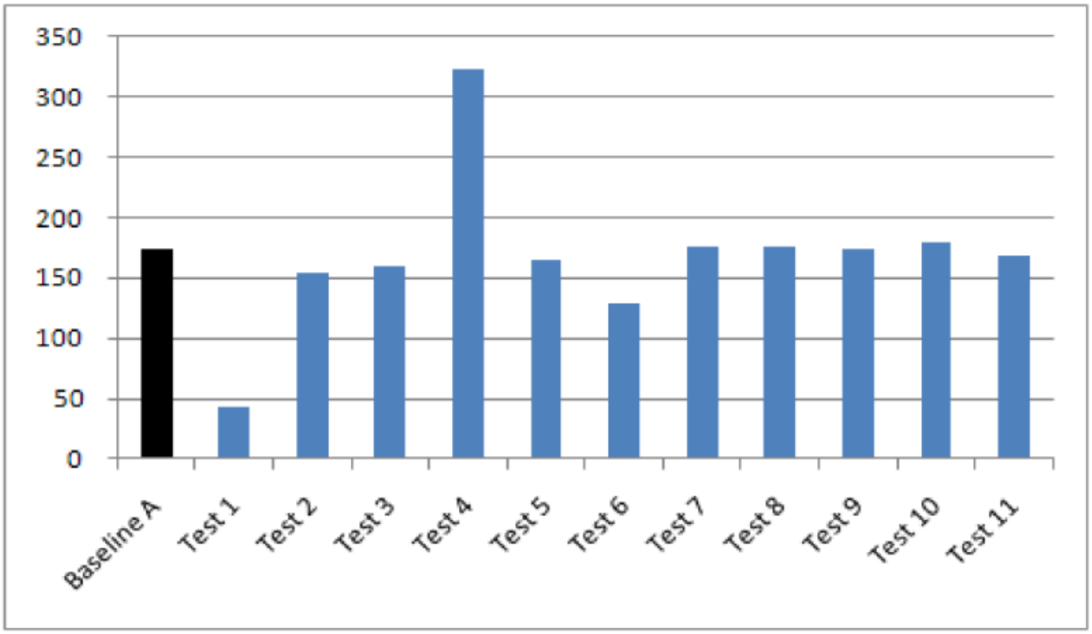


(Source: Figure 15, CER Cost-Benefit Analysis (CBA) for a National Electricity Smart Metering Rollout in Ireland 2011)

Figure 3.13 Summary Comparison of NPVs for information stimuli by ToU A and B

Sensitivity Analyses

- Important sources of variation in estimated NPVs arose from assumptions about the expected pattern of residential demand response, the level of additional billing system OPEX by suppliers and network costs such as the costs of meters, meter installation and IHDs.
- Most other sensitivity tests on network cost items showed modest effects,
- The project's viability does not appear to be particularly sensitive to the assumed discount rate of 4%.
- The results of the main sensitivity tests are depicted in Figure 3.13 below.

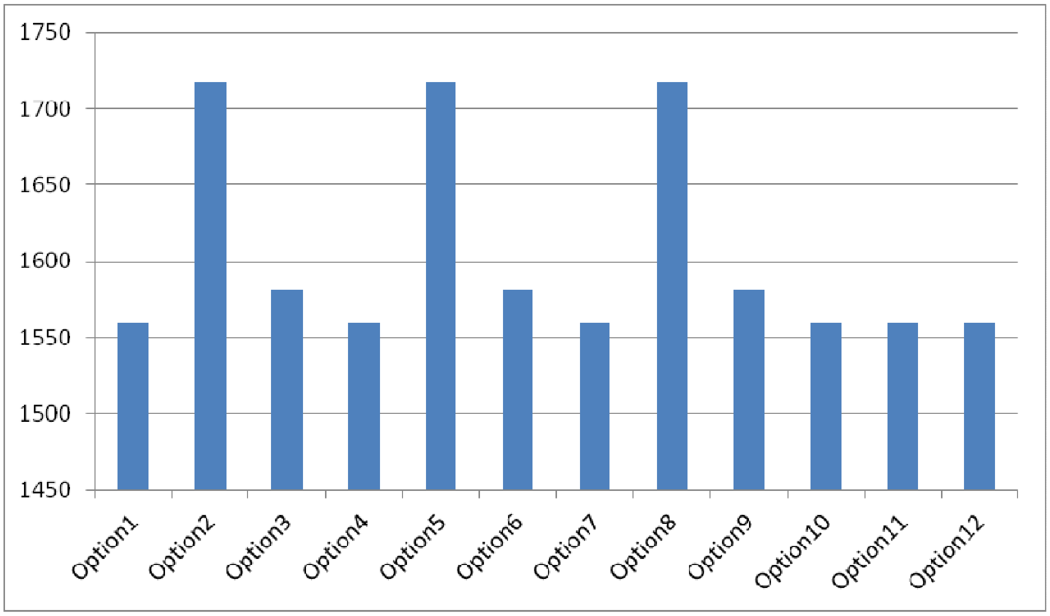


(Source: Figure 14, CER Cost-Benefit Analysis (CBA) for a National Electricity Smart Metering Rollout in Ireland 2011)

Figure 3.13 Impact of Sensitivity Tests 1-11 on NPVs (€m)

Societal Benefits from reduced emissions of greenhouse gases

- By the end of the CBA period, we estimate CO_2 emissions at 100,000- 110,000 Tonnes below baseline each year and annual SO2 emission to be lower by 117-129 Tonnes. Figure 9 below illustrates graphically the total CO_2 emissions reductions by each option.
- The value of CO_2 emissions is assumed already to be included in electricity prices, so it is not added into the savings estimates in quantifiable analysis.



(Source: Figure 8, CER Cost-Benefit Analysis (CBA) for a National Electricity Smart Metering Rollout in Ireland 2011)

Figure 3.14 Total CO_2 emissions reductions (000 Tonnes) by Options 1-12

Qualitative Benefits

- There are a number of potential costs and benefits from a national rollout of electricity smart metering that are very difficult to put a robust quantifiable estimate on and therefore they have been excluded from the quantifiable analysis and are only described qualitatively.
- These qualitative benefits include facilitation of and/or synergies with a 'smart grid' implementation, micro generation, electric vehicles, gas smart metering and water smart metering.
- Generally, these exclusions reflect the conservative approach taken to the quantifiable CBA, which tends towards a likely underestimation of the potential benefits from a national electricity smart metering rollout.

Next Steps

The roll-out of smart meters represents a major national infrastructure project and the publication of this report is one of the defining milestones in its delivery. Given the scale of investment required to deliver smart metering, a thorough and robust analysis is required to substantiate any rollout decision. This CBA, which concludes a positive net benefit for electricity consumers, will facilitate the further development of the Smart Metering Project. The next steps for the project are outlined in the Smart Metering Information Paper 4 (CER/11/080) which accompanies this CBA report.

The CER appreciates the significant contribution of all stakeholders that have been involved in compiling this CBA and the other reports and looks forward to their ongoing involvement in the next steps for the Smart Metering Project.

3.4 The key success factors for AMI roll-out

I. America

- Educate consumers on the availability, advantages, and benefits of advanced metering and communications technologies, including the funding of demonstration or pilot projects
- Work with States, utilities, other energy providers, and advanced metering and communications experts to identify and address barriers to the adoption of demand response programs (EPACT, Sec. 1252(d)). The Federal Energy Regulatory Commission (FERC) Identifies Smart Grid-Enabled Demand Response as Key Priority for Standards Development to Achieve Smart Grid Interoperability
- The Commission issued a Final Smart Grid Policy to guide and prioritize the development of smart grid devices and systems, and to adopt an Interim Rate Policy to encourage investment in smart grid technologies.
- The CPUC began a rulemaking in June 2002 which it concluded in November 2005 with the aim of "developing demand response as a resource to enhance electric system reliability, reduce power purchase and individual consumer costs, and protect the environment.

II. Victoria

- Re-examine the existing governance structure of the AMI project to proactively identify, assess, own and manage the project's strategic risks.
- Develop, appropriately resource and implement a stakeholder engagement plan with a particular focus on addressing consumer issues arising from the AMI project.
- Actively engage with the relevant regulator to monitor and oversee the transfer of expected benefits to consumers.
- Commission a program review by the Gateway Unit of the Department of Treasury and Finance on governance and implementation of the AMI project to date.

- Re-assess the economic viability of the AMI project by updating the cost-benefit analysis to reflect existing and emerging risks as well as the impact of changes to scope and underlying assumptions.
- Use the Department of Treasury and Finance's business case development guidelines and other advice to produce an updated cost-benefit analysis.
- Obtain assurance from Victoria's electricity distributors that their candidate technologies for AMI are capable of achieving the expected functionality and service specification prior to the further installation of these technologies in customer premises.
- Adopt the Department of Treasury and Finance's risk management guidelines as a basis for monitoring and managing the risks that threaten the economic viability of the AMI project.

III. Ireland

- Irish CBT is one of the largest and most statistically robust smart metering behavioural trials conducted internationally to date and thus provides a wealth of insightful information on the impact of smart metering enabled initiatives on electricity consumers. The residential trial participants achieved reductions in electricity consumption, both overall and at times of peak usage.

- Pre-trial provides a good benchmark to make the trial more correct.

- The time of use tariff would be neutral in comparison with the standard electric Ireland tariff to ensure that the ''average'' participant who did not alter their electricity consumption pattern was not penalized financially.

- The combination of bi-monthly bill, energy usage statement and electricity monitor is found to be more effective than other DSM stimuli in reducing peak usage.

- The electricity monitor was deemed to be effective as a support to achieving peak reduction.

- Households headed by individuals with greater educational achievement or social grade achieved higher levels of reduction than those with lower levels.
- The energy usage statement was useful in supporting managers already engaged in energy reduction.

4.0 2011 APEC Workshop on Addressing Challenges in AMI Deployment and Smart Grids in APEC

4.1 Workshop Summary

It was proposed to invite 6 experts in total to the workshop to give presentations about the AMI deployment in their economies as well as Smart Grid system and the connections in between, and the experience can be passed forward to those economies which are planning. In addition, the experience can be exchanged between different economies to get a broad view of the capability of AMI. During the workshop, the opinions of invited experts will be contributed to the modification of the questionnaire before sending out to all economies.

The 「2011 APEC Workshop on Addressing Challenges in AMI Deployment and Smart Grids in APEC Region」 was hosted in August. 2011 as it was proposed, and in total 16 speakers from 8 economies were invited. The agenda for each day is shown in Table 4.1 and Table 4.2. For day one of the workshop, the main stream focused on AMI deployment, and the attention was moved to the applications of AMI and Smart Grids for day two. The number of attendant for the workshop was 216, and included 12 delegates of 7 economies

.

Table 4.1 2011/8/24 agenda

Asia-Pacific Economic Cooperation

2011 APEC Workshop on Addressing Challenges in AMI Deployment and Smart Grids in APEC Agenda

Wednesday, August 24th, 2011		
Time	**Presentation Topic**	**Speak**
8:30~9:00	**Registration**	
9:00~9:10	**Opening Remarks**	
Session 1: The Challenges of AMI Deployment and System Integration		
9:10~9:30	Advanced Metering Infrastructure (AMI) Development in Chinese Taipei.	**Speaker: Morris Liang** Division Director, Industrial Technology Research Institute (ITRI) Chinese Taipei
9:30~10:00	Introduction to the APEC Smart Grid Initiative (ASGI)	**Speaker: Cary N. Bloyd** Senior International Research Advisor, Pacific Northwest National Laboratory U.S.A.
10:00~10:40	Challenges and Benefits of Advanced Metering Infrastructure (AMI) Development in U.S.A.	**Speaker: Brian K. Seal** Technical Executive, Electric Power Research Institute U.S.A.
10:40~11:00	**Tea Break**	
11:00~11:40	AMI – Challenges and Benefits SmartMeter Experience at PG&E	**Speaker: Lanyuen Belvin Louie** Manager, Pacific Gas & Electric (PG&E) U.S.A.
11:40~12:20	AMI Development in Korea	**Speaker: Jerry Yang** Team Leader, Korea Smart Grid Institute (KSGI) Korea
12:20~13:30	**Lunch**	
Session 2: The Challenges of Maintenance and Service		
13:30~14:10	The Construction and Future Development of Intellect Power in China	**Speaker: Wei-Min Hao** Committee Member, The Chinese Institute of Electrical Engineering China
14:10~14:50	Smart Metering in France A sound business model and a proven technology	**Speaker: Antoine Garibal** Vice President, Atos France
14:50~15:10	**Tea Break**	
15:10~15:50	Introduction of Kansai's "New Metering System" (AMI)	**Speaker: Koji Maegawa** Manager, Kansai Electric Power Company Japan
Session 3: The Policy and Strategy Overview of AMI/AMR in APEC		
15:50~16:50	The Policy and Strategy Overview of AMI/AMR in APEC Member Economies	**APEC Delegates**
16:50~17:10	Panel Discussion (Q & A)	**Chair: Morris Liang** Division Director, Industrial Technology Research Institute (ITRI) Chinese Taipei

Table 4.2 2011/8/25 Agenda

Thursday, August 25th, 2011		
Time	**Presentation Topic**	**Speaker**
8: 30~9:00	**Registration**	
Session 4: Market Trends and Opportunities on Smart Grid		
9:00~9:40	Trend and Market Overview of Global Smart Grid Development	**Speaker: Debashis Tarafdar** Head-Asia/Pacific, IDC Energy Insights U.S.A
9:40~10:20	Moving Beyond AMI deployment in Sweden and Realizing the Value of the Smart Grid	**Speaker: Hakan Johansson** Manager, ABB Sweden
10:20~10:40	**Tea Break**	
10:40~11:20	China Smart Grid Development Model and Industry Prospect	**Speaker: Jian-Dong Wu** Vice-chairman, China Wisdom Engineering Association China
11:20~12:00	Smart Grid Development in Japan	**Speaker: Kazuyuki Takada** Deputy Director, Smart Community Department NEDO Japan
12:00~13:00	**Lunch**	
Session 5: Aspects of Technology on Smart Grid		
13:00~13:40	Fast Automated Demand Response to Enable the Integration of Renewable Resources	**Speaker: David Watson** Program Manager, Lawrence Berkeley National Lab (LBNL) U.S.A.
13:40~14:20	Decentralized Energy Systems in Germany: Development and Research	**Speaker: Maren Kuschke** Research Assistant, Berlin University of Technology Germany
14:20~14:40	**Tea Break**	
14:40~15:20	JEJU Smart Grid Test Bed in Korea	**Speaker: Dae Kyeong Kim** Director, Korea Electrotechnology Research Institute (KERI) Korea
15:20~16:00	Advanced Control Arquitectures of Energy Microgrid Clusters: Towards the SmartGrid	**Speaker: Josep M. Guerrero** Professor, Aalborg University Denmark
16:00~16:30	Panel Discussion (Q & A) and Closing Remarks	**Chair: Morris Liang** Division Director, Industrial Technology Research Institute (ITRI) Chinese Taipei

Figure 4.1 2011 APEC workshop on addressing challenges in AMI deployment and smart grids in APEC region speakers

Table 4.3 APEC workshop on addressing challenges in AMI deployment and smart grids in APEC region minutes

<table>
<tr><td>date</td><td>24^{th}, Aug, 2011</td><td>Place</td><td>Taipei International Convention Center, Chinese Taipei</td></tr>
<tr><td colspan="4">Minute</td></tr>
<tr><td>No.</td><td colspan="2">Question</td><td>Respond</td></tr>
<tr><td>1</td><td colspan="2">To Jerry Yang, as you mentioned about the price of a smart meter is about 20 USD, is the price reasonable?</td><td>Within our AMI deployment plans, various of smart meters were under evaluation. To compare Type E with type C, Type E is a relatively cheaper but function limited version. However, budget is a major consideration while deployment planning, so our decision is to use the cheaper version for large scale deployment.</td></tr>
<tr><td>2</td><td colspan="2">To Antoine Garibal, I am confused with the deployment cost. Does a 250,000 meter deployment cost 4 billion Euro?</td><td>It is not true that a 250,000 meter deployment cost 4 billion, and the budget is for deployment over the whole economy, about 35 million meters. In fact, within the Linky project, the actual cost did exceed our original budget and this is because the labor cost, since 40% of the budget is spent for meter replacement.</td></tr>
<tr><td>3</td><td colspan="2">To Dr. Liang, what are the considerations of government and industry while constructing Smart</td><td>Bureau of Energy of Chinese Taipei started a project to propose the smart grid system for Chinese Taipei. Maybe</td></tr>
</table>

date	24^{th}, Aug, 2011	Place	Taipei International Convention Center, Chinese Taipei
Minute			
No.	Question	Respond	
	Grid system?	I can share some experience while we were proposing the AMI deployment, as government may host different opinions against power company. Since the target of government aimed at carbon reduction, power company wanted to maintain the quality of power supply. In addition, the final decision of electricity price is controlled by government, and hence the motivation of power company to start AMI deployment is not strong. Similar situations are expected while proposing smart grid system, and it is essential to find out the balance in between.	
4	To all speakers, what is the acceptance in your economy?	(1) In the US, few users concern the accuracy, reliability and contract, but most users do not care of the types of meters being used (2) Power company are considering value-added services and demand response, but users concern power bill and energy efficiency. (3) The scale of pilot project in Chinese Taipei is small, hence it is too early to discuss public acceptance currently. However, some might make a fuss while replacing meters. (4) Some tension may be caused due to the influence to their habits, since they did not aware of the benefits that new technologies can bring to them. Therefore, education is critical, and more important, it is important to build up the trust mechanism. (5) The situation in France is more or less the same with other economies. Since unclear power takes a huge part in france, hence the price of electricity is cheaper than other economies. Hence users concern less about AMI deployment, so far users are	

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No.	Question	Respond	
		happy with AMI. (6) Privacy is a major concern in France, public hearing were taken place, and we learned from Brition and Germany to ensure the security of system and user privacy. (7) In Korea, the price of smart meter is not very expensive, so the acceptance in public of replacing old mechanical meters by smart meteru is high. About the Smart Grids development in Jeju Island, about 6000 homes joined the pilot project and so far they are happy with the cut down with power bill. Hence, the acceptance of AMI and Smart Grid is high. (8) The development of AMI is fine, but it is not easy for users to understand the benefits of AMI. For example, many of my friend does not aware of smart meter, and in this case, it is difficult to gain public acceptance. From our viewpoint, utility should offer enough information for the users to understand the benefits as well as the billing as it can cause huge society effects due to bill raise. Currently, the cost of AMI is cover by utility, and both utilities and users need to be aware of AMI. The power demand for home of Japan is about half of the US, and it can be the adoption of high efficient home appliance.	
5	To Mr.Garibal, what is the ideal partnership in between Atos and ERDF?	The market of power generation, transmission and distribution is highly controlled by French government, and EDF takes 95% of the market share, and the rest of 5 % is shared by other 200 more companies. If consider AMI as a pure investment, it is hard power company to pay back. Back to your question, it is hard to	

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Minute		
No.	Question	Respond
		judge the best partnership in between Atos and ERDF, since EDF is the biggest customer of Atos. In addition, EDF control the standards and schedule of deployment, and Atos is the execution organization, and hence we want to enter the market with EDF.
6	To Mr.Seal, can you please give more details about the pre-pay AMI system?	The pre-pay AMI system means that users can use cash, cheque, credit card and etc. to top up with small amount of money, and most users are satisfied with this service.
7	The benefits of AMI relates to the purposes, such as usage, time interval, and Time-of-Use. In California, we are considering AMI deployment carefully, since different aspects need to be evaluated for residential and commercial areas. My question is, what are the principles of smart meter management for different areas with different tariff?	In France, CNI has 10 year experience in Time-of-use, they use different contracts and refund mechanisms to control the power consumption. In this issue, French government is more conservative, they will trial projects in different regions to evaluate the results and collect the response before roll out for the whole economy.
8	What are the key issues for the communication standards for AMI system?	(1) About the standards of power-line and wireless communication in France, there is not (2) It is difficult for AMI deployment to decide the standards first for products to follow. So our idea was to use a
9	About the earthquake to hit Japan this year, what actions does the utility take in both power supply and demand management?	This is not an easy question to answer, and actually Japan now is short of power supply. Under current situation, some regions are enforced to cut down the power supply, but it is not a long run policy. What we consider the most is to offer enough power to end users as they need it. One of the possible solutions is to use smart meter to control the demand and save energy, and currently AMI and smart grid are both under discussion and evaluation.
10	To Brian Seal, as you mentioned 10 deployment projects are currently under construction, how will you	It is hard to predict, as there are multiple facts and one of them is the combination of various of meters, such as water, gas and electricity. Thus, it is

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Minute			
No.	Question	Respond	
	project the market size of AMI in 2012?	very difficult to separate the contributions from meters. For a full system installation, it takes about 5 years, so the deployment amount is about 30%. The replacement by smart meter is not a one-shot change-up. While we are promoting the AMI, we will rethink the market	

4.2 Concluding Remarks

The summary of this conference is shown as followings:

(1) Public Acceptance：

A major concern and challenge of AMI deployment is the public acceptance. For AMI deployment, not only the available technologies hold the key to success, but also the incresment of public awareness. As a result, users will understand the system more and also involve more for fututre system aggregration, and it can be beneficial for public affair development.

(2) Standardization：

Standards related to AMI deployment cover wide aspects such as meter production, market domain and business model. In order to overcome the bottlnecks and uncertainty of system deployment and following development, it is essential to standardise the deployment of AMI as well as the supplyment sccheme.

(3) Privacy and Business Model：

New dervited services and business models are currently under reseach and no clear conclusion has been made related to the investment and return of revenue for AMI deployment. However, it is for sure that the services will be based on the power consumption data of the users, and the following acts and regulations to protect the privacy of users will be the major public concern for system deployment.

5.0 Challenges for AMI deployment

5.1 Cost and Benefit Analysis

One of the most important challenges for making a decision on AMI deployment program is to conduct a thorough cost and benefit analysis, based on the feasible alternatives. There are a couple of key components must be clearly evaluated before a cost and benefit analysis can be made. The scope and the items of cost and benefit associated with AMI are sometimes not easy to be identified. This applies in particular when a roll-out plan of AMI is made mandatory by legislation. Such an assessment of all costs and benefits in the form of a cost-benefit analysis (CBA) is widely suggested by the advanced economy. For example, European legislation had relevant regulation on Annex I of Directives 2009/72/EC and 2009/73/EC, and in U.S. a more comprehensive framework standards was set out for cost-effectiveness procedures.

As early in the 1970s, conservation and load management programs have been promoted by the California Public Utilities Commission (CPUC) and California Energy Commission (CEC), as alternatives to power plant construction and gas supply options. With the first publication of the *Standard Practice for Cost-Benefit Analysis of Conservation and Load Management Programs* in February 1983, CEC and CPUC revised it to be a more comprehensive manual, i.e. *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects 2001.* In order to carry out a more complete CBA, detailed information on all possible costs and benefits is needed as input data. As the result of a CBA can be strongly influenced by the selection, definition and specification of the input data, this step is crucial in avoiding bias in favor or against AMI deployment program.

The following sections provide an overview of different perspective of a national CBA to an AMI roll-out and highlight the major steps to carry out the CBA.

5.1.1 Definition of Costs and Benefits

Major costs associated with smart metering are the purchasing, installment and operating costs of the smart meters as well as the investment costs for advanced data collection and data communication tools. Major benefits typically associated with smart metering are energy savings due to increased efficiency or sufficiency and due to load shifting, reduced metering costs, improved security of supply and reduced non-technical losses. Other indirect benefits of smart metering include consumer empowerment for knowing the real-time cost associated with energy consumption, and with consumer choices.

Costs and benefits of smart metering however very much depend on the technical specifications of the smart meters and the smart metering infrastructure rolled-out. More advanced smart metering systems with a larger range of functionalities could provide greater benefits and a larger range of benefits, but are also likely to be more expensive than basic smart metering systems. The technical specifications of a smart metering infrastructure on the other hand are strongly determined by the policy objectives pursued with the roll-out of smart metering. While it is possible to give a rough indication of the costs of different smart meters, it is not meaningful to provide general numbers of the benefits of smart metering per meter or customer, as these strongly depend on the individual specifications of the smart meters, the group of stakeholders concerned, economy or regional specifics and a range of other assumptions assessed in a cost-benefit analysis.

The costs and benefits arising from a smart metering roll-out also strongly depend on the local circumstances and the status quo of the electricity system. The potential of smart metering to contribute to load shifting and energy savings is strongly related to the types of energy consumption and the consumption patterns. Electricity used for heating and cooling for example can be shifted easily. However, this will require automation, which is less likely to be available for household consumers compared to industrial and larger commercial consumers. With cooling and heating as loads which are relatively easy to shift, the percentage of load which could be shifted is much higher in a economy where for instance air-conditioning is widely applied.

The ability to make energy savings also depends on the overall level of per capita energy consumption. In economies with very high (careless) energy consumption, the potential to significantly reduce energy consumption might be comparably high. Likewise, in economies where household budgets are typically very limited and energy costs are consuming larger shares of the budget, the incentive to realize cost cuttings, e.g. by energy savings or demand response measures is much stronger. The latter might be relevant for many Energy Community (EnC) Contracting Parties. As a result, potential costs and benefits of smart metering can be quite varied in different contexts and economies.

Most of the costs and some of the benefits related to smart metering can be estimated before making a roll-out decision. New services and functionalities likely to arise in the future and provide additional benefits cannot however be properly estimated before the roll-out has taken place. Manufacturers of products such as household appliances and the service industry for example will adapt to smart metering technology and will develop and offer a wide range of specially designed products and services, e.g. further increasing energy efficiency by intelligent household control or enhancing consumer welfare with increased comfort.

The costs and benefits of smart metering may be unevenly distributed between the different stakeholders. Clearly costs and benefits directly affect the network operator or the supplier replacing the old meter with a smart meter and the customer whose old meter is replaced with a smart meter. But costs and benefits also affect (indirectly) other market participants, such as other network operators, generators, suppliers or customers and the society as a whole. Different stakeholders are likely to benefit to different extents from a deployment of smart metering. Costs might for example only be borne by one market participant (e.g. the customer), whereas benefits might be split across a larger number of market participants (network operators, suppliers, customers etc). Costs might also mostly arise in the short-term, whereas some benefits of smart metering might only occur in the long-term.

Smart metering is primarily an electricity topic, in particular of course in those economies where gas plays no or a negligible role in residential energy consumption. The benefits of an application of smart metering are also generally greater for electricity than for gas. Benefits from load shifting for example are only applicable to electricity since fluctuations in electricity production and demand have to be balanced in much shorter time intervals than for gas, which generally varies at a much slower pace. Given the nature of gas usage for heating purposes, a load shift from peak to off-peak times would also make little sense. With regards to savings, the impact on gas consumption is more limited, as the purposes of electricity usage are manifold with plenty of individual and independent consumer decisions on whether or not use electricity on a daily basis, where constant or regular feedback will have the strongest effect. In our description of potential costs and benefits of smart metering we therefore focus primarily on smart metering for electricity.

5.1.2 Benefits to Network Operators

Smart metering has several benefits for network operators. A wide deployment of smart metering provides a network operator with precise information on the actual consumption and feed-in at specific sites of its low voltage distribution network, offering a range of potential savings directly to the network operator. System-wide benefits arise from optimized distribution operations, improved network reliability and the contribution of smart metering towards quality of supply, for example by facilitating the detection of outages and by reducing restoration times.

Potential benefits of smart metering for network operators include improvements in the security of supply by a faster fault location and power restoration, improved monitoring of voltage quality, the ability for quick remote disconnection or reconnection of customers and the ability for remote reduction or restoration of power.

Smart metering can help network operators to detect and locate faults and power outages more quickly. Reducing the time period between the time the fault occurs and the time the grid operator‘s control center receives this information (automatically) via the smart metering communication infrastructure allows the network operator to immediately dispatch the technicians required to restore the fault. By identifying fault locations more quickly, the outage time can be reduced. This provides an obvious benefit to consumers and savings to the distributor from reduced costs by more accurately dispatching crews. When a regulatory scheme for quality of supply is applied – linking the actual network reliability (number and duration of outages) to quality standards and penalties or a quality incentive scheme – network operators can also benefit from higher revenues following reduced outage duration times.

Smart metering generates real-time, accurate and comprehensive information on the distribution network (e.g. voltage quality, losses), which allows more accurate prediction of electricity flows to be used for improved network and maintenance planning. Detailed information on the current status of the network also provides a basis for sound investment planning.

Smart metering together with the application of time-of-use tariffs can provide customers with information on consumption and prices and encourage them to shift their energy consumption into times when energy prices are at a lower level. Smart metering can thus reduce the demand at peak times and thereby reduce the maximum network capacities required to distribute electricity at peak load, which in turn reduces the need for network investments.

Integrating smart meters into the IT infrastructure of the network operator can also help to optimize processes and reduce operational costs (process optimization). Further benefits can also be gained from a multi-utility approach integrating gas, district heating or drinking water metering.

Smart metering can also have a significant impact on the reduction of commercial losses (detection of fraud and energy theft). Smart metering allows for an easier detection of previously unmeasured consumption that resulted from bypassing the meter. Furthermore, smart metering also provides more accurate information about the location of losses and theft. Smart meters can also be fitted with anti-tampering devices alerting the DSO automatically when manipulation of the meter is attempted.

In most economies, the metering function is also provided by the distribution network operator. The operation and the reading of the meters (metering services) could also be carried out by the supplier or a separate metering company. Potential benefits of meter operators may include reduced costs of manual meter reading and reduced costs through remote disconnection or reconnection. With smart metering, digital meter data are automatically submitted to the metering operator's data center. Manual meter readings and manual entering of meter data into data management systems are therefore no longer required. Data can be easily processed and evaluated and meter-to-bill operations can be significantly improved. Furthermore, not only the meter reading, but also the disconnection and reconnection of customers can be handled remotely and (partly) automatically, reducing the need to send out technicians to customer sites to suspend and resume electricity supply.

Where a large labor force is employed for manual monthly meter readings, automated meter reading might however have a substantial negative effect on employment. Also when labor costs are relatively low, benefits from a reduction in labor costs (operating costs) with smart metering might be lower compared to the high capital costs resulting from investments in a smart metering infrastructure.

5.1.3 Benefits to Suppliers

Following the unbundling requirements specified in the internal market Directives of the European Union, network operation and supply have to be unbundled into two separate business activities or entities. Therefore separate benefits of a roll-out of AMI for the supplier could and should also be identified.

Smart metering can, for example, reduce the likelihood of incorrectly read or entered meter data leading to faulty invoices, which in turn reduces the number and costs of customer complaints, including reduced customer service center staff. The integration of smart meters in the IT infrastructure of the supplier and the further automation of the data processing and invoicing process can also result in reduced costs of the meter-to-bill operations, i.e., process optimization. The possibility of remote and instant disconnection of customers by the meter operator can also help to reduce the risk of payment default for the supplier.

Smart metering also enables suppliers to offer new tariffs and services arising from detailed information on individual end-user's consumption patterns. Such new services could for example help the customer to become more energy efficient. Suppliers also have the opportunity to offer customized contracts reflecting individual consumption patterns. These contracts may include time-of-use or more sophisticated tariff elements and might also provide for automatic demand side management. Furthermore, smart metering might allow the supplier to use actual load profiles of individual customers rather than standard customer load profiles. Through improved load profiling and forecasting suppliers are able to more precisely predict their customers' demand at specific points of time, which allows them to reduce their whole sale purchasing costs.

Smart metering may also provide benefits to electricity suppliers by improved customer satisfaction resulting in a higher willingness to pay and higher customer retention. Customers could benefit, for example, from more frequent and detailed metering and more accurate billing or from easier and quicker customer switching procedures due to real-time metering, allowing customers to change their supplier in real-time or at very short notice and on any chosen date.

5.1.4 Benefits to Consumers

Smart meters can provide consumers with detailed information on their consumption behavior during different periods of the day. Actual and historic consumption data can, for example, be shown on an in-home display or on a computer screen, either provided by a direct data link or on a web page fed with the meter data. Smart metering together with price signals can therefore make the overall costs of electricity consumption and individual consumption patterns more transparent to the customers. Thereby customers are for example able to understand the impact of individual electricity devices or a certain consumption behavior on their energy bill. Such detailed information might also make the environmental effects of consumption behavior, such as the resulting greenhouse gas emissions, more transparent for customers.

Constant feedback on consumption and associated costs will increase the consumer‘s awareness and willingness to save energy. It allows customers for example to decide when and for how long to connect or disconnect some of their electric devices. Achieving energy savings with smart metering is however highly dependent on the effectiveness of the feedback on energy use given to consumers and the willingness and ability of the consumers to respond to this feedback. The ability and willingness of customers to realize energy savings also depends on the level of the end-user tariffs and the percentage of the monthly income spent on electricity expenses, whereas higher tariffs or a higher share of income spent on electricity consumption clearly set stronger incentives for energy savings. Also the range of electricity devices used by a customer and the customer's ability to replace old devices with more energy efficient equipment influence the scope of customers to realize reductions in electricity consumption.

However, not all consumers may be able or prepared to shift or reduce their demand. Accordingly some of them may even face higher energy bills. Consumer education is necessary to achieve changes in consumption behavior. The existence of the smart meter or some sort of consumption feedback itself will not necessarily result in substantial energy savings. The consumer needs to be taught how to use this new information in order to really achieve sustainable energy savings.

Customers can further contribute to energy savings if they are offered time-of-use or load-variable tariffs enabling them to save on their energy bills by shifting certain usage, e.g., dishwasher, heating, cooling, to cheaper periods.

The possibility to offer real-time pricing and innovative tariffs, as well as interfaces between smart metering and household appliances could result in various new types of energy services being available to customers to help manage consumption (and costs) and to promote more energy efficient and green energy networks (such as demand side management, i.e. the direct control of household appliances). Smart metering can also facilitate pre-payment options which allow customers to pay in advance and hence to better manage their budgets.

In addition to energy savings, customers may also benefit from more frequent and detailed meter reading and more accurate invoices reflecting actual consumption. With smart metering, invoicing is based on real meter data rather than estimated consumption. Customers would no longer face imposed under/over payments which might require settling at a later date. This could help to improve customer satisfaction and reduce the number of customer complaints, compared to traditional metering when the settlement occurs after several months or a year. It is also possible for a customer to agree with the respective supplier on how frequently invoicing takes place and to receive an invoice on demand (e.g. when moving from one home to another).

Smart metering can also have a strong impact in simplifying customer switching procedures as smart meters can be easily read at any time on request. Automation and simplification of data exchange through smart metering should speed up the process for changing suppliers and simplify the action required from the customer to make the change. The transparency of individual electricity consumption patterns and costs provided to the customer by smart metering also allow the customers to make more informed decisions on the selection of the most convenient supplier, further facilitating customer switching.

Customers may furthermore benefit from reduced metering and operational costs through remote meter reading and remote reconnection of customers, if the cost savings made by the meter operator (or network operator) are passed on to the customers. Depending on the location of the conventional meters (whether located outside a building or inside) smart metering may have also the additional benefit that it requires no more home intrusions by meter readers.

Privacy and security concerns surrounding smart meter technology arise from the meters' essential functions, which include (1) Recording near-real time data on consumer electricity usage; (2) Transmitting this data to the smart grid using a variety of communications technologies and (3) Receiving communications from the smart grid, such as real-time energy prices or remote commands that can alter a consumer's electricity usage to facilitate demand response.

Smart meter hacking is usually conducted for one of two purposes. The owner of the premises where a smart meter is located might hack the device to alter transmissions so that use is under-reported and will be billed for accordingly. An external party, on the other hand, might hack the device's data transmissions to obtain information about activities within the premises.

5.1.5 Benefits to Society

Depending on the type of smart meters, the tariff schemes offered and the market environment, smart meters can facilitate energy savings, demand response and direct load control and thereby reduce demand at peak (and off-peak) times, resulting in lower wholesale prices and reducing the need for investments in generation, transmission and distribution capacities (avoided costs). With a contribution to increased energy efficiency and reduced carbon emissions, through reduced consumption and the facilitated integration of distributed generation, smart metering can also play a role in mitigating the effects of climate change. A large investment program, such as deploying a full-scale smart metering infrastructure might also have a positive impact on economic development and employment.

Regulatory authorities can use smart metering to improve quality of supply regulation, in terms of reliability and voltage quality, as smart metering provides the regulator with more precise and detailed statistics on reliability performance (number and duration of outages).

5.2 Key Challenges and Mitigation Strategies

Risk	Description	Mitigation strategies
1. High cost of deploying smart meters	Deploying smart meters requires huge capital investment and hence it is crucial that the utility company is confident of successful implementation.	The American Reinvestment and Recovery Act (ARRA) signed into law on February 17, 2009, by President Barack Obama, and made $3.4 billion available to utilities for smart meter implementation.
2. Large scale deployment of Smart Meters	The deployment of smart meters in such a huge volume demands a very highly organized system with properly managed inventory control. If this mass deployment is required to be carried out by a third party vendor, the challenges increase as co-ordination and synchronization between the inherent systems can be very complex.	Need to have a good roll-out plan like America start from 2005, step by step. April 19, 2012 - The California Public Utilities Commission (CPUC) took action to ensure the effectiveness of Smart Grid investments by developing 19 metrics that will be used by Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas & Electric to report on Smart Grid deployment, as part of annual reports to be submitted to the CPUC. (Source: *Decision Adopting Metrics to Measure the Smart Grid Deployments of Pacific Gas And Electric Company, Southern California Edison Company and San Diego Gas & Electric Company*) Government must authorize utilities to deploy smart meters and supervise those utilities.

3. Data privacy	There are many concerns related to privacy of consumption data being raised as Smart Meters are installed at more and more locations. The meters' data can be mined to reveal details about customers' habits like when they eat, how much television they watch and what time they go to sleep. The retention and storage of this data make it vulnerable to security breaches as well as government access.	In 2012, California SDG&E is joining ''Privacy by Design'' code of conduct for all smart meter deployments. The system of rules would apply to smart meter manufacturers, grid managers, utility billing operations, and other to apply privacy and encode by default all settings.
4. Dynamic adaptation and flexibility of roll-out plan	As is the case with any large transformation program, the carefully crafted requirements document, which is signed off and approved after much deliberation, becomes obsolete from the day the project begins. Dynamic adaption and flexibility of roll-out plan are always a big challenge for massive deployment of AMI.	• Some utilities owned Smart Meters supporting consumer devices with Home Area Network (HAN) or comparable consumer energy monitoring. • Customers with Smart Meters using a utility administered Internet or a web-based portal to access energy usage information or to enroll in utility energy information programs;
5. Cost-Benefit Analysis	One of the most important challenges for making a decision on AMI deployment program is to conduct a thorough cost and benefit analysis, based on the feasible alternatives. The scope and the items of cost and benefit associated with AMI are sometimes not easy to be identified.	Using *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects 2001* for conducting CBA.
6. Healthy and privacy of consumers	Health and Privacy concerns surrounding smart meter technology arise from the meters' essential functions.	Allowing consumers choices for not installing AMI, e.g.: California's Public Utility Commission (CPUC)

		approved a smart meter opt-out option for allowing customers to keep their older analog meters for a fee.

6.0 Conclusions and Recommendations

6.1 Principles for AMI deployment policy

At the planning stage, AMI deployment policy should be consistent with the following criteria; (1) Economic efficiency – the roll-out plan as elaborated in the previous chapter should be cost effective or benefit cost analysis justifiable. (2) Societal equity – although the large customer with more electricity consumption should be more appropriate for installing AMI and smart meter, a comprehensive roll-out plan should cover all kinds of customers in order to full-fill the empowerment and choices of every consumer without social prejudice. (3) Sustainable development - AMI is essential to encouraging renewable energy deployment transiting industries to low-carbon and clean-energy patterns, creating new “green jobs” for more employment, and building an infrastructure for long-term sustainable economic development. (4) Security, privacy and health concerns – although AMI provides greater visibility of and control over the energy usage empowering customers to reduce their energy costs, the issues of cyber security, privacy and health concerns must be treated deliberate allow the consumers to opt-out from choosing smart meters.

At the implementation stage, the policy makers have to consider the following variables; (1) Standardization - There are a couple of AMI standards in this area. The government should considering an AMI standard format for themselves and power companies to analyze justifiable benefit/ cost. (2) Interoperability – Standards of AMI must allow for interoperability. Ensuring systems and devices are fully interoperable from day one holds the key to the success of the smart metering program. (3) Timing - Each AMI standard has different product maturity. In order to cost-down learning curve, the decisions must be continually adjusted, and quality stabilization must be enhanced. (4) Cost-Benefit Analysis – One of the key challenges for making a decision on AMI deployment program is to conduct a thorough cost and benefit analysis, based on the feasible alternatives.

6.2 Guidelines for APEC Economies of Smart Metering Deployment

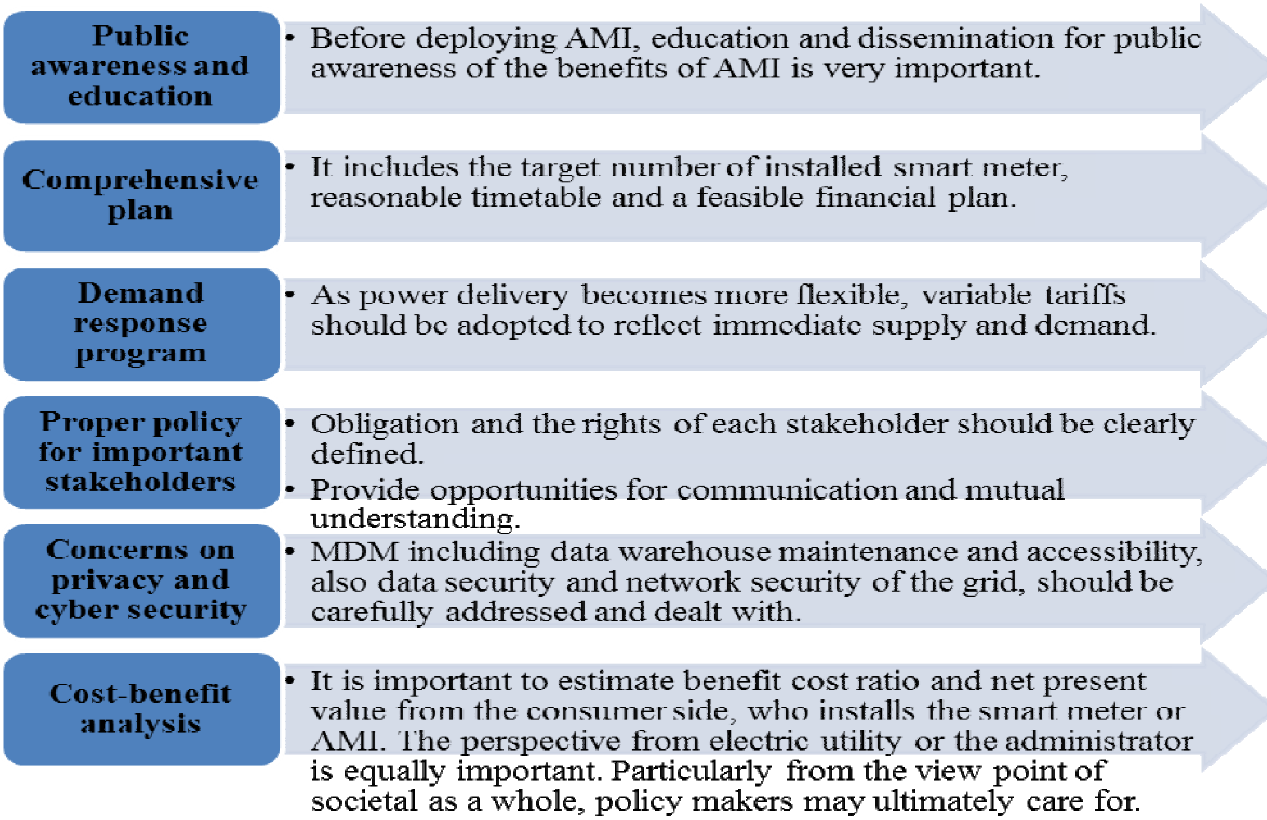

Figure 6.1 Guidelines for APEC Economies of smart metering deployment

I. *Public awareness and education:* the general public should be educated to recognize the importance of AMI and smart grid, including smart meters enable two-way communication between the meter and the central power system. Through the mobile terminal, such as a cell-phone or i-pad, smart meters can help customers gather their energy consumption data for remote reporting.

II. *Comprehensive plan:* it includes the target number of smart meter to be installed, announced timetable, e.g., demonstration and deployment for industrial and residential customers, and a feasible financial plan.

III. *Demand response program:* as power delivery becomes more flexible, variable tariffs should be adopted to reflect immediate supply and demand. Individual appliances in the home will become "smart" - networked and automatically or remotely controlled to manage energy use and cost. Under this circumstance, ICT is not only an essential enabler of smart meters and smart grid, it also serves as the data centers that could help smart grid balance electricity supply and demand.

IV. *Proper policy for important stakeholders:* obligation and the rights of each stakeholder should be clearly defined, e.g., opt-in vs. opt-out choices of the consumer for selecting smart meter or conventional analog meter. As governments are in the process of deciding what should be mandated for all consumers and what should be left to market mechanism. In fact, the support of a wide range of stakeholders is critical for the success of the smart metering program. Stakeholder engagement has therefore been a vital part and will become increasingly important as the program moves forward. In developing the pilot AMI project, it is important to consider from the consumer perspective, as well as the views of industry participants who will take on responsibility for delivery of the smart metering system. It is advised that various stakeholder events, workshops and evidence-gathering sessions, or public hearings with all stakeholders and representative groups, should be held in order to provide opportunities for communication and mutual understanding.

V. *Concerns on privacy and cyber security:* MDM including data warehouse maintenance and accessibility, also data security and network security of the grid, should also be carefully addressed and dealt with. This is a sensitive issue for the public and a new challenge that has not been encountered by conventional electric power systems.

VI. *Cost-benefit analysis:* there are various perspectives for conducting cost and benefit analysis. It is important to estimate benefit cost ratio and net present value from the consumer side, who installs the smart meter or AMI. The perspective from electric utility or the administrator is equally important. Particularly from the view point of societal as a whole, policy makers may ultimately care for.

6.3 From AMI to Smart Grids

6.3.1 The role of smart metering in Smart Grids

Smart Grid is essential to encouraging renewable energy deployment, transiting industries to low-carbon and clean-energy patterns, creating new “green jobs” for more employment, empowering customers to reduce their energy use and costs and building an infrastructure for long-term sustainable economic development. However, the first step towards a comprehensive smart grid is to install smart meters based on advanced metering infrastructure. Therefore, it is important to prudently implement the roll-out plan of smart meters, in order to earn the support from all stakeholders. The role of smart metering is very critical.

6.3.2 Key Considerations from Integration of Smart Grid (scalability、interoperability、integration、customer service)

Utility operators need a robust platform that can quickly expand to meet growing demand across a wide range of applications and provide performance equal to current dedicated hardware installations. As the utility market grows and changes, and as long-term demand rises, utility operators must be able to rely on easy scalability for changing storage, compute, and network requirements

In the past decade, the concerns for energy independence and carbon emissions have created a need to diversify energy sources of generation away from fossil fuels. At the same time, electric power customers are seeking ways to reduce energy consumption as well as become more active in making choices. The evolution toward the smart grid will greatly depend on integrating the needs of consumers and the requirements of regulatory bodies while maintaining a utility's own operational performance objectives.

From government mandates to increasing consumer influence, established energy supply and demand structures are under pressure to change. The technology investments driven by security standards, energy efficiency programs, smart meter mandates, and integration of renewable energy resources are forcing utilities to improve operations. These same technology investments also open new opportunities to create business value and revenue when the smart grid infrastructure is flexible, scalable, and secure. Communications networks are critical to managing energy-controlling equipment, devices, and applications in the field. The future of the smart grid requires the network's edge to grow. The smart grid will depend heavily on the interoperability of converged communications networks that support the seamless flow of system data across the utilities' business units and business partners.

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6.4 Areas for Further Study

I. Data mining (Big data): smart meter which can be read remotely and allows customers to check their own energy consumption at any time. This helps them to control their energy usage better and to identify cost-effectiveness ways to save energy. Every customer can access their own consumption data online in graphic form displayed in quarter-hour intervals. This implies Big Data of energy customer consumption could be available for data mining.

II. Data access authority: in order to ensure consumers' interests are protected, the government should develops a data access and privacy framework to provide clarity about the ways in which energy consumption data from smart meters can be accessed, by whom, for which purposes, and the choices that consumers should have about this. In short, smart meter data can go beyond just capturing customer behavior in very detailed and expansive ways, and become a key pillar to support ongoing market research activities by providing valuable insights for focused research projects.

III. Smart meters would reduce energy company costs by taking away the need to read meters, and this would mean someone would lose his job. All those meter reader jobs are gone. What are the savings from those lost jobs is an issue need to be addressed for further research.

IV. Energy consumers might benefit from the increase in consumption information available through smart meters by being able to have access to detailed appliance diagnostics. By identifying individual energy use such diagnostics could help to identify those appliances where investment in more efficient models would be economical. Other areas of potential benefits include more refined automation of heating and hot water controls and the analysis of heating patterns through the availability of detailed energy consumption data. All these issues are worthy for directions of future research.

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Appendix A

APEC AMI Survey Form

Questionnaire

Dear participants,

This questionnaire is designed to study the key successful factors of advanced metering infrastructure (AMI) development in APEC. The information you provided will help us better understand the effects of challenges of AMI development. There are five parts in this questionnaire. It would take you about 10 minutes to fill this questionnaire.

We would be grateful if you would respond to the questions frankly and honestly. Your response will be kept strictly confidential. Only members of the research team have access to the information you give.

Thank you very much for your time and cooperation. We greatly appreciate your help in assisting us with this research.

Yours sincerely,

Chun-Li Lee

Deputy Director
Electricity Division
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Please provide the data requested or tick the appropriate box

NO	Question	Answer
1	Basic information ： Country, Name, Phone, e-mail	Country：______________________ Name：______________________ Phone：______________________ e-mail：______________________
Part I：Basic Background		
2	Electric Power Market Summary	please answer question #2.1 to #2.6
2.1	energy consumption：2011	Total：____________GWh per year Households LV (low voltage)：__________ GWh per year Commercial LV：____________GWh per year
2.2	number of households：until 2011/12/31	____________Million Units
2.3	number of installed electricity meters：until 2011/12/31	____________Million Units
2.4	number of installed smart meters：until 2011/12/31	____________Units
2.5	Is there a mandatory frequency for electricity meter reading for households defined in your country?	☐ YES (If yes, please answer the following：) ☐ Once a month (12 times per year) ☐ Bimonthly (6 times per year) ☐ Others (____times per year) ☐ NO
2.6	Electricity Meter standard	☐ International Electricity Commission ☐ American National Standards Institute
Part II： Political Aspect		
NO	Question	Answer
3	Smart Meter Roll-Out Plan	please answer question #3.1 to #3.3

3.1	What is the status of smart metering roll-out for households in your country?	☐ Majority of meters are smart ☐ Roll-out underway ☐ Roll-out planned ☐ Roll-out plan discussed ☐ No roll-out plan as yet (If no, you can ignore the following questionnaire)
3.2	How much existed electricity meters need to be replaced in your country's smart meter roll-out plan for households?	___________Million Units
3.3	Please specify the timeline and target units of the Government's plans to roll-out smart meters for households.	Date of beginning： ● Date:_________ ● Target: _______________ units Date of ending： ● Date:_________ ● Target: _______________ units
4	What are main policy drivers to encourage smart metering roll-out in your country? (multiple answers are allowed)	☐ Regulatory push ☐ Financial incentives from government ☐ Saving energy and reducing carbon emissions ☐ Enhancing energy efficiency ☐ Reducing electricity thefts ☐ Reducing meter reading costs ☐ Introduction of more complex tariff systems ☐ Peak-load management ☐ Other(please specify): _____________ _________________________________

5	What role(s) does the governments or the regulator play in the roll-out process? (multiple answers are allowed)	☐ Definition of the roll-out timetable ☐ Definition of the target roll-out units ☐ Organizing the roll-out working group ☐ Definition of minimal technical requirements ☐ Definition of the level of ROI (return on investment) expected ☐ Developing the privacy policy framework ☐ Monitoring and reviewing the roll-out process ☐ Other (please specify):_______________ ___________________________________
6	Key responsible stakeholder for the roll-out program	please answer question #6.1 to #6.4
6.1	Installation	☐ Distribution system operator ☐ Electric power company ☐ Energy service company ☐ Smart metering system integrator ☐ Customer ☐ Other (please specify):_______________
6.2	Maintenance	☐ Distribution system operator ☐ Electric power company ☐ Energy service company ☐ Smart metering system integrator ☐ Customer ☐ Other (please specify):_______________

6.3	Meter reading	☐ Distribution system operator ☐ Electric power company ☐ Energy service company ☐ Smart metering system integrator ☐ Customer ☐ Other (please specify):_______________
6.4	Data management	☐ Distribution system operator ☐ Electric power company ☐ Energy service company ☐ Independent data management company ☐ Customer ☐ Other (please specify):_______________
7	Electricity pricing policy	please answer question #7.1 to #7.2
7.1	Has your country implemented dynamic pricing programs <u>before</u> smart meter roll-out? (multiple answers are allowed)	☐ YES (If yes, what kinds of pricing programs?) ☐ Time-of-Use Pricing (TOU) ☐ Critical Peak Pricing (CPP) ☐ Real-Time Pricing (RTP) ☐ Extreme Day CPP (ED-CPP) ☐ Others(please specify):___________ ☐ NO
7.2	Has your country developed dynamic pricing programs <u>after</u> smart meter roll-out ?(multiple answers are allowed)	☐ YES (If yes, what kinds of pricing programs?) ☐ Time-of-Use Pricing (TOU) ☐ Critical Peak Pricing (CPP) ☐ Real-Time Pricing (RTP) ☐ Extreme Day CPP (ED-CPP) ☐ Others(please specify):___________ ☐ It is in progress ☐ NO

8	What are the most critical challenges for roll-out of smart meters?	☐ Financial issue ☐ Technical issue ☐ Customer resistance ☐ Other (please specify):_______________
	Part III：Economic Aspect	
NO	Question	Answer
9	Who pays for the roll-out of smart meters?	☐ Government ☐ Electric power company ☐ Distribution system operator(DSO) ☐ Customer ☐ Others(please specify):______________
10	Has the government, the regulator or the DSO conducted a cost & benefit analysis of the roll-out plan?	☐ YES (please answer question #10.1 to #10.4) ☐ It is in progress(please continue to Part IV and Part V) ☐ No(please continue to Part IV and Part V)
10.1	The total estimated cost of smart metering project.	__________million US dollars for the ____ year period
10.2	The total estimated benefits of smart metering project.	__________million US dollars for the ____ year period
10.3	Please point out the <u>three major</u> cost elements for the roll-out of smart meters.	☐ Capital cost of meters ☐ Meter installation cost ☐ Meter operation and maintenance cost ☐ Information technology cost ☐ Communication set-up cost ☐ Communication operation and maintenance cost ☐ Others(please specify):_______________ _____________________________________

10.4	Please point out five major benefits from your smart metering project.	☐ Reducing the theft of electricity ☐ Avoided cost of routine manual reading ☐ Loss of load detection and outage detection ☐ Avoided cost of manual disconnections and reconnections ☐ Avoided generation capacity costs ☐ Avoided transmission and distribution costs ☐ Energy saving ☐ Avoided CO_2 costs ☐ Others(please specify):______________ ____________________________________
	Part IV：Technical Aspect	
NO	Question	Answer

11	Which functionalities of smart metering for households should be covered? (multiple answers are allowed)	☐ Two-way communications to the meter system ☐ Interval metering data (load profile measurement) ☐ Remote disconnection and connection of load ☐ Net energy metering between power company and the customer ☐Supporting load management(e.g. time-of-use rates) ☐ Loss of load detection and outage detection ☐ Information display on the meter and/or communication port for in-home display(IHD) ☐ Interface to home area network(HAN) ☐ Firmware Upgrades ☐ Events/Tamper Alarms ☐ Automatic self-registration ☐ Communication port for collection and transmission of other metered data (e.g. gas, water) ☐ Others(please specify):______________ ____________________________________
12	Which is the preferred method of communication (e.g. GPRS, GSM, PLC, Zigbee etc.)	● Wide area network(WAN) :_________ ● Local area network (LAN) :_________ ● Home area network(HAN) :_________

13	Technical challenges (multiple answers are allowed)	☐ Integration of different type of meters and system ☐ Ensuring security & privacy protection ☐ Make sure the meter system is compatible for smart grid development in the future ☐ Expanding functions to offer value-added services in the future (e.g. energy audits, energy management, home automation) ☐ Others(please specify):______________ ________________________________
14	Do you have any solutions or strategies for the technical challenges?	________________________________
	Part V：Social Aspect	
NO	Question	Answer
15	What are the major concerns of the customers? (multiple answers are allowed)	☐ May lead to higher electricity bills ☐ Health concerns of electromagnetic fields and radio frequency radiation ☐ Social justice issues(e.g. the implications of time-of-use pricing for low-income and disadvantaged households) ☐ Safety and privacy issues ☐ Others(please specify):_____________ ________________________________
16	Do you have any solutions or strategies for the social challenges?	________________________________

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