Smart Metering with a Focus on Electricity Regulation

Ref: E07-RMF-04-03
31 October 2007

European Regulators' Group for Electricity and Gas
Contact: Council of European Energy Regulators ASBL
28 rue le Titien, 1000 Bruxelles
Arrondissement judiciaire de Bruxelles
RPM 0861.035.445

Table of Contents

PREFACE

The European Commission and the European Regulators Group for Electricity and Gas (ERGEG) are examining a number of issues that are relevant for the development of a competitive energy market in Europe. One of the topics under investigation concerns recent innovations in smart metering.[1]

The introduction of smart metering is being further accelerated by European legislation. In particular, EU-Directive 2006/32/EC on energy end-use efficiency and energy services (Article 13) and EU-Directive 2005/89/EC concerning measures to safeguard security of electricity supply and infrastructure investment (Article 5) mention explicitly the use of advanced metering systems.

The topic of smart metering is further elaborated upon in the Communication of the European Commission to the Council and the European Parliament on Prospects of the internal gas and electricity market (COM(2006)841 final) stating that the extended use of smart metering could enhance competition of the European energy market.

The regulators conducted a status review on smart metering in 2006, based on a questionnaire addressed to ERGEG energy regulators. The working document which resulted from this exercise contributed to the work on the current report. The findings of the questionnaire are available in Annex 1. The current report was prepared by the Retail Market Functioning Task Force.

Starting with the analysis of existing or planned smart metering schemes and discussions carried out in the past months, this document lists some main recommendations for regulators and some policy options adoptable by them, according to both types of metering frameworks established in EU Member States: regulated and liberalised.

Due to the country-specific role of regulators with regard to metering arrangements, some of the results of this report might not be relevant to all regulators or applicable to the individual member state. The powers and responsibilities of the national regulatory agencies differ from country to country as does the situation regarding both metering and market opening. It is therefore difficult to draw general conclusions which are fully applicable to all countries.

In the context of this document, smart metering refers to the entire meter infrastructure, including availability of processed data to market players and third parties.

[1] Smart metering is a general definition for 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.

EXECUTIVE SUMMARY

Triggered by innovation in IT and communication technology and cost cutting through market liberalisation, various smart metering systems have been implemented in the past few years. Furthermore, in the coming years at least three European countries (Italy, Sweden and the Netherlands) will have completed a full roll-out of smart meters to all of their (residential) customers. In many other countries, pilot projects and public consultations on this topic are on the agenda.

It should be highlighted that introducing a smart metering infrastructure for small-scale consumers is not an objective in itself. International experience indicates that the reasons for metering innovation vary among countries. Having identified the policy objectives and acquired a clear vision of the regulatory and commercial framework, the first step in assessing the case for a policy that favours investments in more innovative metering is to carefully weigh the potential costs against the expected benefits.

Costs
A general experience is that costs are most often easier to quantify than benefits. Given this, there is a higher probability of positive net benefits when taking into account the issues which can only be evaluated qualitatively. Cost could be divided into three categories: capital costs, operation and management costs and stranded costs, which is the cost of removing the old meters. Moreover, installation costs differ across countries because of differences in labour costs. Presenting smart metering data to the customer is another new cost that might potentially be large, depending on the frequency of updating information and the quality of the presentation.

From a regulator's perspective, special attention must be paid to the issue of cost recovery and split incentives, which is when some market actors face the costs while others face the benefits.

Benefits
The range of potential benefits from smart metering for small customers can be rather extensive. These benefits could be system wide, for consumers, DSOs, metering operators and retailers. Regulators should single out their objectives and have a particular focus on those objectives relevant to the key benefits. Only then, should regulators identify potential benefits in other areas.

Smart metering systems:

- provide a range of costs savings such as eliminating manual meter reading costs, theft detection, reduced customer transaction costs and bad debt, thereby transferring to customers the benefits afforded by conducting business remotely,
- ensure that customers are always billed for their actual energy consumption, regardless of billing frequency,
- allow consumers to influence their consumption pattern more easily. By offering prices reflecting actual wholesale prices and hence shifting loads from peak to off-peak, peak load generation can be reduced,
- will improve grid operation and future grid planning by providing on demand and more detailed information about grid condition. Integration of distributed power generation and detection of technical and non technical losses are also important benefits of smart meter systems.

Meter data management

It is crucial that the party responsible for collecting and administrating meter data makes data accessible to all other authorised market players in a non-discriminatory way. If the customer is expected to react to price signals, actual demand etc, then easy access to meter data, for instance on a display, is needed.

Technical aspects of smart metering
AMM systems should have functional and performance characteristics that offer the same minimum options to all customers (household, non-household), whether they remain under a customer protection scheme or opt to switch to a new retailer.

Minimum requirements should apply at system level rather than equipment level, to render them independent from the architectures used by operators or recommended by AMM system vendors, thereby preventing the rejection of solutions whose architectures or philosophies may be different from those currently used but which may be just as efficient.

Standardisation is one of the issues ERGEG is currently considering as a topic for further work, possibly in co-operation with other institutions.

Regulators should encourage the use of standards, e.g. communication protocols.

Functional requirements
After carefully assessing the relevant costs and benefits, it is important to define certain minimum smart meter functionality. In order to allow for economic optimal solution and technical innovation, the individual meter service provider should be left to decide on the technical solution to fulfil the required functionality. The following main functionalities should be carefully considered:

- Remote meter reading
- Load profile data
- On demand metered data access for customer
- On demand meter data access for authorised 3rd party
- Provision of variable time-of-use tariffs (time bands)
- Remote meter management
- Remote demand reduction and connection/disconnection
- Price signal to customer

Policy recommendations for regulators
The legal framework and the powers of the regulator differ in the Member States, and the actual implementation of smart meter policies will differ from country to country.

In a regulated meter market, the regulator could accelerate the development of smart meters by obligatory roll-out or financial incentives. In a liberalised meter market, the policy options are more limited. However, independent of the market organisation, the regulator could set minimum functional requirements for meters installed in order to ensure a certain standard of data quality and functionality within a certain area or country.

ERGEG would recommend that regulators introduce such minimum requirements.

1 INTRODUCTION

In this report, the main focus is smart metering for households and small business customers. In principle, there are two metering market models established in EU Member States: the regulated metering model, where the grid operator or a regulated meter service provider have the monopoly of providing meter services and the liberalised metering market model, where the metering service is open to competition. In this report we highlight the need for minimum functional requirements independent of whether it is a regulated meter market or a liberalised meter market.

The powers and responsibilities of the national regulatory agencies differ from country to country as does the situation regarding both metering and market opening. It is therefore difficult to draw general conclusions fully applicable to all countries.

It should also be underlined that experience with full roll-out of smart metering is limited. It is too early to draw any conclusions on the long term effects of such policies.

1.1 Objective

The objective of this report is to present the issue of smart metering from an energy regulator's point of view and to clarify the role a regulator can play in this matter. The challenge for a regulator is to devise a policy that will favour the deployment of smart meters where the benefits outweigh the costs in the long term. The options are numerous and their advantages and disadvantages should be considered carefully, in light of the existing legal framework for metering activities. In this report, the main focus is smart metering for households and small business customers, as, to a large extent, large customers have already installed smart metering.

In particular, this report describes first the issues that individual Member States might want to assess before making a policy decision. These are:

- Costs and benefits of smart metering deployment.
- Meter data management and impact on market processes.
- Technical aspects of the meter and of the infrastructure.
- Regulatory policies.
- Recommendations.

The final section of this document draws some conclusions and contains a list of points a regulator should have in mind when making an assessment of policies and measures towards promoting smart meters.

In annex 2, a summary of the existing regulatory experiences on smart metering in various European and non-European countries can be found.

1.2 Role of the Regulator

Regulators' areas of responsibility vary from country to country. In most EU Member States, metering is an integrated part of the grid operator's monopoly activities and hence is subject to direct control by the regulator. Even in countries where metering has been liberalised, the regulator has a stake in metering issues, be it through metering price control or market organisation tasks in general.

However, as metering plays a major role in almost every aspect of the market (design, processes, tariffs, etc) it is in every regulator's interest to create an ideal framework for meter infrastructure.

1.3 Scope

Depending on the perspective taken on the issue of smart metering, the definitions and scope of this term can differ greatly. This report focuses mainly on metering of electricity. ERGEG recognises that smart meters can be used not only to meter electricity, but also gas, water, etc...

1.3.1 Metering organisation model

In general, meter service involves various tasks such as purchase, instalment and maintenance of the meter, meter data collection, management and provision of meter data to other market players. These various tasks do not necessarily have to be carried out by one single party. The meter could be owned, for instance, by the customer or by the DSO; meter instalment could be carried out by the DSO and meter data collection, management and provision serviced by the DSO or by a third party.

In principle, there are two metering market models established in EU Member States: the regulated metering market model, where the grid operator or a regulated meter service provider have the monopoly of providing meter services, and the liberalised metering market model, where the metering service is open to competition.

1.3.2 Market processes

As will be outlined in more detail later, data retrieved from meters has to be provided to many different market actors. Furthermore, smart meter systems provide the possibility for authorised market actors to communicate with the meter (e.g. to change tariffs, disconnect or reduce demand) and also with the consumer (e.g. to send price signals). This two-way data communication and remote management of customer demand/supply impacts on the following market processes and involves the following parties (depending on the metering organisation model):

Process	Parties involved
Supplier switching	Customer, new/old supplier, DSO
Demand/generation forecast	Supplier, DSO, generator
Demand side management	DSO, customer, generator, third party
Data for customer information (e.g. for energy efficiency measures)	Customer
Data for billing purposes	Supplier, DSO
Data for clearing & settlement	Clearing & settlement body
Data for energy service company	Any third party (e.g. ESCO)
Electricity price change	Supplier
Grid tariff change	DSO
Customer move in/out	DSO, supplier
Power quality measurement	Regulator, DSO
Demand reduction/disconnection	DSO, supplier
Price signal to customer	Supplier, DSO, customer

Table 1.1 – Process and parties involved

Access to detailed meter data is key to any smart metering system. Meter data exchange between market players is therefore considered within the scope of this report.

The above descriptions show that it is not only the technical specification of the smart metering system itself that needs to be taken into consideration but also the corresponding market organisation and processes.

1.3.3 Smart metering infrastructure

Smart metering as referred to in this paper is not restricted to the meter device alone but also includes other technical devices, communication and IT infrastructure connecting meter and customer (e.g. display) and also meter and the (central) meter control centre, where meter data is administrated and meters are remotely operated. Smart metering in the context of this document therefore refers to the entire meter infrastructure, fulfilling or partly fulfilling the following main specifications:

- Interval meter data (load profile measurement)
- Remote meter reading, data processing to market players.
- Remote meter management (power reduction, disconnection, demand management, etc.)
- Measurement of consumption and generation by distributed units.
- Remote meter parameterisation such as tariff structures, contractual power, meter interval, etc.
- Remote message transfer from market players to the customer (consumer/generator) as e.g. price signals.
- Information display on the meter and/or communication port for external display.
- Main communication port (e.g. GPRS, GSM, PLC, etc).
- Power quality measurement (incl. continuity of supply and voltage quality).
- Communication port for collection and transmission of other metered data (e.g. gas, heat).

The above list is not exhaustive but reflects the current state-of-the-art technology. These specifications are usually referred to as Automated Meter Management (AMM):

1.4 Findings of the status review on smart metering

In Annex 1, there is a description of the status of smart metering in ERGEG Member and Observer countries, based on a questionnaire addressed to ERGEG energy regulators in spring 2006. The survey explored the following issues described in more detail in Annex 1:

- legal framework of metering activities;
- public policies aimed at fostering the adoption of ‘smart’ meters;
- current status and future development of installations;
- economic issues related to meters and ‘smart’ meters; and
- functionalities of ‘smart’ meters and applications in use today.

1.5 Customer issues in ERGEG

This report is part of ERGEG’s work on customer and retail market issues. In this area, in July 2006 ERGEG launched a package of best practice propositions[2], namely on transparency of prices, supplier switching process and customer protection. In April and June 2007 ERGEG launched a report on obstacles to switching in the gas retail market and a status review on end-user price regulation for electricity and natural gas[3]. During autumn 2007, the ERGEG Retail Market Functioning Task Force started working on obstacles to switching in the electricity retail market. Customer and retail market issues will also be focused on in the ERGEG 2008 Work Programme.

[2] Best Practice Proposition Transparency of Prices 21 July 2006 (ref: E05-CFG-03-04), Best Practice Proposition Supplier Switching Process 21 July 2006 (ref: E05-CFG-03-05) , Best Practice Proposition Customer Protection 21 July 2006 (ref: E05-CFG-03-06),

[3] Obstacles to switching in the gas retail market - ERGEG Guidelines of Good Practice and Status Review, April 2007 (ref:E06-CSW-05-03), ERGEG Status Review on End-user Price Regulation, 14 June 2007 (ref. E07-CPR-08-04)

2 THE CUSTOMER PERSPECTIVE ON SMART METERING

Since 1 July 2007, all European citizens have been able to freely choose their electricity and gas supplier. However, market opening as such can not guarantee a sufficient degree of supplier choice and competition. Regulators should have a continuous focus on customer issues and market development.

Smart meters may facilitate better services for customers in various ways. More accurate metering and billing is an obvious advantage. Today, customers with floating prices do not get an accurate bill as, in most countries where floating prices are offered to household customers, consumption is distributed according to one or more standardised profiles. Consumers with a consumption pattern that differs from these standard profiles will get an inaccurate bill, especially if prices fluctuate a lot. In countries where self reading is practiced, smart meters will make those manual readings obsolete.

Smart meters will also facilitate supplier switching. With smart meters, a customer can make a switch any day of the week, and meter reading can be done automatically without involving the customer.

Both for the customers themselves and for the power system as such, it is important that the price signals from the wholesale market get through to the retail market. With AMM technology and a display showing both consumption and price, the customer can reduce consumption when prices are high. In this way, customers can save on their electricity bills.

Retailers can compete by offering customers different electricity prices which apply at different times of the day. Similarly, retailers can target certain groups of customers with particular tariffs that would be most economical for their consumption patterns. Such pricing innovation and variety in smart meters will promote retail competition to the benefit of customers.

Especially for households with relatively high electricity consumption, house and building automation can lead to additional savings and increased comfort: optimisation of heating and lighting of the household and small business.

For customers that are fuel-poor or want to be more in control of their spending on electricity, prepayment meters are an option. With such meters, the customer can pay in advance and get a message when it is time for an additional payment.

Looking at the broader picture, reducing greenhouse gases emissions and global warming will be of benefit to everyone, including consumers. Smart metering can lead to a reduction in peak load demand and also electricity consumption in general. This will possibly result in reduced CO_2-emissions from generation based on fossil fuel.

3 ASSESSMENT OF COSTS AND BENEFITS

It should be highlighted that introducing a smart metering infrastructure for small-scale consumers is not an objective in itself. International experience indicates that the reasons for metering innovation vary among countries. Having identified the policy objectives and acquired a clear vision of the regulatory and commercial framework, the first step in assessing the case for a policy that favours investments in more innovative metering is to carefully weigh the potential costs against the expected benefits.

A general experience is that costs are most often easier to quantify than benefits. Given this, there is a higher likelihood of positive net benefits when taking into account the issues which can only be evaluated qualitatively.

Regulators should clarify their objectives and focus in particular on relevant benefits stemming from these. Then regulators should identify additional potential benefits in other areas and try to quantify these benefits as well.

The regulators have a particular responsibility for a comprehensive assessment of costs and benefits of smart metering roll out. However, it is also important to assess the impact on the different parties, e.g. DSOs, suppliers and customers, in order to analyse the possibility of split incentives.

3.1 Introduction

Introducing a smart metering infrastructure for small-scale consumers is not an objective in itself. International experience indicates that the **reasons** for metering innovation vary among countries.

The main driver in several countries is the hope that exposing consumers to a time varying cost of electricity will lead to a reduction in consumption and to a reduction of peak demand, reducing the need for additional investments in networks and generation. In turn, increased energy efficiency will translate into savings for consumers and the system as a whole. In particular, policies adopted in the States of Victoria (Australia), California (USA), and the province of Ontario (Canada) were clearly motivated by a need to manage high and increasing summer peak demand driven by increased air-conditioning use.

A need for improved billing accuracy was the main driver, for example in Sweden. Shortly after deregulation of the electricity market, energy prices soared while consumer groups heavily criticised electricity bills for being both unclear and inaccurate. Sweden has introduced, from July 2009, a legal requirement for all electricity meters to be read monthly. The most cost effective way distribution companies could meet this requirement is to invest in remote meter reading technology. In addition, environmental concerns are a strong driver for power conservation in Sweden. Italy indicated the billing accuracy as one of the main objectives to be pursued as well.
The requirement to reduce losses due to fraud is of prime importance in both Italy and Northern Ireland where the scale of the losses, and costs associated with their detection, were significant. In particular, Enel, the dominant distribution (and retail) company in the domestic sector in Italy has invested in smart metering for a number of business driven reasons:

- Limiting the large number of visits per year.
- Reducing bad debts.

- Getting into a good position before market opening in July 2007.

The **regulatory and commercial framework** is an equally important variable in the decision. Innovative metering has generally been introduced in an environment where metering activities have been the exclusive responsibility of the network operators. Network operators are often the retailer to the final customer and may well have energy generation interests. In many countries, metering is treated as part of the overall network business and is remunerated as part of the network price control. In this environment, the increased costs of the metering assets have generally been included in the network operators' regulatory asset base.

Where competition has been introduced in metering services (for instance in Great Britain), retailers, and not network operators, are primarily responsible for purchasing metering services: decisions about whether or not to invest in smarter meters for customers' homes are therefore commercial decisions for energy retailers. Regulatory interventions in these types of settings are more difficult to justify. In the state of Victoria (Australia), where the industry is disaggregated, the regulator justified the need for intervention on the basis that benefits were spread across many different decision makers and that prohibitive information and transaction costs exist. The regulator argued that these factors would prevent the market from delivering smarter meters even if they would benefit customers and were cost-effective.

In addition, demand response needs time-of-use pricing (not only smart metering). Regulators should carefully consider their power to mandate/encourage all retailers to offer these pricing arrangements in competitive environments. The case for smart metering and time-of-use pricing might be lessened if some retailers do not give customers this option.

Having identified the policy objectives and acquired a clear vision of the regulatory and commercial framework, the first step in assessing the case for a policy that favours investments in more innovative metering is to carefully weight the **potential costs** against the **expected benefits**.

Any cost analysis will look into the costs of purchasing, installing and operating the meters. In turn, different benefit categories will be explored and quantified depending on the objectives of the policymaker (for instance, increased energy efficiency or increased billing accuracy) and on the point of view taken by the analyst (system wide benefits or business case).

A number of regulatory or governmental agencies have carried out cost-benefit analyses in the past three years.[4] In describing here the main cost and benefit categories to be considered by a regulator, we refer to these valuable experiences. In doing this, we focus on the electricity sector, although the gas sector might be the object of similar studies (water and district heating as well).

In assessing the costs of smart meter deployment, two main cost categories are identified:

- **New costs**: new capital and operation and management (O&M) costs attributable to smart meters;

[4] In particular, we refer to the quantitative analyses conducted in: the province of Ontario, Canada (Ontario Energy Board, 2004), the state of Victoria, Australia (Essential Service Commission, 2004), the Netherlands (Senter Novem, 2005), Great Britain (Ofgem, 2006a), and Ireland (CER, 2007).

- **Stranded costs**: equipment and systems that may be displaced by smart metering;

From a regulator's perspective, special attention must be paid to the issue of **cost recovery**. A third area of the cost analysis deals with the principles that should apply to recovering costs associated with smart metering and the available options.

The range of potential benefits from smart metering can be rather extensive. Regulators should single out their objectives and have a particular focus on those benefits relevant for these. For instance, if peak shaving is the main driver for smart meter deployment, the expected cost savings derived from generation and network investments deferral should be quantified first. Then regulators should identify additional potential benefits in other areas. For instance, enhanced system security, or cost savings in meter reading. It is important to remember that not all benefits can be quantified (or quantified with a given accuracy).

In this document we simply describe potential benefits that have been mentioned in the literature. Regulators will make a decision regarding their own area(s) of interest. For the purpose of clarity, we adopt the following classification of benefits:

- **System benefits**: efficiency gains resulting from consumer responding to price signals provided by the smart meter;
- **Customer benefits:** efficiency gains from demand response, increased competition and other services, security of supply;
- **Network and metering operational savings**: efficiency gains in the operation and development of distribution networks and metering systems;
- **Retailer opportunities**: efficiency gains in the retailing business.

Cost-benefit analyses are complicated by the fact that different stakeholders may benefit from and bear the costs of the introduction of the smart meter technology (the so called 'split-incentives' issue). Cost-benefit analyses should provide an indication of the overall costs and benefits, together with a specification of the expected impact on different market players: consumers, network/metering companies and retailers.

It is worth remembering that a regulatory intervention is justified by the existence of a market failure. In general, a regulatory intervention is needed when the net benefits available from the widespread installation of innovative meters are unlikely to be achieved if the initiative is left to the market.

In the following, we describe the above mentioned costs and benefits in more detail (Section 3.2 and 3.3 respectively). Annex 3 briefly discusses the methodologies used in the available cost-benefit analyses and presents the main findings and implications.

3.2 Costs

3.2.1 New costs

As far as new costs are concerned, cost-benefit analyses include:
- capital costs for meters, communication, associated systems for data handling and installation;
- operating and management costs for reading, service, and re-verification.

Note that costs vary significantly with the type of meter and with the communication infrastructure

(PLC, GSM/GPRS, ADSL or cable). A higher frequency of billing and instalment of display could increase costs.

Capital costs
Capital costs of smart meters are the fundamental cost category in the analysis. Assumptions regarding the technology, the depreciation rate, the timing and scale of the roll-out programme and the lifetime of the metering assets are crucial for the results. Moreover, installation costs differ across countries because of differences in labour costs.

A cost analysis can estimate an average figure, but the cost per meter will vary among utilities because of geography, customer density and customer type.

Operation and management (O&M) costs
Operation and management (O&M) costs of smart meters are an important cost category. Quantifying O&M costs for a new technology is complicated by extremely limited operating experiences. Estimates tend to fall within wide ranges and can vary significantly depending on which technology is adopted and what economies of scale are assumed.

As a general average, the Ontario Energy Board (2004) estimates communication maintenance is about 1% of the installed capital cost of the system. Data storage and management are thought to become a much larger task for distributors/metering companies than presently and the costs may be significant. Presenting smart metering data to the customer is another new cost that might potentially be large, depending on the frequency of updating information and the quality of the presentation.

Estimates can include or exclude new operating costs that are not now being incurred. An example of this is meter re-verification costs. Electronic meters have to be tested more often than electromechanical meters, so the cost of ensuring accuracy will increase with smart metering.

3.2.2 Stranded costs

As far as stranded costs are concerned, it is important to note that most residential and small commercial customers have electromechanical meters that record cumulative energy consumption only. All electromechanical meters will be rendered obsolete by smart meters and there is limited potential to reuse this hardware. Some electronic meters might be adaptable to smart metering systems. However, in general, stranded costs, also excluding the cost of removing and handling the old meters, are expected to be of minor importance.

3.2.3 Cost recovery

In evaluating cost recovery options, the regulatory framework for metering activities becomes extremely relevant.

In Ontario (Canada), where the metering service is carried out by regulated distribution companies, the regulator opted for recovery through distribution rates. A cost reporting and monitoring system was deemed necessary to evaluate cost prudence as the smart metering project was rolled out. This process also needed to consider the appropriate depreciation period for capital costs.

In similar settings, other regulators have proposed to modify the network charge to account for cost recovery. For instance, in Ireland, the distributor responsibilities include the installation of any new meters. This means that the distributor incurs the cost of purchasing and installing the meters. These costs (as approved by CER) would be recovered from all customers through the networks charge. It is important to note that the potential benefits of smart meters are spread across the distributor, the retailers and the customers. CER expects that any benefits accruing to the distributor and the retailers would find their way back to customers either by being included in the calculation of networks charges or by retailers providing the customers with the additional savings when competing to serve that customer.

In Victoria (Australia), customers were not subject to a specific metering charge for basic meters. However, in order to recover the additional costs of smart meters, the Essential Service Commission favoured the introduction of a metering charge to be collected from the retailers of all small consumers. It is important to note that where retailers (rather than distributors) are responsible for the metering installation (i.e. for large consumers), the Essential Service Commission considers the provision of meters a contestable activity. On the one hand, individual retailers and large customers fund their smart meters and, on the other hand do not share the costs of installing smart meters for small customers.

In the Italian electricity sector, the metering tariff is separate from the distribution tariff and both are unique at national level. As from 2007, investments in electronic meters and AMM systems for low voltage customers will be recognised, through equalisation mechanisms, only to DSOs that really invest in these technologies.

3.3 Benefits

3.3.1 System wide benefits

Aside from more accurate metering, one of the most significant benefits for using smart meters could be the shifting of consumption from peak to off-peak periods, making investment in peak-load generation and grid capacity less urgent. For this demand response to be possible, time-of-use tariffs (even hourly tariffs) have to be in place. In other words, it is the combination of time varying tariffs and smart meters that provide consumers with the incentives and the ability to change the way in which they use electricity.

The system-wide benefits resulting from time-of-use tariffs and smart meters are considerable. These include:

- *Efficiency*: Time-of-use tariffs are more efficient, as customers face prices that more accurately reflect the cost of producing electricity. In the long-term, customers responding to these prices can reduce the need for new power stations and investments in the network;
- *System Security*: The use of time-of-use tariffs supports the promotion of system security, as customers are encouraged to reduce demand at times when there is less spare generation available;
- *Market Benefits*: Customers changing the times at which they use electricity can lead to a flatter level of demand in the market. This in turn can reduce the market cost of electricity at peak times which is to the benefit of all customers;
- *Social Equity*: Time-of-use tariffs are better suited to price-sensitive customers. The higher the proportion of a customer’s income is spent on electricity the more they will react to time of day prices as this leads to a reduction in their annual electricity bill;
- *Environmental Protection*: If customer actions lead to a significant reduction in the total amount of electricity used or the level of the peak demand, power stations will run less often, resulting

in reduced emissions. This can include reductions in the amount of carbon used to produce electricity.

The extent to which the benefits listed above are achieved depends upon how customers react to high prices. For example, if customers use less electricity overall and less at peak times, all benefits can be achieved. On the other hand, if customers use less electricity at times of high prices but total consumption remains the same, system security and social aims may be achieved but environmental aims may not be.

Indeed, the main difficulty in estimating these benefits lies in the fact that there is little evidence to assess likely *customer response*. Innovative meters and time-of-use tariffs require changes in consumer behaviour and/or *complementary measures* (e.g. adequate time-of-use tariffs, consumer awareness campaigns) to deliver a reduction in the quantity or timing of load.

Ofgem (2006a) reports that studies on the potential for *customer response* indicate savings could be made of between 5-10%,[5] but it also states that there are a number of problems with some of these studies and the evidence for such high assumed responses is not strong. In addition, studies are not always clear regarding what proportion of the likely load reduction would be derived from better billing information (and therefore could be realised with a simple AMR meter that enabled bills to be based on accurate meter reads) and what would require better in-house consumer display of information on usage and cost (and therefore requiring a more expensive AMM meter). Finally, it is extremely important to consider that any energy saving study, takes place in a specific customer context. This context is a function of the culture, the market rules, the weather and the lifestyle in which the customer lives. This means that regulators cannot simply extrapolate from experience elsewhere to understand how customers will respond in their country.[6]

As far as *complementary measures* are concerned, CER (2007) notes that in order to allow customers to reduce both the total amount of electricity used and the amount used at peak times, a number of conditions need to be satisfied, including:

- The time periods offered by the time-of-use tariff must allow customers to change the way in which they use electricity. For example, a price that reduces at 11 pm or midnight does not give customers much opportunity to change their usage patterns. A tariff with a lower price, say, at 8 pm is more effective;
- The difference between peak and off-peak prices should be considerable because customers are more likely to respond to significant price changes;
- Tariffs with lower standing charges are likely to lead to greater customer response. A standing charge is an amount paid by the customer and does not vary if a customer uses more or less electricity. A variable charge is an amount paid that reduces as customers use less electricity (and vice versa).

---

[5] Ofgem refers to the results of a California state-wide pricing pilot project.

[6] For example, trials that have tested the impact of time on use pricing on peak demand show that, given monetary incentives, customer response does lead to some shifting of peak demand. However, the extent to which this conclusion, which draws largely on Californian experience, is driven solely by flexibility in domestic air conditioning demand is unclear. For a good literature survey on this topic, see Ofgem, 2006a, Appendix 3. Results of Swedish study conducted within the framework of the Market Design Research program, consult the website: www.marketdesign.se.

3.3.2 Consumer benefits

Savings on electricity bills

A more efficient use of energy is indeed an important benefit for consumers. CER (2007) has carried out some desk top analysis and its study suggests that time-of-use tariffs could allow price-responsive customers to achieve savings on their electricity bills. These potential savings, depending on the structure of the tariff, may be sufficiently large to be of real benefit to these customers.

In addition, fuel-poor customers may see a greater benefit than the average customer as they may be more responsive to price differences than the average customer assumed in this study. However, it is not clear if that is at the expense of their comfort.

CER also notes that as production costs are generally higher in the winter than in the summer, Irish customers on time-of-use prices will face higher bills in the winter and lower bills in the summer compared to customers on a flat price. Although these customers may pay a similar amount for their electricity over the year, the within year effect may be of particular concern to those that have a greater requirement to budget. CER is considering whether this concern can be dealt with through payment schemes offered by suppliers.

Similarly, the Ontario Energy Board (2004) notes that consumers who use more peak energy will pay more for the same amount of electricity. This will include schools, hospitals and residential consumers with electric heat. Some of these consumers will take action to lower their bills. Demand-side management programmes could be targeted to vulnerable consumers with poor access to capital to help them act.

Another important source of saving is the potential reduction in prices of services. The Italian regulator believes it is of major importance to transfer the reduced operational cost generated by conducting business remotely to the final customers.

Increased competition among retailers

A second important source of potential benefits for consumers is the increased competition among energy retailers. Retailers can compete to offer customers different electricity prices that apply at different times of day. Similarly, retailers can target certain groups of customers with particular tariffs that would be most economical for their consumption patterns. Such pricing innovation and variety allowed for via smart meters will promote retail competition, to the benefit of customers.

A higher degree of competition is expected also because smart meters will make it easier for consumers to switch between retailers (as meters can be read at any time on request).

More accurate billing

Consumers benefit also from more accurate billing. This is an important benefit as some customers are dissatisfied with estimated bills - particularly at times when the price of electricity changes during a billing period. Customers want to be assured that they are paying the correct price for the correct amount of electricity at the correct time. The decrease in the number of complaints on incorrect bills and the absence of manual readings are additional benefits.

Domotic applications

Another potential benefit for consumers is identified in domotic applications (tuning of the demand of customers[7], optimisation of heating and lighting of the household, security alert, and so on) made available by some categories of smart meter technologies.

Prepayment options
In addition, smart meters can be used by customers who want to pay for electricity in advance of consumption (prepayment option). This approach is similar to that used in the mobile phone market. Customers may prefer this mode of payment for many reasons; e.g. if they experience difficulties paying two-monthly bills, are prone to falling into arrears, or are moving in and out of rented accommodation.

3.3.3 Network and metering operational savings, and retailer opportunities

A number of benefit categories directly concern network and metering operators, as well as retailers.

Network operators
In general, network operators can use area-wide load data to optimise the distribution system, both for planning and operational purposes.

In particular, distribution system management applications include:

- *Remote connections and disconnections*. At present, a network technician needs to visit a customer's premises to disconnect or connect the electricity supply. Smart metering allows this to be carried out remotely by sending a signal to the meter, thus reducing the costs associated with technicians visiting customer premises. Rather than fully disconnecting the electricity, it is also possible to limit the amount that a customer can use;[8]
- *Faster fault location and faster reconnection after outages*. The system operator can locate faults more accurately through the meter data. Thus the network can be operated more efficiently as efforts are focussed on identified problem areas. The same is true for reducing the number and length of customer interruptions. Overall, this helps improve the quality of the electricity supplied to customers;
- *More accurate calculation of network losses and reactive power*. Smart metering can help in reducing technical losses, which also represents a saving to customers. Technical losses are reduced because smart meters can provide accurate information about where the loss occurs, allowing more effective corrective actions to be taken. In addition, smart meters can be used to record power factors or reactive power (kVAR);

---

[7] It requires a communication protocol for the meter that uses, for example, PLC transmission over the narrowband required by CENELEC EN 50065-1 (band *C*, 125 to 140 kHz), the use of broadband transmission methods (1.5 to 30 MHz), again over a power line, or else alternative means of transmission such as optical fiber, coaxial cables or wireless interfaces. At the request of the home/building energy manager, the meter should send information useful for tuning electricity demand. Today, that information could consist of contracted power, instantaneous power withdrawn, price band in effect, and price scheme. In future, it could also include the price signal originating, for example, on the Power Exchange (AEEG, 2006a).

[8] Limiting the amount of electricity that can be used may help customers who are paying off outstanding bills. Customers would continue to have enough power for basic requirements, such as cooking, lighting and heating but would not have sufficient power available to use other appliances until the bill is cleared.

- *More accurate monitoring of continuity of supply and voltage quality*. Smart metering allows a large amount of data to be transferred to the network operator automatically. This will increase the number of available measures on power quality (as of today, in general, not large).

It should be kept in mind that demand response, by reducing the amount of investment required in network reinforcement, creates significant potential savings in terms of capital expenditure.

It is important to remember, once again, that any network cost savings should be passed back to consumers in the form of lower network charges.

Metering operators

The metering operator can avoid manual meter reading costs of both cyclical and final reads. Metering operators read their meters, on average, once or twice per year. Innovative meters would enable suppliers to read them as frequently as they wanted at lower cost.[9]

Smart meters provide large volumes of accurate data that are valuable for different stakeholders engaged in marketing, load profiling, energy management (retailers), system modelling and preventive maintenance (network operators). On this topic, see also chapter 3.

Retailers

Retailers can use smart metering data to design pricing options and to offer energy management services that customers might find attractive.

In addition, smart metering permits a wide range of cost savings/benefits:

- Potential savings in operational costs derived from the reduction in *costs of managing queries* regarding estimated bills or of re-issuing bills;
- Similarly, meter and billing enquiries generate a certain volume of *calls to customer contact centres* and these are expected to be reduced;
- *Reduced theft* from more sophisticated tampering mechanisms is another potential benefit;[10]
- Smart metering is likely to result in *reduced bad debt costs*. Smart metering allows the remote de-energisation and re-energisation of customers and also allows load limiting at specific connection points. This allows retailers to limit bad debts;
- Other cost savings derive from smart meter applications that allow *remote switching between different tariff schemes*, including credit and prepayment;
- A number of meter related services are performed by the distributor on behalf of retailers. These services include connections and disconnections, special meter reads and meter checking. Smart metering allows these services to be performed remotely without incurring the cost of sending a network crew to the premises. Part of these *transactions costs* can be saved;[11]

---

[9] CER (2007) estimates that 95% of meter reading costs can be saved if all meters are replaced by smart ones.

[10] The cost of theft is estimated by Ofgem (2006a) at about £100m per year (UK). This amount is effectively recouped from all customers through their bills. Ofgem estimates that tampering alarms and more frequent meter reads would combine to reduce this level of theft by 25%.

[11] CER (2007) estimates that 75% of these transaction costs can be saved (Ireland).

- In a number of countries, an important element of the electricity market is the payment of the *balancing power* (consumptions above or below the amount declared at gate closure). To date, retailers have settled balancing payments monthly, based on load profiles for their small and medium consumers. A net payment, based on the annual meter reading, was received only once a year. Smart meters will enable retailers to bill these consumers monthly, using actual data, instead of estimated consumptions.

Third parties
In general terms, smart meters have a positive effect on data accessibility from authorised third parties. Among them, it is worth mentioning ESCOs which can use data for energy efficiency and for demand side management purposes (e.g.: domotics and building automation).

4 METERING MANAGEMENT

It is crucial that the party responsible for collecting and administrating meter data (independent meter service provider or grid operator) makes data accessible to all other authorised market players in a non-discriminatory way. If the customer is expected to react to price signals, actual demand etc...then easy access to meter data, for instance on a display, is needed.

To date, there are a number of smart metering technologies, and the sector is in constant evolution. A possible classification of innovative metering technologies has been presented in the introduction of this document. It includes the main groups with different functionalities: automated meter reading (AMR) and automated meter management (AMM).

4.1 Remote meter management

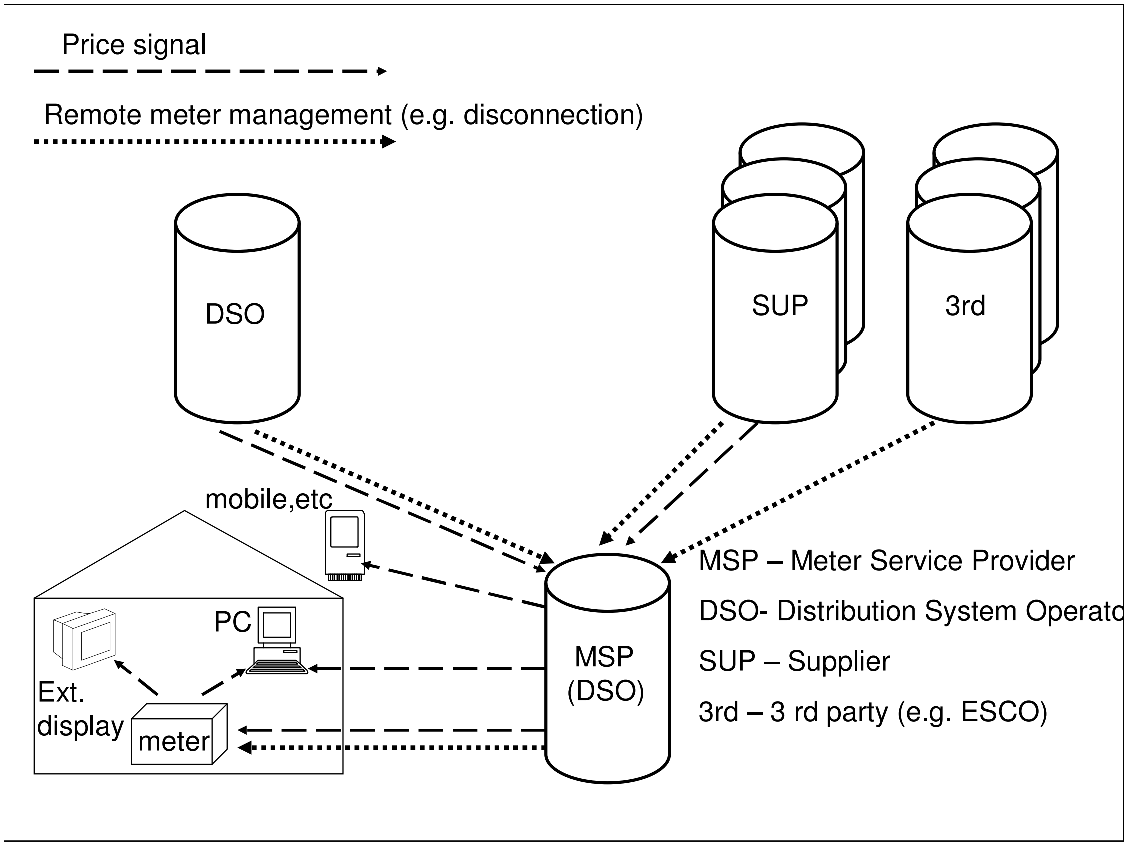
Smart metering is not only about collecting information from a meter, but also about sending information such as price signals to the consumer or producer. AMM systems are therefore equipped with bi-directional communication, which allows for various remote meter management functions. The most important are the following:

- Interval meter data (load profile measurement);
- Remote meter reading, data processing to market players;
- Remote meter management (reduction, disconnection, demand management, etc...);
- Measurement of consumption and generation by distributed units;
- Remote meter parameterisation such as tariff structures, contractual power, meter interval, etc.
- Remote message transfer from market players to the customer (consumer/generator) as e.g. price signals;
- Information display on the meter and/or communication port for external display, e.g. on cell phone, PC or a wireless display in house;
- Main communication port (e.g. GPRS, GSM, PLC, etc) ;
- Power quality measurement (incl. Continuity of supply and voltage quality);
- Communication port for collection and transmission of other metered data (e.g. gas, heat).

Depending on the organisation of the metering market, the implementation of remote meter management in a non-discriminatory way has to be ensured.

Regardless the type of classification, from an architectural point of view solutions currently in use or proposed by manufacturers of smart metering systems are based on (lower part of graph 3.1):

- Power Line Carrier communication: this type of system requires the installation of data concentrators in MV/LV substations of the electricity distribution networks, which communicate with smart meters by using the low-voltage distribution grid as a means of communication and with the control centre through public telecommunications systems (GSM, GPRS, PSTN, ADSL, optical fibre, etc...);
- Access to the public telecommunications system directly from the meter. Generally, this type of system does not require intermediate equipment like data concentrators;
- The use of radio frequency telecommunications systems between the smart meters and the data concentrators, often on several hierarchical levels, and of public telecommunications systems between the highest-level concentrators and the control centre.



Graph 3.1 - Remote meter management & price signal

4.2 Meter data

One of the main drivers for the introduction of smart meters is the need to improve the quality of market data and particularly the meter values for all stakeholders in the market. The provision of detailed and frequent data from smart meters to market actors is beneficial in various ways: it enables the implementation of energy efficiency measures, enhances monitoring and management of grids, helps optimise and automate market processes and improves service levels of suppliers and DSOs. Smart meters are not only a valuable tool to achieve a fully competitive energy market by introducing full transparency in wholesale and retail markets but can also improve security of supply by providing detailed data on grid condition and power quality.

It is crucial that the party responsible for collecting and administrating meter data (independent meter service provider or grid operator) makes data accessible to all other authorised market players in a non-discriminatory way.

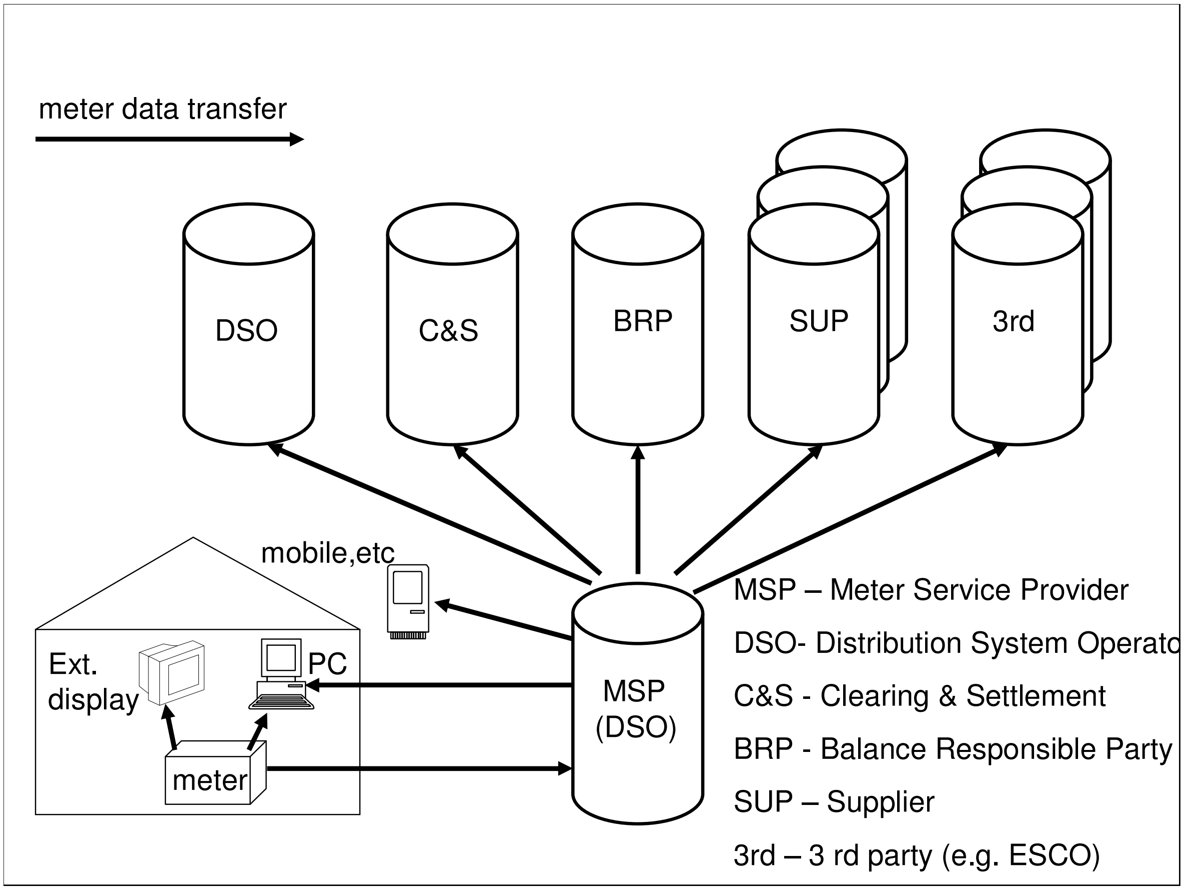
Meter data has be provided not only to the market and its players, but must also be accessible on demand on-site for the grid user, be it a consumer or a producer. This requires in general two independent communication ports, one for data used off-site (e.g. supplier, grid operator, energy service provider) and one for an external display.

4.2.1 Meter data management

There are various market actors who have different data requirements. The following table and graph give an overview of the actors and their data needs:

Parties involved	Use of data
DSO	Grid operation, billing, forecast, loss detection, customer service, process automation, customer switching, power quality monitoring
Supplier	Billing, Tendering, Forecast, Trading
Generation (distributed)	Plant operation
Customer	Decision making
Third Party (ESCOs)	Energy efficiency measures, Input to home and building automation
Government Body or Regulators	Power quality monitoring, statistics

Table 3.1 – Actors and their data needs



Graph 3.2 - Meter data transfer

An important issue with regard to meter data availability is the organisational and technical set-up of meter data services in an energy market.

Market processes such as customer switching, clearing & settlement, billing, scheduling, etc… rely on non-discriminatory and efficient data provision to all market actors. Due to historic reasons, in most countries metering has traditionally been part of grid operation. Incomplete unbundling in most countries results in an availability of market data to third parties (including second tier suppliers), which is not satisfactory. One way to ensure non-discriminatory data access is the introduction of an independent meter service provider, responsible for meter data collection and meter data management.

Aside from the organisational nature of meter data service, the way data is actually exchanged or can be accessed by market parties is important. Currently, meter data is exchanged using standardised data formats (e.g. EDIFACT standard) in most European countries, by request or by a fixed time schedule from the meter data responsible to the various market players. To guarantee an efficient and non-discriminatory on-line access to (smart) meter data, modern IT – systems, such as web-based electronic data storage facilities appear sensible. 24h access to meter data for authorised third parties must be ensured.

Due to the sensibility of detailed meter data, only the customer and authorised third parties should be able to access meter data.

4.2.2 Display

Smart meters do not only give market players such as suppliers and grid operators the information they need to efficiently fulfil their roles in the market, but the customers should also be provided with on demand information on their energy usage and price information in order to be able to make sound purchase decisions or change their consumption pattern.

This information could either be displayed on the meter itself or, if the meter is inaccessible, it could be shown on a separate display or sent via SMS to a cell phone. Information on the display should include, but is not limited to the following items:

- actual demand
- actual price/kWh
- actual tariff
- total consumption per time band (e.g. peak and off peak).

Apart from having on demand information on price and usage on display, the consumer should also have access to usage and price information for the previous day e.g. via on-line data access. This data could however be provided via web portals. It is expected that a continued development of display solutions will give customers better access to price signals and information about actual demand.

5 TECHNICAL ASPECTS OF SMART METERING SYSTEMS

AMM systems should have functional and performance characteristics that offer the same minimum options to all customers (household, non-household), whether they remain under a customer protection scheme or opt to switch to a new retailer.

Minimum requirements should apply at system level rather than equipment level, to render them independent from the architectures used by operators or recommended by AMM system vendors, thereby preventing the rejection of solutions whose architectures or philosophies may be different from those currently used but which may be just as efficient.

The regulators should encourage the use of standards, e.g. communication protocols.

It already has been underlined in chapter 3 that the sector of smart meters and AMM systems is in constant evolution, there are a number of smart metering technologies on the market and AMM system architecture can vary a lot.

When sizing the system and defining its application profile, the metering operator could undervalue or neglect some important aspects. A first possible criticality comes from the fact that, independent of the model of meters, the intermediate equipments and the control centres, the metering operator has major decisions to make at its own discretion, such as the choice and sizing of the public telecommunications system, the definition of the hardware and software architecture of the control centre, and one of the most important decisions of all, the functional and application profile of the AMM system[12]. These decisions can lead the operator to undersise the system, especially from the communication point of view, to define an unsatisfactory functional and application profile and to create potential discrimination among customers.

A second possible criticality is related to the fact that the performance of an AMM system depends significantly on the number of smart meters to be remotely managed, in other words the same model of system can react in different ways when making a transaction towards a part or the totality of meters.

As stated in the introductory part of this document, smart metering deployment is not an objective in itself but rather a means to reach different objectives. The use of smart metering systems, therefore, should entail the pursuance of objectives (e.g.: development of competition in the supply of electricity, operators' opex reduction, transferring more benefits to customers, peak demand reduction, increase security of supply, etc..). As already described in the previous chapters, these objectives can vary from country to country according to the different regulatory frameworks and visions. A general principle the regulator can adopt is to require operators to use smart metering systems with characteristics which do not generate obstacles for the given objectives. At the same time the pursuance of the objectives should not create barriers to

[12] Date collected by the Italian Regulator in early 2006 highlighted that the functions enabled by the various types of smart meters and AMM systems, including interval metering, marketed in Europe by major manufacturers are similar to one another, with differences depending essentially on the specific uses typical of the countries in which the equipment is used or has been subject to more detailed specifications (AEEG, 2006a).

innovation and technological progress.

In defining minimum requirements for a competitive market, the regulator may want to adopt the following:

- AMM systems should have functional and performance characteristics that offer the same minimum options to all customers (household, non-household), whether they remain under a customer protection scheme or opt to switch to a new retailer;
- Minimum requirements should apply at system level rather than equipment level, to render them independent from the architectures used by operators or recommended by AMM system vendors, thereby preventing the rejection of solutions whose architectures or philosophies may be different from those currently used but which may be just as efficient;
- Smart metering systems should be qualified by performance levels rather than intervention in their architecture or in the size of the system or any of its parts. This criterion seems to be more important where there isn't any regulation of commercial quality in force. In fact, the presence of performance requirements can balance the absence of guaranteed standards. Furthermore, this criteria should allow the Regulator to not interfere with the decisions made by operators or recommended by system vendors and to prevent holding back or limiting technological progress;
- Meter interoperability is a fundamental pre-requisite (see chapter on Recommendations).

Annex 2 reports on the experiences of Italy and Ontario in defining minimum requirements and the UK decision aimed at working with the industry in order to agree common standards to provide for interoperability of smart meters.

6 REGULATORY POLICIES

Based on the information gathered, it can be stated that countries where regulators can determine the framework conditions for smart meters are more likely to promote full roll-out of smart metering.

As the legal framework and the powers of the regulator differ in Member States, the actual implementation of smart meter policies will differ from country to country.

In a regulated meter market, the regulator could accelerate the development of smart meters by obligatory roll-out or financial incentives. In a liberalised meter market, the policy options are more limited. However, independent of the market organisation, the regulator could set minimum functional requirements for meters installed in order to ensure a certain standard of data quality and functionality within a certain area or country. **ERGEG would recommend that regulators introduce such minimum requirements.**

As the survey on the status of smart metering shows, only a limited number of countries have smart meter policies in place. However a growing number of Member States are in the process of drafting policies or at least planning to do so in the (near) future.

This somewhat slow development may also be caused by the fact that in most countries smart meter policy would require new legislation by parliament, which takes more lead time. Another reason is that only recently has there been a significant cost reduction of smart meter technologies. At the same time, the quality of meter data from AMR and AMM technologies has improved.

In general, it can be stated that countries where regulators can determine the framework conditions for smart meters are more likely to promote full roll-out of smart metering.

As the legal framework and the powers of the regulator differ in Member States, the actual implementation of smart meter policies will differ from country to country.

As outlined in this document, there are various market participants who can profit from the implementation of smart meters. Not only can the grid operator streamline his processes, but suppliers, energy service companies and customers will benefit from the availability of data and the possibility to manage consumption. As the benefits of smart meters are spread between all market stakeholders, but costs are only incurred by the grid operator or meter service provider, these have in general only limited incentives to invest in metering systems.

In principle, there are two metering market models established in EU Member States. Firstly there is the regulated metering market model, where the grid operator or a regulated meter service provider have the monopoly of providing meter services.

There is also the liberalised metering market model, where either the customer or supplier can mandate an independent (from grid operation) meter service provider, who is responsible for meter services. In this case, meter service is open to competition.

In the following section, the regulatory policy options for both models are discussed.

6.1 Regulated meter market

Currently and with few exceptions, metering services in Europe are a monopoly business carried out by grid operators and therefore paid by the final customer by regulated metering tariffs.

It is therefore a main task of energy regulatory authorities to decide whether the additional costs for smart metering for customers are justified by the benefits. The following policies can either be introduced individually or in combination with other policies.

Obligatory roll-out of smart meters

This policy requires the regulated meter service responsible party to install and operate smart meters within their monopoly area. Within this policy, the authority defines one or more of the following aspects:

- Scope of meters affected (customer group, demand threshold, etc)
- Timeframe within which the meters have to be replaced by new smart meters
- Basic functionality of smart meters

Limiting the deployment of smart meters to certain customer groups or gradual replacement of old meters by smart meters tends to discriminate those customers being last to get smart meters installed. For practical reasons, it seems difficult to avoid any discrimination of certain customers within a cost efficient roll out of smart metering.

Financial incentive

In a regulated meter market, metering tariffs are set by the regulator or they are part of the grid tariffs. By allowing for higher meter tariffs for smart meters, incentives can be given for the installation of these meters. Investments in meter technologies should in principle be treated like any other investment made by the DSO or the regulated meter operator. However, the issue of split incentives could be an argument for some additional financial measures to the ordinary regulation.

In general, those companies responsible for metering will only consider whether it is profitable for the company to invest in smart meters. Regulators on the other hand, have a responsibility to review the socio-economics of smart metering to see if the investment is beneficial for society as a whole. Thus, in order to get the metering operator to make the investments that realise the full socio-economic benefits of smart metering, some financial incentives could be necessary.

6.2 Liberalised meter market

When opening the meter market to competition, it is up to the consumer or the supplier to decide on the meter type to be installed. Metering services are to be carried out by an unregulated third party. This results in having an inhomogeneous meter infrastructure with different levels of functionalities within grid areas. It is therefore necessary to provide for certain standardisation and interoperability of the meters installed.

On a more general level, regulatory policies could also help remove barriers to smart meters such as more frequent calibration periods for electronic meters, assistance in meter data communication standardisation, etc...

Some policies and measures will be possible in both a regulated and a liberalised meter market:

Introduce minimum functional requirements

The minimum criteria for meters installed such as functionalities, technical standards will still allow the meter responsible party to choose freely a meter type, as long as it meets the given criteria.

These minimum criteria ensure a certain standard of data quality and functionality within a certain area or country. The regulated meter tariffs should reflect the level of functionality. In countries where there are no separate meter tariffs this will be reflected in the grid tariffs.

It is important to underline that these requirements should secure non-discrimination of suppliers, customers or third parties (e.g. ESCOs).

Require more frequent meter reads or bills based on actual consumption

This approach puts an obligation on the meter responsible to ensure frequent (daily, monthly) data retrieval and access. As frequent meter reads cannot be carried out manually in an economic way, it indirectly forces the meter responsible to install at least AMR (automated meter reading) systems. However, this approach might fall short when it comes to the benefit from additional functionalities of smart meters such as remote tariff change, transferring price signals to the customer, etc…

7 RECOMMENDATIONS

This document “Smart Metering with a focus on electricity” examines the issue of smart metering from a regulator’s perspective. Although individual national regulators’ tasks and responsibilities vary from country to country and metering can be either regulated or open to competition, some key factors have been identified.

Depending on existing or future national legal requirements on smart metering and meter regulation, there are several ways to introduce and organise smart metering. The smart meter as interface between customer and other market participants plays a key role in all market processes and therefore impacts on the overall functioning of an energy market. It is therefore vital for regulators to consider the full picture and ensure that the energy market as a whole and all its participants benefit from its various functionalities. The following main recommendations have been drawn from the analysis of existing or planned smart metering schemes and discussions carried out in the past months:

Costs and benefits
The introduction of large-scale smart metering infrastructures for consumption by small-scale customers needs to be carefully assessed in terms of costs and benefits. There are many factors that can influence the result of a cost-benefit analysis, among which:

- the metering regulatory framework;
- the metering organisation model;
- the choice of a given technology;
- the conjectured roll-out time-period;
- other ex-ante assumptions (financial assumptions, life of the metering assets, etc.).

It is essential that regulators, once the scenario has been drawn, clearly identify what are the costs, potential benefits, avoided investments, etc… deriving from such an initiative and quantify them as much as possible. Furthermore, regulators should be conscious of who faces the costs and who gets the benefits in each phase of the implementation plan; taking into account the model for income regulation of DSOs and tariffs is essential when analyzing this.

Access to meter data
The meter service responsible party plays a key role in energy markets. Its services include meter data services such as meter reading, data provision and additional smart meter functionalities such as remote disconnection and tariff change. Some or all meter services can be provided by one or several parties. These parties can either be regulated monopolies (grid operators) or independent meter service providers. Whatever metering model is in place, it is essential to ensure non-discriminatory access to meter data and/or smart meter functionalities.

Meter data access for authorised third party has to be guaranteed, either by establishing an independent meter service provider, third party accessible data platforms, complete IT system related unbundling of grid and supply business or a combination of these measures. (How the cost of such system should be dealt).

In addition to conventional meters, whose only purpose was to meter consumption or generation, smart meters have a number of additional functionalities. These range from remote demand reduction or disconnection, power quality measurement, remote tariff change to message transfer from market players to customers (e.g. price signals). Depending on the type of functionality itself and the organisation of metering (see above), the non-discriminatory use of these additional functions by the various market players has to be governed carefully. E.g. remote disconnection of a customer can be triggered either by the grid operator or a supplier or even an authorised third party, which market rules should ensure.

Market model
Current market models are based on the deployment of traditional manually read meters for households. Furthermore, are all meter data dependent processes such as supplier switching, standard load profiling, clearing & settlement and scheduling are based on this technology. In contrast, smart meter systems can provide for interval on demand data for every customer. Introduction of smart meters could therefore result in the requirement for new market processes. E.g. meter data accessibility (via data platform) for all parties can lead to an automated supplier switching process, without any manual meter read or meter data transmission necessary, making conventional switching processes redundant. The use of standardised load profiles for small customers in the clearing & settlement process could be replaced or improved on by individual customer load profiles or/and more frequent meter reads.

Minimum functionality
Smart meters are a general term used for meter systems providing additional functionalities. For detailed information on smart meters types such as AMR, AMM, etc… see the glossary of this document. Each smart meter functionality has additional costs but also one or several benefits associated with it. It is therefore necessary, when considering the deployment of smart meters, to analyse the functionalities and the impact they have on all market participants involved. Particularly in a regulated meter environment, the meter tariff set will impact on the functionalities a smart meter provides for. After carefully assessing the relevant costs and benefits, it is important to define certain minimum smart meter functionality. In order to allow for economic optimal solution and technical innovation, it should be left to the individual meter service provider to decide on the technical solution to fulfil the required functionality. The following main functionalities should be carefully considered and taken into account each Member State's legal and institutional settings.

- Remote meter reading
- Load profile data
- On demand meter data access for customer
- On demand meter data access for 3rd party
- Provision of variable time-of-use tariffs (time bands)
- Remote meter management
- Remote demand reduction and connection/disconnection
- Price signal to customer

Standardisation
Depending on the number of roles and technical functionality, there will be various communication interfaces. Standards for the following interfaces partly have been defined and partly still have to be defined.

Due to relatively new developments in smart metering, there are several tools in use. In order to ensure interoperability between different players and different applications the use of standards as far as they are available is recommended.

Meters and control centres
This interface regards standard communication protocols between meters and control centres (via

data concentrators if present in the systems architecture). This interface seems to be more important for a liberalised market, where providing for a minimum level of standardisation makes meters more interchangeable and helps AMM system components work together more smoothly. This should boost competition in the meter market and possibly reduce prices to the consumer's advantage. But standardisation is essential also in a regulated market as it can avoid the establishment of possible local monopolies of meter vendors, bringing the same advantages as above.

In order to render the devices of different manufacturers compatible from the communication point of view, they must adopt the same standards for the following layers of the communication architecture:

- Physical layer (e.g.: type of transmission channel like GSM, ADSL, PLC, etc, - for PLC also the frequencies and the type of modulation);
- Data link layer (e.g.: addressing and reporting mechanism, error control, repeating scheme for PLC, etc);
- Application layer (e.g.: network management, detection of new stations, etc).

Furthermore. in order to be interoperable, devices must use the same data models and the same objects (e.g.: reading the daily consumption register, reading the hourly load profile, programming the tariff scheme, programming the contractual power, synchronizing the calendar/clock, etc…).

In addition, meter interoperability is a fundamental pre-requisite that should ensure:

- customers with smart meters can switch supplier without necessarily having to change their meter;
- suppliers or metering companies will not face technical barriers to interacting with smart meters installed by their competitors;
- full competition in the market of meters that can lead to a decrease of their prices, for the benefit of customers.

EDIFACT standard
EDIFACT (Electronic Data Interchange For Administration, Commerce, and Transport) is the international EDI (Electronic Data Interchange) standard developed under the United Nations. It has been adopted by the International Organisation for Standardisation (ISO) as ISO standard ISO 9735. The EDIFACT standard:

- Provides a set of syntax rules to structure data.
- Provides an interactive exchange protocol (I-EDI)
- Provides standard messages (allows multi-country and multi-industry exchange)

Communication with building automation
This interface could be very useful for tuning the demand of residential and small non-residential consumers. It requires a communication protocol for the meter that uses, for example, PLC transmission or other alternative transmission media like optical fibre, coaxial cables or wireless interfaces towards the home/building energy manager system. When this is requested, the meter should send information useful for tuning electricity demand.

Today, that information could consist of contracted power, instantaneous power withdrawal, price band in effect, and price scheme. In the future, it could also include the price signal originating, for example, on the Power Exchange. Currently, some communication protocols have been developed by vendors of appliances or automated devices for buildings, but a standard providing a data exchange between meters and home/building energy managers seems to be unavailable,. Standardisation bodies are working in order to develop this standard.

Communication with external display

Standards for this type of application seem to be unavailable for the direct communication meter-external display. Some meter manufacturers have developed customer interfaces using proprietary communication protocols and mainly PLC as a transmission medium. But other transmission media, like radio frequency, optical fibres, etc... can be used. Where the external display is constituted by a standard communication device (e.g.: cell phone), the standardisation is required at control centre level (e.g.: EDIFACT or standards required by bodies of the Telecommunication standardisation sector) and not at meter level.

Summing up, ERGEG recognises that the use of smart metering has to be analysed within a national context, taking into account the characteristics of the national market and the regulatory model for metering. Notwithstanding market models, ERGEG would recommend that functional requirements for smart meters are established in order to guarantee minimum services for customers and reduce investment risk for meter operators. The use of technical standards both within and between countries should be promoted and third party access to metering data should be established.

A further exploration of this issue could be undertaken in the emerging collaboration of CEER/ERGEG with CENELEC (The Committee for Electrotechnical Standardisation) and DG Enterprise.

REFERENCES

AEEG (2006a). *Recommendations for the use of electronic meters and AMM systems with low voltage customers.* Consultation document, 26/07/2006. Available from (English section): www.autorita.energia.it.

AEEG (2006b). *Obligations for the installation of electronic meters for low voltage withdrawal points*. Decision 292/06. Annex A. Available from (English section): www.autorita.energia.it.

AEEG (2006c). *Disposizioni in materia di tariffe per i servizi di misura e di acquisto e vendita dell'energia elettrica destinata al mercato vincolato e in materia di opzioni ulteriori domestiche per l'anno 2007. Modificazioni del Testo integrato approvato con deliberazione dell'Autorità 30 gennaio 2004, n. 5/04.* Decision 275/06. Available from: www.autorita.energia.it.

AEEG (2007d). *Telemisura dei clienti finali allacciati alle reti di distribuzione del gas naturale.* Consultation document no. 27/07 of 9 July 2007. (AMR roll out for customers connected to natural gas distribution networks)Available from: www.autorita.energia.it. (English section)

CER (2007). *Demand side management and smart metering*. Consultation paper, 13th March 2007. Available from: www.cer.ie.

Commission of the European Communities (2007). *Communication from the Commission to the Council and the European parliament. Prospects for internal gas and electricity market*. Brussels, January 10 2007.

CRE (2006). *Comparatif international des systèmes de télé-relève ou de télégestion et étude technico-économique visant à évaluer les conditions d'une migration du parc actuel de compteurs*. 8th March 2007.

EC (2005). Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment. Available from:
http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_033/l_03320060204en00220027.pdf.

EC (2006). Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC. Available from:
http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_114/l_11420060427en00640085.pdf.

EC and CPUC (2005). *Energy action plan II – Implementation roadmap for energy policies*. Available from: http://www.cpuc.ca.gov or from: http://www.energy.ca.gov.

E-Control (2007), *Einführung innovativer Messysteme in Österreich- Konsultationspapier der Energie-Control GmbH* April 2007 (Introduction of smart meter systems in Austria – Public consultation paper E-Control GmbH, April 2007). Available from: www.e-control.at

Energy Regulatory Office (2006). *Perspectives of installation of automated meter management (AMM) in the Czech Republic.* Written communication for purposes of ERGEG status review study.

EPRI (2006). *What advanced metering and intelligent infrastructure can do*. PowerPoint presentation of the Power Delivery and Markets to NARUC Annual Convention. Available from the authors upon request.

Essential Services Commission, (2004). *Interval meter rollout. Mandatory rollout of interval meters for electricity consumers.* Draft Decision. Available from: http://www.esc.vic.gov.au/.

Frontier Economics (2006). *Smart metering – maximising the benefit.* PowerPoint presentation to DTe. Available from the authors upon request.

Ofgem (2006a). *Domestic Meter Innovation*. Consultation Document 20/06. Available from: www.ofgem.gov.uk.

Ofgem (2006b). *Domestic Metering Innovation - Next steps*. Decision Document 107/06. Available from: www.ofgem.gov.uk.

NVE (2007). *Policy recommendations on smart metering to the Ministry of Petroleum and Energy*, available at www.nve.no.

Ontario Energy Board, (2004). *Smart meter implementation plan*. Draft Report of the Board for Comments. Available from: http://www.oeb.gov.on.ca/.

Rosenzweig, M., (2003). *Market Power and Demand Responsiveness: Letting Customers Protect Themselves*. The Electricity Journal, 16 (4), 11-23.

Senter Novem (2005). *Implementing smart metering infrastructure at small-scale customers.* Recommendation. Available from: http://www.ez.nl/.

VTT (2006). *Automatic meter reading status of small electricity consumers and opportunities offered by AMR*. Final report. Available (in Finnish) from: http://www.vtt.fi/.

8 GLOSSARY

AMM
Automated Meter Management. Technologies which allow a two-way communication between the meter and the data collector. In comparison to AMR technologies, AMM technologies allow some additional features such as for example:

- to disconnect remotely users (in an emergency or when they leave or move to a new home) or to remotely set a limit on the amount of power or energy to be used;
- to allow energy prices to be remotely changed and to make information on tariff data on demand available in the customer's house;
- to allow contractual power to be remotely changed;
- in general to improve customer service.

AMR
Automated Meter Reading. Technologies allowing a one-way communication from the meter to the data collector and enabling a meter to be read remotely through a communication system without the costs of manual meter reading. Each meter must be able to reliably and securely communicate the information collected to some central location. Many forms of communication exist and have been explored, like fixed telephone line, SMS (text) messaging, GSM, GPRS, the Internet, radio and power line carrier (PLC). In comparison with traditional meters, AMR entails several improvements:

- to eliminate problems from inaccurate billings, based on estimates;
- to make switching process easier, as accurate meter readings are available when a customer changes supplier;
- to detect frauds, by communicating that a meter has been tampered with.

Domotics
Application of computer and robot technologies to domestic appliances. It is a portmanteau word formed from domus (Latin, meaning house) and robotics.

ESCO
An Energy Service COmpany (ESCO) is a business that provides energy management services to an energy user. Services provided by an ESCO may be contracted through an Energy Services Agreement (e.g., an Energy Performance Contract) or through specific energy management solutions identified by the ESCO that provides maximum return on investment for the customer.

GPRS
General Packet Radio Service. It is a Mobile Data Service available to users of GSM and IS-136 mobile phones. GPRS data transfer is typically charged per megabyte of transferred data, while data communication via traditional circuit switching is billed per minute of connection time, independent of whether the user has actually transferred data or has been in an idle state. GPRS can be utilised for services such as WAP access, SMS and MMS, but also for Internet communication services such as email and web access.

GSM
Global System for Mobile communications. It is the most popular standard for mobile phones in the world. GSM is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity. GSM networks operate in four different frequency ranges. Most

GSM networks operate in the 900 MHz or 1800 MHz bands. Some countries in the Americas (including the United States and Canada) use the 850 MHz and 1900 MHz bands because the 900 and 1800 MHz frequency bands were already allocated. The rarer 400 and 450 MHz frequency bands are assigned in some countries, notably Scandinavia, where these frequencies were previously used for first-generation systems.

Interval metering
Technologies with AMM allow not only a two-way communication but also store more information (e.g. one or half or ¼ hourly data) which can be collected and sent to the data collector. These smart meters allow suppliers to introduce different prices for consumption based on the time of day, so that customers may be encouraged to move some of their use away from periods of peak demand when electricity is more expensive.

PLC
Power line communication (or carrier). Systems for using power distribution wires for data transmission. It can include broadband over power lines with data rates sometimes above 1 Mbps and narrowband over power lines with much lower data rates. Traditionally electrical utilities use low-speed power-line carrier circuits for metered data transmission, control of substations, protection of high-voltage transmission lines and domotic purposes.

Smart meter
This is a general definition for an electronic device that can measure the consumption of energy (electricity or gas) adding more information than a conventional meter (price schemes, interval data, quality of supply, etc...), and that can transmit data using a form of electronic communication. Similar meters, usually referred to as 'time-of-use' or 'interval' meters, have existed for years, but smart meters usually involve a different technology mix such as automated meter reading, automated meter management and a different application mix such as domotics, value-added services, etc...

ANNEX 1 - FINDINGS OF THE STATUS REVIEW ON SMART METERING

In 2006, ERGEG conducted a status review on smart metering based on a questionnaire addressed to ERGEG energy regulators in Spring 2006. The survey explored the following issues:

- legal framework of metering activities;
- public policies aimed at fostering the adoption of 'smart' meters;
- current status and future development of installations;
- economic issues related to meters and 'smart' meters;
- functionalities of 'smart' meters and applications in use today.

Concerning both the current ***legal framework*** and existing public policies aimed at deploying innovative metering technologies, it emerged that the prevailing regime for metering services in both electricity and gas sectors is still a non-unbundled one (see Table A1.1). In fact, the metering service has been traditionally carried out by the distribution network operator, intended also as the only energy supplier for household consumers. On the other hand, it also emerged that a small number of countries have indeed liberalised the service or have introduced some form of unbundling. With the opening of the supply service to free competition, the metering service is being viewed as an activity that can be carried out also by other subjects, such as the supplier or an independent specialised company.

Legal status	Electricity	Gas
Liberalised	DE, UK	DE, NL, UK
Unbundled	BE (2), CZ, PT	BE (3), IT, SI, SK
Not unbundled	AT, CY, DK, FI, GR, HU, IT, LT, LV, NO, PL, SI, SE, SK, TR	AT, CZ, DK, ES, HU, LV, PL, SE, TR
None of the above	BE (1), ES, FR, LU	BE (1), FR, LU

Table A1.1 – Legal status of the metering service

The metering device is, in most cases, property of the distribution network operator (DNO). However, the DNO is not the only possible owner of the meter. Different scenarios are found, as shown in Table A1.2.

Ownership	Electricity	Gas
DNO	BE (1), DE, ES, IT, LT, LU, LV, NO, PL, PT, SE, SK, UK	BE (1), CZ, DE, ES, IT, LU, PL, SI, SE, SK, UK
Supplier	ES, UK	UK
Metering company	DE, UK	DE
Municipality	FR	CZ
Consumer	ES, PL, SI, UK	CZ, PL, SI, ES, UK
Ownership not regulated	DK	DK, LV
None of the above	BE (1), GR	-

Table A1.2 – Smart meters ownership

Smart meters are generally operated by the DNO, as illustrated in Table A1.3, both for the electricity and the gas sectors. In some cases, however, other subjects can assume the responsibility of one or several operation activities. The questionnaire covered four main functions: installation, maintenance, meter reading and data management.

Operation	Electricity	Gas
DNO		
Installation	AT, BE (1), DE, ES, FI, FR, IT, LT, LU, LV, NO, PL, PT, SI, SE, SK, TR	AT, BE (2), CZ, DE, IT, LU, NL, PL, SI, SE, SK, UK
Maintenance	AT, BE (1), DE, ES, FI, FR, IT, LT, LU, LV, NO, PL, PT, SI, SE, SK, TR	AT, BE (2), CZ, DE, IT, LU, NL, PL, SI. SE, SK, UK
Meter reading	AT, BE (1), DE, DK, ES, FI, FR, GR, IT, LT, LU, LV, NO, PL, PT, SI, SE, SK, TR	AT, BE (2), CZ, DE, DK, IT, LU, PL, SI, SE, SK
Data management	AT, BE (1), DE, ES, FI, FR, GR, IT, LT, LU, LV, NO, PL, PT, SI, SE, SK, TR	AT, BE (2), CZ, DE, IT, LU, PL, SI, SE, SK
SUPPLIER	Installation: TR, UK Maintenance: TR, UK Meter reading: TR, UK Data management: FR, UK	Installation: UK Maintenance: UK Meter reading: IT, UK Data management: BE (1), NL, UK
METERING COMPANY	Installation: DE Maintenance: DE	Installation: DE Maintenance: DE Meter reading: BE (1), NL Data management: BE (1)
CONSUMER	Installation: FI, FR, PL, TR, UK Maintenance: ES, FI, PL, TR, UK	Installation: PL Maintenance: PL
NOT REGULATED	Installation: BE (1), DK Maintenance: BE (1), DK Meter reading: BE (1) Data management: BE (1), DK	Installation: BE (1), DK, ES, LV Maintenance: BE (1), DK, ES, LV Meter reading: BE (1), ES, LV Data management: BE (1), DK, ES, LV
NONE OF THE ABOVE	Installation: GR Maintenance: GR	

Table A1.3 – Smart meters operation

It is important to note that the authorities responsible for introducing changes in the legal framework are, for most countries, the government and/or the energy regulators.

Another important aspect in the legal framework is access to consumption data by third parties. The issue is particularly relevant when switching behaviour is considered, as potential alternative suppliers are interested in knowing the consumption profile of prospective consumers. In the electricity sector, rules on these issues are already in place (or under construction) in more than half of the surveyed countries (see Table A1.4). In practice, we can identify two different approaches to the issue. In a first group of countries there are rules for the DNO (or the meter operator) to provide data to the consumer or the supplier (or to the DNO). In a second group of countries, the law establishes that the consumers are the owners of their consumption data. This data is treated under confidentiality rules by the DNO or the supplier and cannot be provided to third parties (for instance, prospective suppliers) without the consumer's authorisation. Finally, where the service is liberalised (e.g UK) there are no rules, as suppliers are responsible for making metering arrangements and they already have access to customer consumption data.

Third party access to data	Electricity	Gas
Rules are in place	AT, BE (1), CZ, DE, DK, ES, FR, GR, NO, PT	CZ, DE, DK, ES, FR, NL
Rules are under construction	HU, IT, LV, PL	AT, HU, IT, SI
No rules	BE (2), FI, LT, LU, SI, SE, SK, TR, UK	BE (2), LU, LV, PL, SE, SK, TR, UK

Table A1.4 – Third party access to data

Public policies in electricity sector have been adopted or are under construction in a number of countries. Roll out obligations are not a frequently employed instrument. More indirect policies are preferred, such as the introduction of technical and operational standards, or financial incentives for roll-out and co-funding of operational expenses. A smaller number of public policies are in place (or are under construction) in the gas sector, in general in the form of co-funding programmes or promotion of meter standardisation (see Table A1.5).

Existence of policies	Electricity	Gas
No	AT, BE (3), CZ, DK, FI, FR, DE, GR, LT, LU, PL, SI, SK	AT, BE (3), CZ, DE, DK, ES, FR, IT, LU, LV, NL, SE
No, but under construction	HU, IT, LV, UK	HU, PL, SI, SK, UK
Yes, partly compulsory	ES, NO, PT, TR	
Yes, totally compulsory	SE	

Table A1.5 – Existence of policies

The questionnaire distinguished between three main directions: roll out obligations, financial support (in terms of either financial incentives for roll out or co-funding of operational expenses), and actions oriented at developing meter and operational standards (in terms of either support for standardisation or obligation to use 'public' meter standards).

In conclusion, policies are developing more in the electricity sector, even if it seems that in the gas sector a growing number of countries are considering to review options oriented to promote 'smart' meters, even if at present most countries still do not implement any form of policies (Table A1.6).

Profile		Electricity	Gas
Financial incentives for roll out	in place	PT	
	Planned	*SI*	SI
Co-funding of operational expenses	in place		
	Planned	*SI, LV*	
Roll out obligations	in place	PT	
	Planned	*IT, ES, SE*	
(Support for) the development of meter standardisation	in place	TR	NL
	Planned	*HU, UK*	*HU, UK*
Obligation to use 'public' meter standards	in place	PT, SK	
	Planned	*LV, SK*	
(Support for) the development of operational standards	in place		
	Planned	HU, UK	*HU, UK*
Obligation to use 'public' operational standards	in place	SK	
	Planned	*SK*	SI

Table A1.6 – Profile of policies

A second part of the survey tried to gain deeper insights into the current and expected status of 'smart' meter installations as well as into economic and technical issues.

As far as ***current deployment*** is concerned, 'smart' meters are currently a very small percentage of installed meters in most of the surveyed countries. This means that there is little evidence available on how customers may respond to time-based pricing structures and whether the potential benefits of this innovation (energy saving, market openness promotion, etc…) may be realised. However, in the electricity sector, there are a number of frontrunner countries where the percentage of smart meters is already significant (18% and above, 86% in Italy). Italy and Sweden are planning to substitute 100% of the meters with 'smart' meters by 2011 and 2009 respectively. Denmark, Spain and Finland are planning to reach significant percentages of installations: Denmark 13% in 2010, Spain 65% in 2015 (and 100% by 2019, with no extra cost to electricity consumers) and Finland 60% in 2015. On the other hand, in the *gas sector* the percentages are extremely low for all the respondents (see Table A1.7). The definitions behind the figures in the Table A1.7 could differ somewhat between countries and this should be taken into account when comparing the numbers.

Country	Electricity	Gas
BE (IBGE)	0.22% (2005)	0.05% (2005)
BE (CWaPE)	0.28%	0.05%
CZ	5.78%	
DK	4.00%	
FI	**18.00%**	
FR	**25%** (2005)[13]	
GR	0.37%	
IT	**86.20%**	
LT	1.00%	
LV	7,00%	
NO	4.00% (2005)	
PT	0.32%	
ES	2.40%[14]	0.05%
SE	**21.00%**	
SK	0.001%	

Table A1.7 – Current status of installation

The expected evolution in the ***electricity sector*** is illustrated in Figure A1.1 for the countries that provided historical and/or forecast data for a significant number of years.

Unfortunately, it was not possible to collect any significant evidence regarding ***economic issues*** such as metering tariffs and expected economic life of the meters, nor investment and operational costs of smart meters. The number of respondents to this part of the questionnaire was indeed extremely limited in number.

Similarly, an extremely low response rate characterised the section concerning ***functionalities and applications*** in use of installed 'smart' meters. It would not be appropriate to draw general conclusions from such a small number of observations. Instead, we refer to the single experience of each country, which is detailed in the dedicated section.

[13] France's percentage refers to 'smart' meters with only limited ,'smart' functionalities; in particular only partial AMR/AMM is allowed. For more details see paragraph 8.1.
[14] Spain's percentage refers to industrial customers (small business).

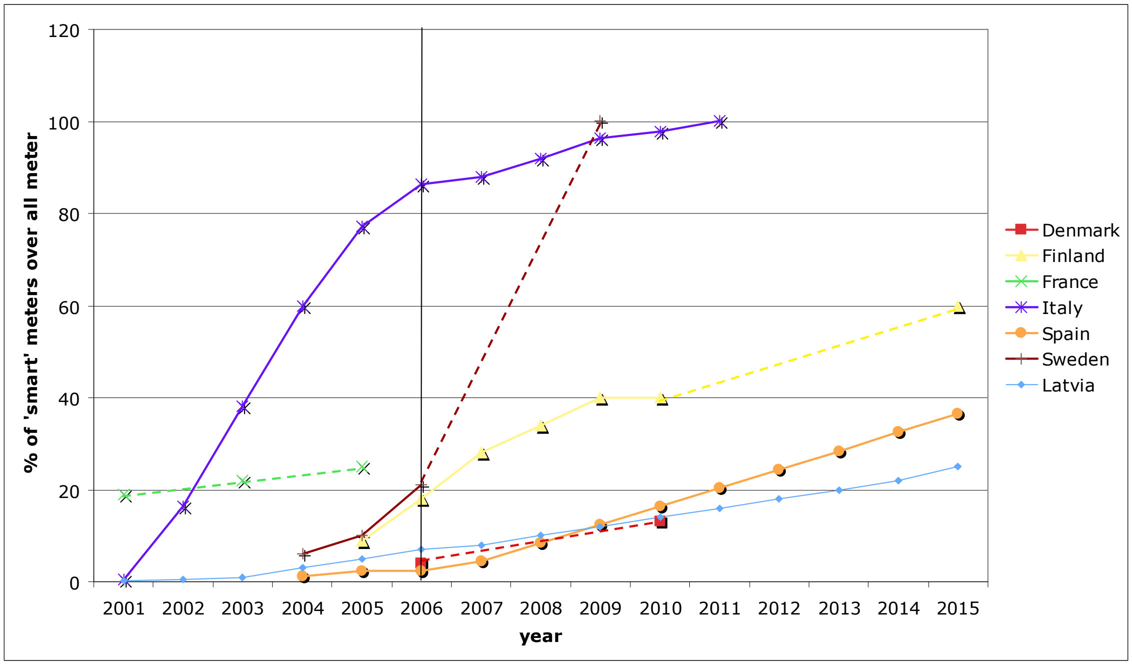


Figure A1..1 – Smart meters installation: expected evolution in the electricity sector

In conclusion, smart metering technologies are technically feasible and mature, at least for the electricity sector and at least on the technical side. Many manufacturers can supply competitive solutions, based on different functionalities, architecture and telecommunication systems. On the other hand, with the exception of Italy, experience with a large deployment of smart meters is still unavailable.

The Status Review highlighted that the metering regulatory frameworks vary a lot across Member States, also depending on the fact that powers of regulators are different. Furthermore, the historical experiences on metering result in different views on smart metering. This implies that policies could be implemented under various regulatory contexts and focus on different aspects.

ANNEX 2 - EXISTING REGULATORY EXPERIENCES ON SMART METERING

This annex briefly describes the existing regulatory experiences on smart meters: the regulatory framework is indicated, together with, where relevant, the policy decision and, possibly, the technological choice, and the consequences for costs recovery. For each experience the relevant status (act, decision, consultation document, study, etc.) is also indicated.

A2.1 Regulatory experiences in Europe

Austria (Consultation document)
Currently, all household customers in Austria are equipped with standard electromechanical meters (app. 5.3 Mio), which are in general read once a year. App. 600.000 customers have an interruptible supply for electric heating or hot water, managed via a ripple control receiver. App. 30.000 large industrial or commercial consumers (> 100.000 kWh and > 50 kW) are equipped with remotely read interval meter (AMR) systems. Metering services are by default delivered by the grid operator, who charges a regulated meter tariff to all customers.

There is currently no technical or legal requirement for grid operators to install smart meters in household premises. However there are two major grid operators who have voluntarily initiated smart metering projects, aiming at a full roll out of AMM systems within the next years. In 2006, the Austrian Regulatory Authority for the Electricity and Gas Market (E-Control) launched an information campaign (conference, website, discussions) to raise awareness in smart meter technologies and its role in energy markets. In April 2007, E-Control issued a public consultation paper on the introduction of smart meters in Austrian households. The regulator is in general in favour of smart metering as long as certain minimal functional requirements and data access for third parties are met. In addition, AMR/AMM systems have been identified as one of the energy efficiency measures listed in the upcoming energy efficiency law (national transformation of EU Directive 2006/32/EC) in Austria. In the coming months, a more in depth cost/benefit analysis and further discussions with market participants are planned.

Czech Republic (Energy act)
Current Czech legislation with respect to the smart metering issue does not use the term AMM (or AMR) and does not envisage the scope of functionalities which the AMM system should match. The Energy Act and pertinent Public notice no. 218/2001, which lays down the details of electricity metering and technical data transmission, as amended in no. 326/2005 use the term 'continuous metering with remote data transmission' and 'continuous metering' (Energy Regulatory Office, 2006).

The said public notice sets three categories of measuring:

- type A stands for 'continuous metering of electricity with daily remote data transmission';
- type B means 'other continuous metering of electricity; and
- type C means 'other metering of electricity'.

According to the Czech DNO's data, by the end of 2006, 194.000 measuring devices of type A and B would be installed in the Czech Republic which represents about 5,78 % of all measuring devices deployed in the country. Generally, all larger consumers (industrial and small business) fall within the type A and B.

Practical aspects of deployment of continuous measuring devices including the setting of their technical specifications falls under the responsibility of the DNO, e.i. ČEZ Company, E.ON

Company, PRE Company. These companies have or already carry out pilot projects on AMM systems and technologies and on their full roll out, irrespective of the fact that the present legislation does not require deployment of AMM or continuous metering for domestic customers (Energy Regulatory Office, 2006).

With regard to current European legislation, the Ministry of Industry and Trade and the Energy Regulatory Office are considering options for promoting AMM full roll out with the aim of developing a suitable policy for coming years. In cooperation with consultants, feasibility studies have been prepared on modalities and terms of AMM full roll out, because only full deployment might bring the needed effect. The focus of these analyses are basics economic questions, assessment of costs and gains. Generally, for the Czech Republic the question is not whether to deploy AMM systems for all customers but rather when will this deployment bring the overriding positive influence on the whole electricity sector - when it will payoff for both DNOs and for customers and when it might practically keep down the growth of consumption (Energy Regulatory Office, 2006).

In compliance with Directive 2006/32/EC, the Ministry and the regulator are considering legal options of step by step deployment of main AMM functionalities for all customers in several years (earliest 2009 – 2012). For example, amendments to the respective current legislation are under consideration which might oblige the DNO to introduce measuring devices that will display to the end customer information about their real consumption and the current price and which oblige the DNO to provide billing al least monthly to all end customers connected to the LV distribution network. Naturally, there are other options under consideration in this respect and more studies to be done (Energy Regulatory Office, 2006).

Finland (Investment without decision)

A recent report by the Technical Research Centre of Finland (VTT, 2006), partially based on a questionnaire sent to the distribution network companies, indicates that by the year 2010 almost 50% of the meters in Finland would be read automatically. The survey also revealed that the requirements set by the network companies for the metering systems and the meters vary widely. Thus one would urgently need unified specifications of basic requirements that would better recognise the needs of various counterparts.

According to the report, automatic meter reading could bring cost savings for the distribution network company. Yet these benefits are not large enough to justify the cost of the metering investment of the network company, though the cost per consumer has decreased. On the other hand, the infrastructure of automatic meter reading could bring further benefits to electricity end-users, companies selling energy, Fingrid, and the electricity market as a whole (VTT, 2006).

Great Britain (Decision)

Full electricity metering competition entered into force in GB in 2003. A key principle of this policy was to make retailers, not network operators, primarily responsible for purchasing metering services – the so called ‘retailer hub’ principle. Decisions about whether or not to invest in smarter meters for customers’ homes were therefore commercial decisions for electricity (and gas) retailers.

Nonetheless, Ofgem recognised that smart meters could have a significant role to play in improving customer service and in bringing numerous other potential benefits. For this reason, in 2006 it carried out a consultation process where it outlined a wide range of policy options aimed at unlocking these potential benefits: These options included issues such as the extent to which smart metering is more likely to develop in a competitive or regulated environment, whether the current regulatory framework creates barriers to the introduction of smarter meters and whether a trial should be carried out (Ofgem, 2006b).

On the basis of a cost benefit analysis and on the responses to the consultation, Ofgem concluded that competition, rather than regulation, was the best way to deliver smart metering. On the one hand, Ofgem believes that retailers are best placed to understand how different groups of customers are likely to respond to the information that smarter meters will provide, as well as the costs and benefits to different groups of customers of the different technologies available. On the other hand, Ofgem is aware that some barriers could prevent retailers from rising to this challenge.

Therefore, Ofgem has identified three major areas where the regulator has a role in helping to make smart meters a real option for domestic customers (Ofgem, 2006b):

- First, Ofgem plans to work with the industry to agree common standards to provide for interoperability of smart meters. This will ensure that consumers with smart meters can switch retailer without necessarily having to change their meter and that retailers will not face technical barriers to interacting with smart meters installed by their competitors.

- Second, Ofgem plans to review the supply licence, in order to identify and remove any barriers in the supply license such as the requirement to manually read a meter every two years.

- Third, Ofgem plans to discuss with government about a possible role for Ofgem in running the trial that government is funding to collect evidence on how customers respond to a range of smart meter technologies.

This work supplements other work in which Ofgem is already engaged. This includes reviewing metering price controls, providing clearer guidance to retailers seeking Energy Efficiency Commitment accreditation for smart meters, ensuring that settlement rules can accommodate smart metering and removing obstacles to installation of better prepayment meter technology. Ofgem plans also to use the work on standards to look at the metering needs of customers installing micro-generation as well as those in the non- domestic sector (Ofgem, 2006b).

Ireland (Consultation document)
In the Irish electricity market, a single distribution company, ESB Networks, is responsible for building the networks that carry electricity from the power stations to customers' premises. This includes the installation of any new meters.

The Commission for Energy Regulation (CER, 2006) has been reviewing developments in the area of metering for some time. The focus on metering solutions was a response, in part, to the issues raised in the 2004 'Alternative Tariff Structures' paper which identified the need for metering solutions to enable time of day tariffs. An analysis made at the time showed that, for domestic customers, the cost of the meters outweighed the benefits. Since then the Commission has requested additional information from ESB Networks and the dominant electricity retailer, ESB Customer Supply. Using this information, the CER has developed a model to quantify the financial benefits that could potentially be realised by an investment in smart metering. The CER's analysis suggests there is the potential to introduce large savings over a fifteen year period following the roll out of smart meters and the introduction of the relevant tariffs.

Based on this initial analysis, the CER is in principle in favour of introducing smart metering for all customers. However, the CER is of the view that the net benefit of introducing smart metering is such that a more detailed cost benefit study is required. The CER proposes to engage with ESB

Networks, ESB Customer Supply, other suppliers and interested parties to develop an approach to determine more accurately the costs and benefits of introducing time of day prices for customers and a smart metering solution to the Irish market (CER, 2006).

More specifically the CER proposes to (CER, 2006):

- Develop a project plan for the feasibility study which will consider the appropriateness of implementing pilot project;
- Request ESB Networks to provide latest estimates for installing smart meters and the necessary infrastructure;
- Work with ESB Networks and suppliers to critically assess the categories of benefit that should be assessed in the feasibility study;
- Work with ESB Customer Supply and other suppliers to develop “test” time of day prices and estimates of likely customer response to these prices.

Following on from this more detailed assessment, the CER will determine whether or not now is the right time to introduce time of day pricing and smart metering into the Irish electricity market.

If a smart metering project is approved by the CER, it means that ESB Networks incurs the cost of purchasing and installing the meters. These costs (as approved by the CER) would be recovered from all customers through the networks charge. At the same time, the potential benefits of smart meters are spread across ESB Networks, suppliers and customers. The CER expects that any benefits accruing to ESB Networks, ESB Customer Supply and other suppliers would find their way back to customers whether by being included in the calculation of networks charges, ESB Customer Supply tariffs and by other suppliers providing the customers with the additional savings when competing to serve that customer (CER, 2006).

In particular, the CER is considering a number of approaches to dealing with the recovery of meter charges through network charges, including (CER, 2006):

- Charges smoothed to reflect costs and benefits over time; or
- Charges reflective of costs and benefits in any year; or
- Upfront charge to customer followed by lower charges as benefits are delivered.

Italy (Electricity, Decision)
With decision 18 December 2006, no. 292/06 (AEEG, 2006b), the Italian regulator introduced the mandatory installation of smart meters, characterised by minimum functional requirements, for all household and non-household LV customers. The mandatory replacement programme will take place starting from 2008, will last four years and involves all DSOs, regardless of the number of the customers served.

Phase	Percentage of smart meters installed	By (date)
1	25%	31 December 2008
2	65%	31 December 2009
3	90%	31 December 2010
4	95%	31 December 2011

Table A2.1 – Italian plan for the installation of smart meters with LV customers

With the aim of dispatching purposes (interval metering) DSOs are obliged to install smart meters for 100% of LV customers with contractual power higher than 50 kW by 31 December 2008. From

1 January 2007, all customers in the free market with contractual power higher than 50 kW and equipped with interval meters or smart meters will be treated on an hourly base.

As from 2007, investments in smart meters and AMM systems will be approved only for DSOs that really invest in these technologies, through equalisation mechanisms. Furthermore, starting from 2008 financial penalties shall be applied to DSOs that do not reach the minimum yearly percentage of installation of electronic meters determined by the regulator. Efficiency-gain targets for metering service in the period 2008-2011 shall take into account AMM's potential in cutting operating costs.

Objectives:

- development of competition in supplying electricity to LV customers;
- transfer to customers as much as possible the benefits afforded by conducting business remotely (opex reduction);
- lowering the interval metering (1h) to a population of LV customer for dispatching purposes.

Criteria:

- customers served by small DSOs should have access to the free market and to AMM services with the same opportunities as those served by large ones;
- requirements should be defined at system level;
- avoid creating barriers to innovation: minimum functional requirements should be independent from architectures used by DSOs or recommended by AMM system suppliers and from telecommunication systems.

Main minimum functional requirements:

- weekly profile: four price bands; at least five intervals throughout the day in which to apply the four price bands; weekly programming including holidays (the local patron saint's holiday as well); at least two changes of the weekly profile a year per meter must be allowed;
- interval metering capability: depth of 36 days;
- security of withdrawal data: required protection through checksums or CRCs (Cyclic Redundancy Checks), even during their transmission to the AMM control centre. If a protected memory area is corrupted and cannot be recovered from the backup (if present), an alarm should be sent to the AMM control centre. Meters must also be equipped with a programme status word, read continuously, that signals with timeliness any errors to the control centre;
- remote transactions:
  - periodic readings for billing purposes;
  - reading of interval metered data;
  - contractual changes: meter activation (including for succession) and deactivation; name change (without interruption of supply); change in contractual power; change in weekly profile; reduction, suspension and reactivation of contractual power;
  - meter reparameterisation;
  - synchronisation of meter clocks;
  - transmission of messages on the meter display;
  - continuous reading of the status word;
  - reading information related to slow voltage variations, according to EN 50160;
- freezing of withdrawal data (billing, contractual changes, switching, etc.)
- meter display;

- upgrade of the programme software;
- slow voltage variations (according to EN50160).

Use of smart meters and AMM systems for quality of supply purposes:

- starting from 2008, the obligation to record the number and the list of the LV customers actually involved in each long unplanned interruption shall come into force;
- this mandatory rule shall replace the current one in force based on the estimate of interrupted LV customers and is preparatory to the introduction of automatic compensations for LV customers who suffer too many interruptions (already in force for MV and HV customers);
- a financial incentive is provided for DSOs that use smart meters and AMM systems to this purpose.

Italy (Gas, consultation document)
With a consultation document of 9 July 2007 (Aeeg, 2007d), the Italian regulator made a first proposal for a full smart metering roll out for final customers of the natural gas distribution sector. All DSOs, regardless the number of the customers served, are involved.

Objectives:

- timely and accurate carrying out of the daily balance;
- development of the regulated market of the capacity and of the gas;
- promotion of the competition;
- bills always based on actual consumptions;
- opex reduction;
- improvement of the customer service.

Criteria: the same as those identified for the electricity sector (see above).

Main minimum functional requirements:

- total consumption register;
- interval metering capability (parameterisable from one hour to one day): depth of 62 days;
- security of withdrawal data: the same as those identified for the electricity sector (see above);
- meter display;
- correction of temperature and pressure on board of meters;
- standard communication protocols (e.g.: DLMS);
- remote transactions:
  - periodic readings for billing purposes;
  - reading of interval metered data;
  - supply activation/deactivation (-> AMM);
  - synchronisation of meter clocks;
  - reading of the status word.

In parallel, the Italian Regulator started a cost-benefit analysis, a technical feasibility analysis and a worldwide survey. Results of these activities, among other things, will allow the Authority to determine the deadlines to implement smart metering for customers whose annual consumption is below 5.000 standard m^3 and to verify whether in the same consumption band specific conditions exist that require a delayed replacement/upgrade of meters or a delayed start up of the AMR function.

Annual consumption (Standard m3)	Percentage of smart meters installed	By (date)
> 200.000	100%	End 2008
100.000 – 200.000	98% - 100%	End 2009
50.000 – 100.000	96% - 99%	End 2010
5.000 – 50.000	94% - 98%	End 2011
0 – 5.000	25% - 30%	Step 1: to be defined
	55% - 60%	Step 2: to be defined
	90% - 95%	Step 3: to be defined

Table A2.2 – Italian plan for the installation of smart meters for final customers of the natural gas distribution sector

Norway (Study and recommendation to the Ministry)
The existing regulation states that all metering points with an annual consumption exceeding 100.000 kWh/year shall be metered with an hourly interval. This is also the case for all metering points feeding into the grid regardless of annual production. However, customers with an annual consumption below this threshold can get smart meters installed with a regulated maximum price of NOK 2 500 or about € 300.

Manual meters should be read at least once a year. For household customers with an annual consumption between 8.000 and 100.000 kWh/year, the meter should be read periodically with periods of equal length and at least four times a year. The meters are read by the customers. Only rarely does the DSO send personnel to read the meter. Meters shall also be read when switching supplier or moving. This is also done by self reading.

Some DSOs have developed smart metering in all metering points within their grid area. This is mainly smaller DSOs (less than 10.000 metering points). There are also some full scale development projects within certain areas of the larger DSOs' grid areas as well. However, these are mostly for research and development and to gain experience.

Thus, NVE's recommendation to the Ministry is that a full scale development of smart metering in Norway should be initiated with 2013 as a possible deadline for implementation. Regardless of this, functional requirements of smart meters should be defined in order to reduce risk for those DSOs investing in smart metering systems and to assure essential benefits are realised. The functional requirements should be developed in co-operation with the industry during the forthcoming year. A full scale development of smart metering shall be financed within the existing income regulation of the DSOs. Thus, new meters will be treated like all other investments.

The Netherlands (Consultation)
In the Netherlands, the network companies are responsible for installing and replacing meters, they own the meters and carry out maintenance. They are also responsible for making metering data accessible to third parties.

Retailers are responsible for data gathering (but can hire a subcontractor), and can ask for prioritisation of smart meter roll-out.

Customers can decide which parties (apart from their DSO and retailer) have access to their metering data for commercial activities (Frontier Economics, 2006).

The Ministry of Economic Affairs has indicated the following priorities:

- guarantee freedom of choice for consumers;
- stimulate energy savings;
- open the market for third parties to offer data management services.

In this framework, the Ministry has proposed a smart meter roll-out plan. The roll-out will commence in August 2008 and should be finalised within a 6 year period when all households (13 millions users) will have smart meters (Frontier Economics, 2006).

The market model for the plan is being finalised, in a joint effort which includes the Ministry of Economic Affairs, the energy regulator (DTe), the network companies, the metering companies and the retailers. The plan will also include minimum specifications and technical standards for the smart meters to be installed.

Further work includes a modification of the current legislation by the Ministry of Economic Affairs as well as a modification of the tariff regulation by the DTe (Frontier Economics, 2006).

The current figures for covering the incremental investments, maintenance and operational costs indicate that, with a 10-12 year recovery time, there will be no need to increase the current tariffs. Therefore, customers are not expected to incur any additional costs with respect to the current average tariffs (Frontier Economics, 2006).

Sweden (Decision)
The Energy Markets Inspectorate[15] exercises surveillance of the tariffs of the grid owners and ensures that they comply with regulations concerning metering. Distribution companies are responsible for metering and meter reading. Prior to 2003, utilities only had to collect metering data more than once a year from large customers that consumed more than 100,000 kW per year (Ofgem, 2006a).

In May 2002, the Energy Markets Inspectorate (at that time called Swedish Energy Agency) presented a report outlining the benefits of more frequent readings of electricity meters. The Agency's proposal was supported by all but one of the political parties, in spite of another report by an energy consultant dismissing significant benefits from AMR. As a result, a new bill was proposed in March 2003 and passed, that required monthly readings of all electricity users (5 millions) by 1 July 2009 (Ofgem, 2006a).

The legislation has stimulated investment in innovative metering systems. The continuing roll out of meters has led to rapid developments in both investments of new meters and advancement in the technology used. Initial deployments of meters utilised AMR, while current instalments are utilizing complex systems and state of the art technology (Ofgem, 2006a).

Distributors are responsible for ensuring that monthly readings are obtained, which has driven technological advancements. The customer will pay for the innovation (Ofgem, 2006a).

[15] (www.energimarknadsinspektionen.se)

Case: smart meters – impact on consumer behaviour, Swedish experiences

During the winters of 2003 and 2004, the Market Design Research Programme* (www.marketdesign.se) demonstrated the effects of confronting households with electrical heating with electricity prices during peak hours in the 300-1000 EUR/MWh interval. The aim was to study the price sensitivity of domestic customers. Previous trials have indicated that the price sensitivity of households is small. However, these trials have been carried out with considerably lower price differences than the extreme price levels expected in the future for peak hours.

The first winter's trials with the local distribution company Skånska Energi yielded very interesting results. The trial was therefore extended for the second winter season with additional customers from Skånska Energi. The distribution company Vallentuna Energi was also tied to the project. In total for the 2004/2005 winter season, 53 Skånska Energi customers and 40 customers of Vallentuna Energi took part.

For the trials, a special pricelist was constructed. The pricelist allowed the electricity supplier to apply a higher electricity price for a maximum of 40 hours. For the rest of the year the customer receives a deduction on the regular price. The higher electricity price lies in the 300-1000 EUR per MWh interval. Notification is given to the customer via text message or e-mail on the day before as to the time and level of the high price. All customers in these supply areas were already equipped with hourly metering.

The pricelist was constructed to create cost neutrality relative to the ordinary pricelist if the customer doesn't take any action. If the customer does take measures, the electricity bill will be smaller. In an example from Skånska Energi, the customer could save 140 EUR per year if electricity consumption was reduced by 70% during high price hours. In the Vallentuna Energi trials in the winter of 2004/2005, the promised level of savings was dropped to 100 EUR per year to investigate customer interest even at a lower rate of savings.

Along with customer agreement, advice was given on how to temporarily reduce electricity consumption and which measures are suitable depending on heating systems and alternatives.

The technical results, questionnaires and in-depth interviews show an unambiguous and consistent picture, that customers generally have considerable interest, ability and persistence when it comes to reducing electricity consumption during instances of high prices. The load was reduced by an average of no less than 50% at times of high electricity prices.

Another important conclusion from the project is that the results were attained without having to install any technology on the customer's end (they were already equipped with hourly metering). The results also show great similarities between the years and the respective electricity suppliers' customers.

The interviews carried out can be summarised in the following points:

- ✓ It is felt that the trials have gone well;
- ✓ The motives for taking part vary; it was economically profitable, it was both economically profitable and interesting, it was good from an environmental perspective, it was a challenge to see how much one could reduce power usage;
- ✓ It was not viewed as troublesome or time-consuming to affect changes;
- ✓ No major drawbacks were experienced in connection with bringing down electricity usage.

- ✓ The level of profit wasn't that important, rather it was about doing something beneficial for the environment;
- ✓ All types of deductions are important;
- ✓ Despite many not having a grasp of how much they saved, they were happy with the trial.
- ✓ A continuation with this type of tariff was viewed positively;
- ✓ Households were ready to finance and install some form of control equipment themselves.
- ✓ Large-scale application was not viewed as likely to present any major problems.

The positive response that was received indicates that this customer segment offers a potential for demand flexibility. The peak demand of electrically heated family homes is about one third of the total peak demand in Sweden.

The experience from the Market Design Programme indicates that hourly metering together with suitable tariffs, can increase the price elasticity of demand in the market and by that give a substantial contribution to the security of supply and a well functioning electricity market.

A2.2 Regulatory experiences outside Europe

California, USA

In California, the current market structure consists of investor owned utilities (IOU), regulated by the California Public Utilities Commission (CPUC), private generating companies and state agencies. The Californian Independent Systems Operator (ISO) manages the transmission lines and supervisors the maintenance, but the transmission systems are owned and maintained by individual utilities. The Electricity Utilities are responsible for metering. The CPUC approves the tariffs charged by these companies (Ofgem, 2006a).

In 2003, the three key energy agencies in California - the California Energy Commission (CEC), the California Power Authority (CPA), and the California Public Utilities Commission (CPUC) - came together 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. This document declared that energy efficiency is the resource of first choice for meeting California's energy needs (Ofgem, 2006a; CEC and CPUC, 2005).

As part of this plan, the CPUC authorised voluntary demand response programmes for large consumers and a state-wide two-year pilot programme to study the demand response capability of residential and small commercial customers. In addition, the CEC provided funding to install 23,300 interval meters for large customers starting in 2001, and the CPUC directed the IOUs to complete the process and authorised funding when general funds were exhausted (Ofgem, 2006a).

The IOUs submitted plans to deploy advanced metering infrastructure (AMI) systems or to develop them for all customers for consideration in 2005 and 2006. Each of the three major utilities was producing its own plans: Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric Company (SDG&E), and Southern California Edison Company (SCE) (Ofgem, 2006a).

The proposal is for state-wide installation of advanced metering infrastructure for all small commercial and residential IOU customers by mid-2006, with supporting tariffs.

The IOU's will roll out the advanced metering systems. Their cost recovery mechanisms will be approved by the CPUC (Ofgem, 2006a).

Ontario, Canada (decision)
In the province of Ontario, customers are either supplied electricity by their local utility or can elect to contract with a licensed retailer. The transmission and distribution of electricity continues to be provided by regulated distribution utilities (Ofgem, 2006a). The local distribution company is responsible for meter maintenance.

In July 2004, the Minister of Energy asked the Ontario Energy Board (OEB) to develop and implement the plan to achieve the Government of Ontario's smart meter targets for electricity. This plan directs that 800,000 smart meters are to be installed by 31 December, 2007 and that there should be installation of smart meters for all Ontario customers by 31 December, 2021. The OEB was to identify and review options for achieving the targets (Ontario Energy Board, 2004).

In the proposal, large customers throughout Ontario with peak demand over 200 kW will be the first to receive the new meters. The remaining installation will occur in two geographical phases, beginning with large urban distribution companies, which collectively account for more than 40% of customers. Thereafter, the implementation will begin in the remainder of the province in 2008. Within each geographical group, the roll-out would begin with industrial and commercial customers with peak loads between 50 and 200 kW, before residential and small commercial customers were brought in (Ofgem, 2006a).

In response to this plan, six of the province's major urban electricity utilities are working cooperatively under the brand name PowerWISETM to implement delivery of smart meters to customers on a province-wide basis. They are each undertaking smart meter pilot projects that involve installing the meters in customer's homes in order to test the various technologies that will be required to deliver smart meter services. These include wireless communication and other technologies (Ofgem, 2006a).

In fact, the plan does not mandate a specific system or a particular vendor, on the basis that the type of system that is best for any distribution territory depends on many factors, particularly customer density and geographic factors. Each electricity distributor will have to determine what works best in its territory, as long as the system selected meets the minimum technical standards proposed by the Board.

The basic smart meter system proposed by the Board is based on one-way communication (data transferred from the meter to the distributor). The Board considered requiring two-way communication (signals can be sent to and from the meter) but concluded that it eliminated viable systems from contention and could compromise competitive bidding. Also, the basic system proposed by the Board does not include all technical features currently available from vendors. Distributors will be permitted to select smart meter systems that have enhanced functions, such as voltage monitoring, earlier payment, load limiting and remote cut-off. Inclusion of the cost of such enhancements in distribution rates will depend on a business case acceptable to the Board.

The Board expects that retailers and other energy services companies will be prepared to offer enhanced services for a fee to those customers who desire extra functionality.

Responsibility for implementation is spread over 5 parties (Ofgem,2006b):

- The Minister of Energy retains responsibility for policy decision and will guide the communication process to the public;
- The Ontario Energy Board will focus on amending and reviewing the regulatory framework,

including licence conditions and rates, and review distributor plans. It will also have overall responsibility for managing the smart meter project;

- The distributors will select the appropriate smart metering system and will continue to be responsible for the installation, servicing and reading of the meter;
- Voluntary buying groups will be encouraged to enable economies of scale;
- The Independent Electricity System Operator will identify priority instalment areas and monitor the power system.

It has been proposed that the capital and operating costs of the smart meters is included in the distributor's delivery rates and that these costs would begin to be charged to all customers in a particular class as soon a the distributor begins to install smart meters, whether or not they have a smart meter. While it is suggested that this may provide for a small initial impact on customers' bills, the initial period will also include data management and billing system costs. In addition, it has been proposed that the stranded costs from old meters and other assets made obsolete will continue to be included in distribution charges (Ofgem, 2006a).

Customer group No.	Customer Segment	Billing quantities	Meter data Collection Requirements	Smart Metering System Specification
1	Residential and General Service < 50 kW	kWh	Hourly data Single-phase	See Main technical requirements
2	General Service 50 kW – 200 kW	KWh kW	Three phase hourly data with in-meter time stamp	See Main technical requirements
3	General Service > 200 kW	KWh KW KVA/kVAR	Three phase 15 minutes interval data potentially with power factor	Remote interrogation by established distributor practice

Table A2.3 – Ontario: customer billing and data requirements

Main technical requirements:

- One-way communication;
- The system must be able to provide hourly consumption data from every meter connected to it without the need to remove the meter or visit the site;
- The distributor must provide daily feedback to customers on their previous day's energy use. This information must be available in hourly intervals for at least the first four months after the Smart Meter is installed;
- Hourly reads and pricing changes of the TOU and CPP registers must, if necessary, occur on the hour with 24 hours advance notice. Reconfiguration of the TOU and CPP registers to comply with changes must be completed 16 hours after notification of the change;
- Distributors must choose systems that have a proven track record in the field, with at least 10,000 units that comply with the proposed technical requirements installed and working;
- The architecture of each SMS must include sufficient redundancy to ensure the integrity of data collection and adherence to performance specifications outlined in Ontario Energy Board, 2004 - See Appendix D-6 (Smart Meter Technology requirements);
- Read transmission success rate must be over 95% over any three-day period. Missing reads must be logged and reported through the system by 6 am the following morning;

– The system must be able to construct the peak hourly demand for Group 2 customers. It must collect data time-stamped in the meter or be able to read TOU registers or demand registers in the meter;
– The system must be capable of providing the same level of functionality for the initial implementation as for full-scale deployment in the distributor's service area. Monitoring, management and data collection capabilities of the system must be measured to SMS specification standards.

Victoria, Australia (decision)

The electricity market in Victoria is partly deregulated. Regional distributors have their network charges regulated by state authorities. Local distributors are responsible for reading electricity meters, which usually happens every 3 months.

The Essential Service Commission's decision was, in 2004, to mandate a rollout of smart meters to all Victorian electricity customers, in accordance with the details contained in Table A2.3.

Consumption band	Metering installation	Typical customer	Proposed timeframe for interval meter rollout	Rollout cost recovery approach
Business >160 MWh/year	Three-phase, CT connected; three-phase direct connected	Large office, large restaurant or industrial plant	Changeover in two years commencing 2006 New and replacement commencing late 2004	Costs shared between first tier customers only
Business and residential <160 MWh/year	Three-phase, CT connected; three-phase, direct connect; two-phase	Medium office, café or large residential customer	Changeover in five years commencing 2006	Costs shared among customers with this type of meter
	Single-phase, off-peak; time of use	Residential, shop or small office usually with electric hot water	Changeover in five years commencing 2006	Costs shared among customers with this type of meter
	Single-phase, non-off-peak	Residential, shop or small office without electric hot water	New and replacement commencing 2006	Costs shared among customers with this type of meter

Table A2.4 – Essential Service Commission's decision[16]

This decision means:

- that in the 5 years from 2006 around a million traditional meters would be upgraded with smart meters for large customers and customers with electric water heating;
- over an extended period, when a new or replacement meter is required, all remaining meters (around 1.3 million) would be upgraded.

Interval AMM meters were chosen in light of the continuing advancement in technological innovation. It was judged that creating an 'installed base' of interval meters would best enable

[16] Note that: *(i)* subject to the National Electricity Code requirements, automatic or remote reading will not to be mandated; *(ii)* second tier customers using more than 160 MWh per year are already required to have an interval meter; *(iii)* meters for customers using more than 160 MWh per year must be suitable for communication.

future technological and/or service innovations to develop. Without this base, there would be reduced capacity and incentive for developments.

When the decision was taken to make smart meters compulsory, meter costs were collected through a combination of the network tariff and the connection charge, and customers were not subject to a specific metering charge for traditional meters. It was then foreseen that the meter charge would remain a component of the network tariff until the next regulatory price control period in 2006.

For small first tier consumers (those consuming below 160 MWh per year), distributors had a monopoly on providing basic meter services, the costs of which were recovered through existing charges. It was stated that they would need to recover the additional costs for smart meters through a further charge. The Commission was in favour of using a shared charge to all customers consuming less than 160 MWh per year. It was proposed that this charge would be established, possibly as an excluded service charge based on meter type, at the time of the next price control period.

For large first tier customers (those consuming greater than 160 MWh per year), a smeared charge to the customers affected—that is, large first tier customers—was thought equitable. This arrangement was to be achieved through an excluded service charge.

For large second tier customers (those consuming greater than 160 MWh per year, retailers (rather than the distributors) were responsible for the metering installation. The provision of this type of meters was already a contestable activity, and the distribution charges did not provide for cost recovery in this case. Where customers in this segment had smart meters, individual retailers and customers had funded the meters. It seemed reasonable, therefore, that customers who had already paid for their own smart meter—that is, second tier customers—should not share the costs of installing further smart meters for first tier customers (Essential Service Commission, 2004).

ANNEX 3 – ANALYSES OF COSTS AND BENEFITS: METHODOLOGIES AND MAIN FINDINGS

The first part of this Annex 3 briefly presents the methodologies employed in the available cost-benefit analyses. The objective of this brief survey is to highlight similarities and differences in the approaches. The second part summarises the main findings.

A3.1 Methodologies

Broadly speaking, estimates of costs and benefits refer to different scenarios. They are calculated in terms of one or more selected metering technologies, and making different assumptions on smart meters deployment rates.

Estimated costs are generally incremental or differential costs incurred with the current metering technology and the full deployment of the smart meter technology.

Estimated benefits refer to the overall or social impact of smart metering, as well as to the impact for the different stakeholders (because of the split-incentives issues).

Regulators are sometimes interested in valuing the possibility that smart meters are developed on a business case.

Finally, the impact of smart meters on consumers' costs is often estimated.

The approaches differ in terms of the complexity of the models: number of cost and benefit parameters included in the analysis, number of scenarios considered, accuracy of the demand response model, presentation of sensitivity analyses and so forth.

Differences in the costs are driven by the assumed lifetime of the meters, the discount rate, the rapidity of the technology deployment and, of course, the choice of the meter. Differences in computed benefits depend fundamentally on the demand response model employed and/or the assumptions made on the peak shaving potential.

In the following are summarised the methodologies employed in the Netherlands, in the state of Victoria (Australia), in the province of Ontario (Canada), in Great Britain and in Ireland.

The Netherlands
The cost-benefit analysis conducted by Senter Novem defines two scenarios. 'Situation zero' is the current situation. In 'situation one' all small-scale customers are connected to smart infrastructure (gas and electricity) that uses smart meters and feedback on the actual consumption is provided at least once per month.

Only the costs and benefits that differ from 'situation zero' are examined. Furthermore, the study considers the situation throughout the Netherlands. This social cost-benefit analysis is therefore not comparable to a business case conducted by an individual market player.

All qualifying costs and benefits are put together in a financial model. This financial model makes it possible to calculate the project value with a breakdown of costs and benefits according to the various market players. It is also possible to perform sensitivity analyses.

Ontario (Canada)

The Ontario Energy Board (2004) conducted a cost analysis estimating the potential savings and costs of installing smart meters for all consumers, for a selected basic technology, assuming to complete full implementation by 2010. The Board estimated an overall capital cost and the incremental monthly cost for a typical residential customer to cover capital costs and net operating costs. Because it will take several years to complete the installation of smart meters in a distributor's territory, the impact on customer bills is initially small and it rises as the implementation programme progresses.

The analysis identified, however, did not quantify benefits.

Victoria (Australia)

The analysis commissioned by the Essential Service Commission (2004) included several scenarios, where different meter technologies and different rates of meter replacement were considered. The analysis assumptions where discussed with interested shareholders and eventually modified.

The potential benefits were estimated by predicting the change in peak demand by means of a demand model that incorporated price elasticity (this model also validated by an additional engineering model that predicted hourly loads by end use).

The cost model included the purchase cost of meters and related capital equipment (for example, modems and other communication equipment); installation costs; maintenance costs; and the costs of meter reading, including the cost of two-way communication and data management costs. The net benefit for each deployment strategy was given in terms of the difference between the present value of benefits and the present value of incremental costs.

In addition, smart meter incremental costs per consumer per year were calculated, together with the expected change in consumer bills for different consumer types.

Great Britain

Ofgem (2006a) explored two cases for investment in smart metering:

- An investment case from a retailer perspective that seeks to assess how likely retailers are to invest in this technology, given basic knowledge of possible costs and benefits; and
- A cost-benefit analysis that, in addition to the retailer benefits, explores the wider economic benefits of metering to customers, such as the potential for reduced energy use and shifting use away from times of peak demand (including the contribution that could be made to meeting carbon emission targets).

The results are given in terms of annualised costs and benefits over and above those associated with existing meter costs. In the investment case the retailer benefits plus the network benefits[17]

[17] The most significant potential benefit to network operators comes from the avoided peak capacity investment that could be associated with the introduction of a sophisticated innovative meter that allows time of use pricing. However, the proportion of this benefit that could be captured by the network operators (transmission and distribution for gas and electricity) is relatively small, since the effect of the network price controls is to allow such benefits to be retained by the networks for a maximum of five years. Customers would, however, see the long term benefit of any reduction in network investment through lower network charges (Ofgem, 2006a).

are compared to the costs of the meters (two different technologies are studied). In the cost-benefit analysis the meter costs are compared to retailers, network and consumer benefits.

Ireland

The Commission for Energy Regulation (CER, 2007) carried out a 'desk top' analysis for quantifying the main costs and benefits of time-of-use tariffs and smart metering.

As for time-of-use tariffs, CER quantified the main benefit in terms of savings on electricity bills, reduced emission from power stations, and savings related to generation investment deferral.

As for meters, the analysis focused on:

- Areas of current expenditures and costs that smart metering could be expected to reduce;
- Areas of potential savings can be made over the lifetime of the meter.

These areas are the following: meter reading; theft and losses, transaction costs; bad debts; costs of smart meters; other benefits. For each of these areas, CER simply estimated the percentage savings over current costs.18

A3.2 Main findings

We observe that cost-benefit analyses that take a social view of the issue (i.e. include all benefit categories) result in net positive benefits. Analyses that take a narrower point of view (the retailer business case, for instance) do not lead to similar outcomes.[19]

The positive results of broader scope analyses have been taken as motivations for a regulatory intervention in the majority of cases.

For instance, the Essential Service Commission (2004) observes that the rollout of interval meters would have significant benefits that no individual decision maker would capture, and prohibitive informationa and transaction costs exist that could be expected to prevent the market from delivering efficient outcomes. And concludes that there is a case for regulatory intervention to support a timelier and widespread uptake of smart meters in the market than would result if the pace of rollout of interval meters was left to commercial decisions and market forces.

Similarly, Senter Novem (2005) remarks that the "cost-benefit analysis shows that the cost-benefit relation is optimal when implementation of smart metering infrastructure is fast and full (100%). Furthermore, the issue of a split incentive emerges: households profit the most, while the costs are borne mainly by the metering companies and the suppliers". In this setting, "government actions are required to enable the implementation of smart metering devices at small-scale customers to run its course under the most optimal circumstances".

---

[18] For instance, smart metering is estimated to reduce theft significantly and an 80% reduction of the current loss factor was assumed.

[19] The Canadian cost analysis had the sole objective to estimate the expected costs of smart metering deployment for the end consumers: the decision of a smart metering implementation was already made, in the context of a more general energy efficiency policy.

Also the desk top study conducted in Ireland concluded that the system-wide savings of introducing smart meters and time-of-use tariffs may be considerable and may be greater than the cost of implementing these schemes. Accordingly, CER (2007) declared to be "in principle in favour of introducing smart metering for all customers provided that savings either outweigh or are relatively close to covering costs" and has decided to carry out a full feasibility study to more accurately ascertain the likely costs and benefits. In a different regulatory and commercial framework, the results of the cost-benefit analysis have led to dissimilar conclusions.

Ofgem (2006a) has considered several elements. First, that Ofgem's analysis suggests that, for many customers, there may be a case for introducing smarter metering. Note that benefits are higher than costs only in the broader scope analysis and for the more sophisticated metering technology (larger load reduction). Second, that the high potential benefits from the introduction of time-of-use tariffs and smart meters are strongly correlated with a higher energy efficiency. However, this analysis depends on assumptions made about how customers will respond to the information that smart meters will provide and whether they will change the way they use energy. Unfortunately, there is little hard evidence that customers in Great Britain will reduce their energy use or shift their use away from peak periods in response to better information and energy prices that vary across the day. And third, that competition has been introduced in domestic metering services in Great Britain with the hope that this would lead to innovation and more choice.

For all these reasons, Ofgem thinks that competition, rather than a "one size fits all" regulated solution, is the best way to deliver smarter forms of metering.

Below is a summary of the main findings from a benchmarking and a cost-benefit study done in France.

France

The Commission de Régulation de l'Energie (CRE, 2006) commissioned an international benchmark analysis and a cost-benefit study on AMM.

The purpose of this study was to assess the costs and benefits of replacing the current meters with AMM meters. The study was carried out from September to December 2006. Interestingly, EDF announced in August 2006 that they were considering an AMM experiment (300.000 meters), to be launched before the end of 2007. CRE has published the study on its website.

The cost-benefit analysis defines 3 different technological and functional scenarios (A, B, C), and for these 3 scenarios, 2 deployment durations (5 or 10 years).

The benefits estimated are for instance: avoided investment in grid and generation, reduction of non-technical losses, reduction of unpaid bills (with prepayment functions), easiness of switching supplier for customers, avoided operational costs (meter reading, connection/reconnection...) and reduction of electricity consumption thanks to consumer information.

Discounted cash flows are calculated for all these scenarios within the DSO strict scope, and also within the scope of all the value chain, from generation to commercialisation.

It turns out that the business case of replacing all meters is negative for the DSO but can be extremely positive taking into account the impact on generators, suppliers and customers. Benefits from a change in customer behaviour could be huge but are nonetheless subject to a great deal of uncertainty.