SmartRegions

European Smart Metering Landscape Report 2012

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INTELLIGENT ENERGY EUROPE
FOR A SUSTAINABLE FUTURE

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Overview

Table of contents

1 Executive Summary

Due to the regulatory push by the European Union's Third Energy Market Package, most EU Member States have, or are about to implement, some form of legal framework for the installation of smart meters. Moreover, in some Member States electronic meters with bi-directional communication are installed for economic reasons even without any specific legal requirements.

Due to the regulatory push and the efforts of market players, the development of legislation and regulation for smart metering in Europe is highly dynamic. Based on the information gathered in this Smart Metering Landscape Report, we analysed all countries along two dimensions:

(1) Legal and regulatory status: by the legal and regulatory status we evaluate whether or not a framework has been created to not only provide clear guidelines to utilities for installing meters and do so with the goal of achieving energy savings and/or peak load shifting.

To classify each country the status quo has been assessed on the following dimensions:

a) cost benefit analysis and rollout plan,

b) timeline for the rollout,

c) barriers from additional legislation and regulation, e.g. privacy and data protection, measurement and calibrating meters,

d) legal minimum functional requirements;

(2) Progress in implementation: by the progress in implementation we not only refer to the number of pilot projects, smart meters and corresponding services in the field, but also the existence of and progress towards a clear and realistic implementation roadmap for metering technologies that enable metering services once again, with the goal of achieving energy savings and/or peak load shifting.

To classify each country the status quo has been assessed on the following dimensions:

a) enabling infrastructure,

b) rollout status,

c) services already available to customers;

As the functionalities of smart meters are crucial for the future deployment of the full potential of the meter-related services, the functionalities were the special focus of the survey.

It should be noted that a modified methodology has been used compared to the Landscape Report 2011. Therefore the graphical overview of the Landscape Report 2012 cannot be compared without constraining that of the Landscape Report 2011.

Along these lines we classified all Member States and Norway in five groups:

1. The “***dynamic movers***” are characterised by a clear path towards a full rollout of smart metering. Either the mandatory rollout is already decided, or there are major pilot projects that are paving the way for a subsequent decision. Estonia, Finland, France, Ireland, Italy, Malta, The Netherlands, Norway, Portugal, Spain, Sweden and the UK come under this group.

2. The “***market drivers***” are countries where there are no legal requirements for a rollout. Some DSOs or legally responsible metering companies nevertheless go ahead with installing electronic meters either because of internal synergetic effects or because of customer demands. We classified Denmark, Germany and Czech Republic in this group.

3. Austria and Poland (“***ambiguous movers***”) represent a situation where a legal and/or regulatory framework has been established to some extent and the issue is high on the agenda of the relevant stakeholders. However, due to lack of clarity within the framework, at this point only some DSOs have decided to install smart meters.

4. The “**w*averers***” show some interest in smart metering from regulators, the utilities or the ministries. However, corresponding initiatives have either just started, are still in progress or have not yet resulted in a regulatory push towards smart metering implementation. We rank Belgium, Greece, Latvia and Romania in this group.

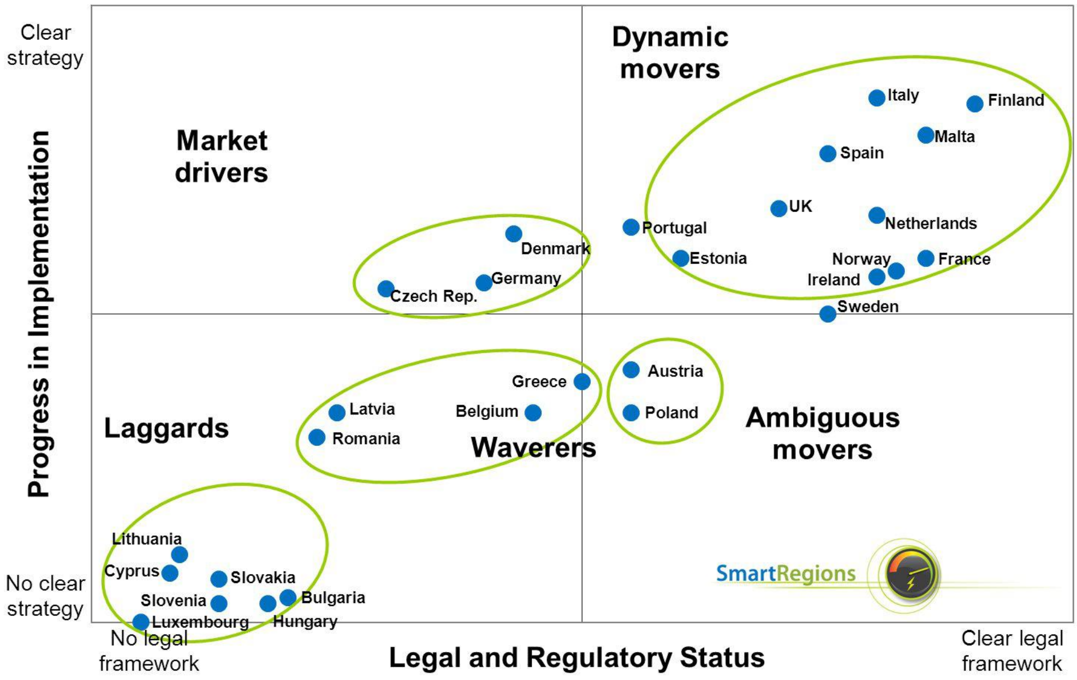
5. Finally, “***laggards****”* are countries where smart metering is not yet an issue. This group consists of Bulgaria, Cyprus, Hungary, Lithuania, Luxembourg, Slovenia and the Slovak Republic. However, since transposition of Directive 2009/72EC is on-going, it is possible that the laggards will suddenly gain momentum.

The developments since the Landscape Report 2011 showed that progress were strongest in the countries with a significant regulatory push. Many of the so-called dynamic movers have defined very ambitious rollout plans. In addition, in most of these countries a clarification of the minimal requirements of smart meters was clarified.

On the contrary, countries, which are classified as market drivers, there is only moderate progress. In general it should also be stated that in many countries there is still a lot of scepticism among customer associations and privacy activists.

In most countries the DSO are responsible for the installation and maintenance of the smart meters. Only in Germany and the UK the suppliers are responsible

The following picture provides a graphical overview of the legal and regulatory situation vis-à-vis the process of implementing smart metering enabling technologies and services with the goal of achieving energy savings and/or peak load shifting.



As regards **smart metering services** in Europe there is a wide range of feedback tools available to energy utilities and customers in the form of displays, websites, information on mobile devices and TV, informative bills etc. The development within this market and the services that are offered to the end customers are key to achieving actual energy savings from the alleged saving potential.

Even though the literature disputes the extent of these services, in fact, achieving energy savings, it is at the same time clear that **without these feedback tools and additional metering services there is no benefit for end customers**. It will be difficult to convince customers of the added value of new metering technology and the modernisation of the European electricity grids if metering data is only of use for operational changes within utilities (to reduce non-technical losses, for remote reading and switching or the simplification of billing procedures, etc.). This is particularly important because there al advantages of smart metering will and have to be compared with the related costs that will be borne by customers (not only in monetary terms, but also in terms of privacy intervention and other non-monetary issues). Only services based on metering data will provide added value for customers.

Only metering services will provide added value to the customers.

Besides feedback tools that enable customers to regulate their energy consumption, a number of utilities test and operate **demand response and direct load control programmes** in order to limit the peak load that has to be provided to the market. The Nordic countries in particular, have used trial demand response programmes that give customers economic incentives to achieve a certain behaviour or apply direct load curtailment within the contractual framework with promising results. While these programmes are small-scale research projects, some of the programmes show promising results with very little intervention. This report summarises trials that are complete or in progress.

Overview of developments in EU Member States and Norway

The following table provides an overview of the situation in each EU Member State and Norway regarding the regulatory and legal situation and the actual implementation of smart metering on the ground.

Table 1: Smart metering landscape in Europe

Member state	Legal and regulatory status	Implementation status
Austria	In October 2011 the Energy Regulatory Authority (E-Control (2011)) issued a decree according to the Electricity Act which determines the functional requirements of smart metering systems in Austria. As expected by the stakeholders, the regulator mainly determined in this decree the topics mentioned in a catalogue with minimum function requirements for smart metering systems, which was already published in June 2010 for public consultation. In spring 2012 E-Control published a proposal for the mandatory Information of customers equipped with a smart meter. This regulation will enter into force in January 2013.	On 24 April 2012 the Minister of the Economy issued a decree, which determines the mandatory timetable for the rollout of smart metering services in Austria (BMWFJ (2012)). The new decree will accelerate the rollout of smart meters. The main rollout of smarter can be expected in 2016 and 2017.The electricity network operators have to equip at least 95 per cent of all metering points by the end of 2019.According to the an estimations by the regulatory authority, there are already about 150.000 electricity customers equipped with smart meters within the different pilot projects and early rollouts.
Belgium	No legislation regarding the introduction of smart metering yet. However, smart metering is high on the agenda of all stakeholders mainly due to late or erroneous invoices. Regional regulators have conducted various studies such as functionalities and cost-benefit analyses for all regions. General attitude in Flanders towards the (costs of) introduction of smart meters is reserved.	The focus in Belgium is on technical tests of the meters and the communication technology. A number of pilot projects are in progress or being prepared (Sibelga with 200 electricity meters, Eandis with 4,000 meters in the cities of Leest and Hombeek, some 40,000 meters by 2012 and a plan for a complete rollout of 2.5 million electricity and 1.5million gas meters by 2019.
Bulgaria	There are no official plans for a nationwide rollout of intelligent metering systems and no legislative or regulatory initiatives. A cost-benefit-analysis has not been carried out yet.	A considerable number of electronic meters with remote reading have been installed since 2006 in order to reduce non-technical losses and the number of complaints about erroneous invoices.
Cyprus	There is no legal framework demanding a mandatory rollout, but at the same time the current legislation does not hinder the development of smart metering markets.	The DSO of Cyprus started a pilot project in July 2010 with 3000 smart meters. The goal is to publish a cost-benefit analysis report by July 2012. The declared strategy underlines the objective of moving towards a full rollout of smart meters for all electricity customers in Cyprus that will be based on the findings of the pilot project.
Czech Republic	There are no legal obligations concerning smart metering in the Czech Republic. A national rollout plan is under discussion, but progress in the regulation of smart metering will depend on the results of a new cost-benefit analysis, required before September 2012. A cost-benefit analysis in 2006 led to a negative result.	Several smart meter pilot projects have been carried out or are still in progress in the Czech Republic: E.ON Česká Republika installed 4000 smart meters in South Moravia in 2006, PRE recently completed a project in Prague with 3000 meters, and ČEZ installed 2000 meters in east Bohemia. ČEZ is currently involved in FUTUR/E/MOTION, a smart grid project with 32,000 meters which will provide a basis for the cost-benefit analysis. Further rollouts are not currently planned.

Member state	Legal and regulatory status	Implementation status
Denmark	Since 2005 hourly metering has been mandatory for customers with a yearly consumption larger than 100,000 kWh. There is no legal framework for the provision of smart meters for domestic customers. Mandatory metering of the electricity consumption of household customers has been suggested, but a cost-benefit-analysis led to a negative result. Minimum functional requirement for electronic electricity meters are available (Energistyrelsen, 2009).	Several trials have been conducted and a number of DSOs install electronic meters even without legal requirements. Of a total of 3million metering points in Denmark, by 2011 approximately 50% will have remote reading (ESMA, 2010). Demand response is one of the main drivers.
Estonia	According to the responsible ministry (The Ministry of Economic Affairs and Communications), the plan is to rollout smart meters by the end of 2017. The rollouts are led by DSOs, and the government exercises its policy to rollout smart meters through the dominant DSO OÜ Jaotusvõrk. Establishing requirements for smart meters is part of the Estonian NEEAP (2006/32/EC).	The major DSOs are rolling out smart meters. The dominant DSO OÜ Jaotusvork is having a major rollout (638,000 meters) to be implemented in four years between 2011 and 2015. After the rollouts of the largest DSOs are ready, the national smart meter coverage should be97%.
Finland	Electricity Market Decree (66/2009) demands 80% smart meter penetration by 2014, and the DSOs are responsible for the rollout. The regulator has defined minimum functional requirements for the metering system, including hourly metering, two-way communication and load control abilities.	All DSOs have started their rollouts. Over 2million electricity meters are installed (around 1 million remain to be installed). Utilities are intensively developing and deploying information & feedback systems for their customers, along with other new smart metering-based services and develops (demand response, in-home displays, smart homes). For district heat, it is estimate that over 80% of meters are remotely readable and most of these are capable of providing data hourly.
France	A government decree in September 2010 defined the terms of a mandatory rollout, aiming to achieve 95% coverage by the end of 2016. Since January 2012, all new electricity meters installed must be smart meters. The regulator has defined some guidelines and minimum functional requirements for electricity meters. A cost-benefit analysis was carried out in 2007 with positive results.	In September 2011, after several successful pilot projects, the French government announced the rollout of 35 million smart electricity meters, starting in 2013 and ending in 2018. ERDF is responsible for the deployment. An initial smart gas meter pilot was carried out by GrDF, installing around 18,500 smart gas meters from April 2010 to June 2011. A rollout is still being discussed.
Germany	Germany continues to follow a market-driven policy - a government-led rollout is therefore not planned. The metering sector is liberalised. Legal obligations on smart metering have been expanded in recent years: smart meters must be installed for certain customers and in certain buildings, and utilities must offer load-variable or time-of-use tariffs. Minimum functional requirements and technical specifications are under development. A cost-benefit analysis should be completed in early 2013.	Although progress has been made with recent legislation, some obstacles to the introduction of smart meters remain. Many utilities have not yet fulfilled their obligations regarding meters and tariffs, and incentives for utilities and customers are small. An estimated 500,000 smart meters have been installed in Germany. Six pilot projects are being carried out as part of the state-sponsored “E-Energy” programme – utilities and smart meter manufacturers are gaining important insights into the technical and economic issues of smart metering.
Greece	Greece is proceeding with a rollout of electricity smart meters and has adopted a legal framework (Article 15 of law	The dominating Public Power Corporation (PPC) has plans to install 60,000 smart meters in large-end customers with low

Member state	Legal and regulatory status	Implementation status
	3855/2010). Greece has defined some minimum functional requirements and has defined two-way communication as the minimum requirement for the communication system for smart meters in electricity. A final schedule for a full rollout has not been announced yet.	voltage connections, many of which are residential. This project will later be extended to all customers throughout Greece. Possibilities of extending the electricity metering system to include metering water and natural gas consumption are currently being explored with the Athens Water Supply and Sewerage Company (EYDAP SA) and the Athens Gas Supply Company (EPA SA).
Hungary	No legal framework for a mandatory rollout. But a decision is expected in 2011 with transposition of Directive 2009/72/EC. Currently there is only an obligation to provide smart meters and variable tariffs where it is economically reasonable. A cost-benefit-analysis was carried out in 2010 with the recommendation to implement a system with legally separate but regulated meter operators and to start the rollout for domestic customers in 2014. Minimum functional requirements are proposed.	Pilot projects are expected to start in 2011.
Ireland	The regulator (CER) has almost finished a consultation process on a rollout strategy and functional requirements for electricity and gas, including a cost-benefit analysis for electricity as well as gas meters. The CER is proposing to rollout smart meters nationally in a manner which: ▪ Includes an In-home Display screen to give customers more real-time information on both the cost and usage of electricity and gas. ▪ Provides customers with Smart Bills, containing detailed consumption and cost information. ▪ Involves suppliers offering Time-of-Use pricing for all electricity customers, facilitating a shift in electricity consumption to cheaper times of the day and giving customers more choice. ▪ Provides prepayment services as standard with smart metering, i.e. energy customers will be able to automatically switch between prepay and bill pay options. The CER has also set out proposals for the design and functionality requirements of the national smart meter rollout, as well as the procurement model and high-level timelines involved. A final decision on the national rollout is expected before the end of 2012, with the process of installing meters is likely to occur in the following years.	The CER proposes that electricity and gas smart metering should be rolled out to all residential customers and to a significant proportion of business customers, including all business electricity customers currently with non-interval meters and all business gas customers. This corresponds to a total of about 2.2 million electricity customers and 600,000 gas customers. It is also proposed that gas smart metering will leverage the electricity smart metering communications infrastructure, and that time-of-use electricity tariffs will be mandatory for all electricity customers. Prepayment services will also be provided as standard, enabling customers to automatically switch between prepay and bill pay options. Other aspects of the proposals include the design and functionality requirements of the electric and gas smart meters, and the wide area network (WAN) and home and area network (HAN) requirements. On 5 July, the Irish energy regulator CER decided that electricity and gas smart metering will be rolled out to all residential customers and a significant proportion of small-to-medium enterprise (SME) customers. Furthermore, the CER is mandating the rollout of in-home displays, energy usage statements containing detailed consumption and cost information, and time-of-use electricity tariffs for all electricity customers. Prepayment services are also required to be provided as standard for both electricity and gas customers.
Italy	The installation of remotely readable electronic meters is mandatory. Minimum functional requirements are available. Focus of metering system is on reduction	Rollout started in 2008 and by the end of 2011 95% of 36 million customers will have received electronic meters. Data from meters can easily be displayed in home

Member state	Legal and regulatory status	Implementation status
	of non-technical losses, not energy savings.	screens and become part of a more complex HEMS (Home Energy Management System), currently being tested and deployed on a pilot scale.
Latvia	No legal framework is in place, the installation of smart meters depends on the activity of DSO. The current monopoly situation is not encouraging. The dominant DSO Latvenergo has developed a smart network concept (approved on 1 March 2011 by the decision of the Latvenergo Board of Directors).	Latvenergo (dominant DSO) is preparing a concept for rollout. Conventional meters are gradually replaced by electronic meters (not necessarily AMM). 10,000 meters are already connected to the AMR system (7,000 of them are industrial customer). Latvenergo is planning to start a smart metering pilot scheme in 2012 for domestic customers. According to the plan the company will install smart meters into 500 households (which are selected by different monthly consumptions) and will implement a new MDC system.
Lithuania	No legal framework, cost-benefit-analysis in place and no national rollout plans are available.	No activities known.
Luxembourg	No rollout plans and no cost-benefit analysis available.	Some DSOs started with trials testing internet portals, displays, etc.
Malta	A mandatory rollout started in 2010 to reduce the costs of bi-monthly billing and non-technical losses. Functional requirements are available.	Mandatory rollout was decided and started in 2009 with a pilot phase. In 2010 Enemalta launched a rollout plan to replace all electricity and water meters for270,000 customers by the end of 2012. 140,000 smart meters have been replaced to date and an online portal allows customers to access to their details.
Netherlands	The revised Dutch Electricity Act and the Gas Act (approved in 2011, in force since 2012) obliges network operators (owners of the smart meters) to offer all small customers (households and small businesses) a smart meter. Customers have a legal choice over whether they accept a smart meter, ranging from having no smart meter at all to a smart meter with full functionality to provide interval data to the network operator and a chosen service provider. When accepting a smart meter, the customer has to authorise the network operator to collect and use a minimum set of consumption data for specific regulated purposes such as bimonthly cost-statements, annual billing, switching supplier and moving home. The revised law requires energy companies to provide customers with these bimonthly cost statements as a basic form of feedback. Additional regulation sets out the minimum information requirements for these cost statements. Providing customers with more detailed consumption and cost information for household energy management is considered to be a market responsibility. The customer will choose and authorise a commercial service provider to use (real-time) data beyond the minimum regulated	The rollout of smart meters in the Netherlands will take place in two stages. From 2012 until 2014 a small-scale rollout will take place for experience purposes. The small-scale rollout will take place in case of regular meter replacements (e.g. malfunctions), new meters to be placed in newly built houses/ renovated houses and new meters at the request of customers. Important aspect, that will extensively be monitored during the small-scale rollout are related to technical and economic matters and the level of energy savings and smart metering services market development. From 2014, the rollout will continue on a larger scale, based on the experiences mentioned above. The large-scale rollout aims to have a smart meter fitted by at least 80% of households and small businesses in 2020, as mandated through the 3rd Energy Package.

Member state	Legal and regulatory status	Implementation status
	level. To be able to access the measurement data, the network operators set up uniform authorisation and authentication procedures. These procedures ensure that individual measurement data is only used for the specific purposes for which the customer has given their consent.	
Norway	Currently, hourly metering is required for large customers with a yearly consumption larger than 100,.000 kWh. New regulations for smart metering were provided on1 July 2011, and according to this all customers should have a smart meter installed by1/1/2017. 80% of customers should have a smart meter by1/1/2016.	The Norwegian DSOs were obliged to report their status for deployment of smart meters by1 January 2012. According to this, most of the DSOs at the moment are in the planning phase of their installation of smart meters. 38 DSOs reported that they have installed smart meters for most of their customers (NVE, 2012). Some power retailers offer contracts at the spot price on an hourly basis.
Poland	No legal framework is currently available but legislation is in progress and is expected to be ready for decision in 2012. In 2008, the regulator presented a feasibility study and presented a timetable for a rollout within 10 years.	National energy platform and smart grid consortium were founded in November 2010 to support the implementation. Energa, RWE Stoen, EnergiaPro, Enea are carrying out pilot projects. Decisions for a rollout depend on clear legal and regulatory guidelines.
Portugal	No legal framework for a mandatory rollout. In 2007, the regulator presented a meter substitution plan for the period 2010–2015 and a list of functional requirements. That plan is co-ordinated with Spain.	The national meter replacement plan started with a pilot phase in 2010. A consortium led by EDP Distribuição started the project InovGrid. Around 100,000 smart meters have been installed in several points of the country (no geographical concentration). EDP also presented the project InovGrid in 2010 (with the InovCity of Évora as a key location, with 30,000 meters), where customers receive near real-time consumption information. In 2012 another 100,000 meters should be installed in 7 Portuguese regions.
Romania	A decision on a rollout is expected in 2012. Currently there is no official plan for a rollout and a cost-benefit-analysis has not been carried out yet. The Electricity Act does not specifically refer to smart metering. The Romanian Energy Law 13/2007 has been recently updated with Article 73 introducing smart metering services but waits for promulgation. The government's strategy and the legislative position are expected to be clarified in 2012.	Some DSOs started with pilot projects. The dominant domestic DSO, Electrica S.A., started with 59,000 meters. The lack of standardisation and both legal and regulatory requirements obviates further investments. The majority of pilot projects are integrated into the billing system.
Slovakia	There is currently no official strategy, legal framework or cost-benefit-analysis available. A possible rollout is under discussion.	DSOs gradually installing smart meters on a voluntary basis preferably for customers with large consumption.
Slovenia	No legal requirements for a mandatory rollout. A cost-benefit-analysis was carried out in 2008 which assumed investment costs of EUR 266 per metering point and a payback period of 11 years for total investments. An update of the study was done in 2010 with positive macroeconomic results. There are no minimum functional requirements available.	So far only Elektro Gorenjska has decided to start a full-scale role out for all of its approx.80,000 customers in 2011. Other companies have not decided on a rollout yet, but some of them are also running pilot projects. Since 2008 all industrial customers have been equipped with AMR-systems.

Member state	Legal and regulatory status	Implementation status
Spain	The Energy Act of December 2007 includes a meter replacement plan for household electricity meters for the period until the end of 2018. Due to some delay in the SM deployment this Act has to be updated in February 2012 with new dates to install meters by DSOs. A set of functional requirements is available. A cost-benefit-analysis has not been performed yet.	The five main companies in Spain (Endesa, Iberdrola, Gas Natural Fenosa, Hidrocantábrico and EON) have already installed over 2,000,000 smart meters in the country. After the launching phase during 2010 and 2011, where first tests were executed, massive installation is currently in progress with hundreds of thousands of units per month. Communications and data bases are also in progress to allow remote management.
Sweden	Sweden was the first country to (indirectly) mandate a full rollout of smart meters. Since July 2009 monthly meter reading is required for smaller customers with a fuse description less than 63 A. Hourly metering should be performed for larger customers. DSOs are responsible for metering. A cost-benefit-analysis resulted in net benefits of more frequent meter readings. Functional requirements are available. There are no mandatory requirements for remote meter reading of gas, heat and water.	From 2009 nearly all end customers had remotely readable electricity meters. 90% of the meters installed have the possibility of hourly metering of consumption, but they cannot fulfil requirements related to hourly settlement because of problems with daily collection and reporting of the hourly values. It is suggested that all customers should have the possibility of entering into agreements that require hourly metering free of charge, but this is not decided yet.
UK	In March 2011, the Government set out the conclusions on the rollout strategy and policy design for the smart metering implementation. Mandatory rollout for larger customers until 2014 (electricity & gas), and mandate in place for domestic and non-domestic electricity & gas rollout starting from 2014 and to be finished in 2019. The main energy suppliers, rather than distribution networks, are responsible for the rollout. The current foundation phase makes the preparations needed for the start of the mass rollout, with minimum requirements for meters and displays set out in SMETS1 (sent to the EC for notification). The next Enduring Phase covers the main rollout period expected to begin in 2014, for which the minimum requirements (SMETS2) are being developed until Sept 2012.	Few utilities are already implementing their rollouts, ahead of the national rollout schedule. First Utility and Spark Energy are offering nationwide rollouts. British Gas and Scottish Power are upgrading customers who need their old meters replaced, and also E.ON UK has started installing smart meters. The UK's largest smart metering trial Energy Demand Research Project (EDRP), with around 58,000 households, was finalised in 2011. The trial was initiated by the regulator (Ofgem). Four suppliers (EDF, SSE, Scottish Power and E.ON) installed smart meters, in-home displays and trialled feedback mechanisms, financial incentives and ToU tariffs

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2 Smart Metering in Europe

2.1 Scope of this report

The progress of defining the regulations and technologies for smart metering differs between Member States. The goal of SmartRegions is to promote innovative smart metering services that have the potential to achieve energy savings and peak load reduction in all Member States. In order to do so this report collects information on the situation of smart metering throughout Europe. This is done by identifying the current national regulations and the offered smart metering services in EU27 Member States and Norway. The information is gathered from national energy agencies and officials, previous and on-going IEE- and other European projects, and other secondary sources as well as literature.

In the particular countries, the respective situation is monitored by the project partners. Table 2 provides an overview of the responsibilities. The responsibility for the content of the country profiles lies with the responsible organisations. The Austrian Energy Agency is responsible for the overall coordination of Work Package 2 and this Deliverable.

Table 2: Responsibility of project partners for monitoring the smart metering landscape

CFEA	**Finland, Estonia, Latvia and UK**
EnCT	**Germany, Czech Republic and France**
SINTEF	**Norway, Sweden and Denmark**
AEA	**Austria, Hungary and Slovenia**
NLA	**Netherlands, Belgium, Luxemburg and Ireland**
ISPE / UPB	**Bulgaria, Greece, Romania and Cyprus**
KAPE	**Poland, Lithuania and Slovakia**
ESCAN	**Spain, Italy, Portugal and Malta**

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2.2 European legal framework for smart metering services

With the requirements of Art. 13 of the so-called *Energy Services Directive* (2006/32/ED, ESD) and the adoption of the *Directive on the internal electricity market* (2009/72/EC), it became clear that the modernisation of the European meter infrastructure and the introduction of intelligent metering systems will have to happen.

The introduction of smart metering represents another major change in the energy sector in Europe. Until the start of the liberalisation process with the transposition of the Directives 96/92/EC and 98/30/EC in the late 1990s, most European energy markets could be characterised as local monopolies. Energy customers were dependent on the local (city or regional) electricity or gas distribution companies to purchase their electricity or gas. These companies were characterised by so-called *vertical integration*: production, transmission, distribution, supply and metering services were supplied by one and the same energy company.

With the start of the internal market for network-dependent forms of energy (electricity and gas), the old energy companies were legally divided into a minimum of two new parties, namely the party involved in supplying the energy (the supplier) and the party managing the distribution network (the network manager). The distinction between the supply of energy (electricity and gas) and the transport of energy was made to ensure fair competition. All energy suppliers are entitled to use the existing networks. Suppliers deliver the energy to the customers via agreements that are concluded through the free-market principle. Electricity and gas are transported and distributed by the network managers. Among others, it is the responsibility of the network managers, who are region-bound and regulated, to maintain the networks they manage. An independent regulatory authority appointed by the government supervises the entire energy market. For early accounts on the policy of the liberalisation of energy sectors in the European Union see e. g. Midttun (1997), Newbery (2000) or Serrallés (2004).

As for the introduction of smart metering in EU Member States, there are two directives that act as drivers: the so-called Energy Services Directives (2006/32/EC, ESD) and the so-called Third Energy Package and particularly Directive 2009/72/EC. Additionally, the recast of the Energy Performance of Buildings directive (2010/31/EU, EPBD) includes a provision on the introduction of intelligent metering systems. An additional push can be expected from the work of the Smart Grid Task Force of the European Commission and the on-going work of European standardisation bodies.

2.2.1 Energy Services Directive 2006/32/EC (Art. 13)

Article 13(1) of the so called Energy Services Directive (ESD) demands that Member States ensure that end customers are provided with competitively priced individual meters that accurately reflect consumption and provide information on the *actual time of use*. The goal of this Directive and thus the objective of introducing individual meters and frequent bills are ultimately to save energy.

However, Article 13(1) only applies to situations where it is technically possible, financially reasonable and proportionate in relation to the potential energy savings. When an existing meter is replaced, the ESD demands that such individual meters are provided, unless it is technically impossible or not cost-effective in relation to the estimated potential long-term savings. There is no limit to the provision of competitively priced individual meters when a new connection is made in a new building or following major renovation work. This therefore means that for new connections, Art. 13 (1) demands that Member States (MS) ensure that final customers are always provided with individual meters providing information on actual consumption rates and actual time of use.

As a consequence, in order to be able to implement Art. 13 (1) ESD a Member State (MS) needs to have an idea of:

- the technical possibilities for providing individual meters,
- the estimated potential long-term energy savings that can be achieved,
- the costs of providing and operating individual meters that also provide information on the actual time of use;

Secondly, the ESD demands in Art. 13(2) that Member States shall make sure that the energy bills are based on actual energy consumption, are clear and understandable, and are provided frequently enough to enable customers to regulate their own energy consumption. Finally, Article 13 defines minimum requirements for energy bills, such as

- current actual prices and actual energy consumption;
- comparisons with previous year's consumption, preferably in graphical form;
- comparisons with comparable average normalised or benchmarked user in the same user category;
- contact to customers organisations, energy agencies from which information could be obtained on available energy saving measures, comparative end-user profiles, tech. specification of equipment;

As ESD Article 13 does not make an explicit link to smart meters, there is substantial variation in the interpretation of Article 13. There are different opinions about the exact meaning of the “actual time of use” or the term “frequently enough”. While for some Member States the existence of individual meters for all final customers combined with an energy bill once a year and meter readings less than once a year fulfils the requirements of the ESD, others interpret the paragraph as a claim for smart meters and monthly bills(Renner and Martins, 2010).

The experience with the transposition of the Energy Service Directive shows that there is a wide variation in the interpretation of the Directive as to which information is to be provided to the customer and how frequently. Moreover, since the general savings target of the ESD is not binding and some of the provisions (such as Art. 13) are rather vague, the causal influence of Art. 13 ESD to the practice of metering and billing in the Member States is weak. In most Member States did the ESD by itself not (and probably will not) trigger the development of smart metering policies? It was rather a combination of legal requirements and the support by the dominating domestic energy utilities that turned out to be the driving force for certain policies (Renner and Martins, 2010).

2.2.2 Directive on internal markets 2009/72/EC (Annex I)

The second and arguably more influential Directive for smart metering policies in EU Member States is the Directive on internal markets (2009/72/EC),[1] which is part of the so-called Third Energy Package.

This Directive demands in Art. 3(11) that, in order to promote energy efficiency, Member States or regulatory authorities shall strongly recommend that electricity undertakings optimise electricity use by, for example, introducing intelligent metering systems or smart grids.

Annex I(1)(i) states that customers must be properly informed about actual electricity consumption and costs frequently enough to enable them to regulate their own electricity consumption. This provision is similar to Art. 13(2) ESD.

Moreover, as part of the measures on customer protection as listed in Annex I, Member States shall ensure the implementation of intelligent metering systems. The implementation

[1] OJ L 211, 14.8.2009

of those metering systems “may be subject to an economic assessment of all the long-term costs and benefits to the market and the individual customer or which form of intelligent metering is economically reasonable and cost-effective and which timeframe is feasible for their distribution.” This is similar to the provisions of Art. 13 ESD that demand cost-effective solutions.

The Directive obliges Member States to produce cost-benefit assessments for the rollout of smart metering before 3 September 2012. Subject to that assessment, a timetable with a target of up to 10 years for the implementation of smart meters shall be prepared.

Where the rollout of smart meters is assessed positively, the Directive on internal markets demands that at least 80% of customers shall be equipped with intelligent metering systems by 2020.

2.2.3 Interpretative note by the European Commission

The European Commission (2010) provided further information and interpretations to guide the implementation of measures in the new Electricity and Gas Directives. Particularly, it outlined the new customer protection measures and provided guidance for the long-term assessment of the cost-benefit analyses that may be carried out on the implementation of intelligent metering systems.

Regarding **billing information** for end customers as demanded by Annex I(1)(i), the Commission services noted that the introduction of appropriate smart meters would greatly assist the fulfilment of this obligation.

For the implementation of intelligent metering systems, the European Commission services (2010, 7) argue that such a system should be able to provide bi-directional communication between the customer and supplier/operator and should also promote services that facilitate energy efficiency within the home. Moreover, the Commission considers the implementation of smart meters as an essential first step towards the implementation of smart grids.

With regard to the **frequency of meter reading**, the Commission's services (2010, 8)consider that receiving information on a monthly basis would be sufficient to enable a customer to regulate their consumption.

As regards the goal of installing intelligent metering services in 80% of households, the interpretation of the European Commission (2010, 8) is that “where an economic assessment of the long-term costs and benefits has been made, at least 80% of those customers who have been assessed positively, have to be equipped with intelligent metering systems for electricity by 2020.”

That is to say that in an economic assessment a Member State may determine these groups of the total number of end customers that have an overall net benefit from the introduction of intelligent metering systems. Only from this group do at least 80% of the customers have to be equipped with electronic meters. Where no economic assessment of the long-term costs and benefits is made, the European Commission issued a declaration to the effect that in that case at least 80% of all customers have to be equipped with intelligent metering systems by 2020.[2] With regard to gas, although there is no specific target date for the implementation of smart metering, the European Commission argues that it should be achieved within a reasonable period of time.

2.2.4 Recast of Building Directive EPBD 2010/31/EU

Art. 8(2) of the recent recast of Directive 2010/31/EU on energy performance of buildings specifies that Member States shall encourage the introduction of intelligent metering systems whenever a building is constructed or undergoes major renovation.[3] Additionally, Member States may encourage the installation of active control systems such as automation, control and monitoring systems that aim to save energy.

2.2.5 Commission Recommendation of 9 March 2012 on preparations for the rollout of smart metering systems (2012/148/EU)

The Commission published a recommendation on the preparations of the rollout of smart metering systems in March 2012. This recommendation addresses the following issues:

1) Data Protection and Security Considerations

2) Methodology for the economic assessment of the long-term costs and benefits for the rollout

3) Common minimum functional requirements

2.3 Smart metering landscape in Europe

The legislative push by the European Union is currently the main driver for the introduction of intelligent metering systems in Europe. As a consequence, the smart metering landscape is highly dynamic at the moment with many Member States adjusting their energy legislation to comply with the third EU energy market package and the Energy Services Directive.

On the other hand, across the European Union, countries are moving towards electronic energy metering as a way of modernising electricity grids and improving the information that is available for grid operators. The modernisation of the electricity grids is the key for the integration of highly volatile sources of electricity such as wind. An intelligent grid does not stop at electricity production but includes flexible customer that help to balance demand and supply.

There are various layers of action in and between EU Member States and different EU institutions that are currently working on standardisation, regulatory recommendations, technical functionalities, and other issues of importance. While some Member States are awaiting the results of these various working groups and task forces, some are actively moving towards smart metering and starting with a rollout independent of existing barriers to the deployment of smart grids.

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[2] Council Document 10814/09 ADD 1 REV 1.

[3] OJ L 153, 18.6.2010.

The overall goal of the SmartRegions project is to promote innovative smart metering services in all Member States that have the potential to achieve energy savings and peak load reduction. That is to say that for this project the matter of importance is the contribution of innovative metering technology and metering services to a sustainable energy system.

Due to the regulatory push and the efforts of market actors, the development of legislation and regulation for smart metering in Europe is highly dynamic. Based on the information gathered in this Smart Metering Landscape Report we analysed all countries along two dimensions:

(1) Legal and regulatory status: By the legal and regulatory status we evaluate whether or not a framework has been created to not only provide clear guidelines to utilities for installing meters but to do so with the goal of achieving energy savings and/or peak load shifting.

To classify each country the status quo has been assessed on the following dimensions:

a) cost benefit analysis and rollout plan,

b) timeline for the rollout,

c) barriers from additional legislation and regulation, e.g. privacy and data protection, measurement and calibration of meters,

d) legal minimum functional requirements;

(2) Progress in implementation: By the progress in implementation we not only refer to the number of pilot projects, smart meters and corresponding services in the field, but also the existence of and progress towards a clear and realistic implementation roadmap for metering technologies that enable metering services with, once again, the goal of achieving energy savings and/or peak load shifting.

To classify each country the status quo has been assessed on the following dimensions:

a) enabling infrastructure,

b) rollout status,

a) services already available to the customers;

As the functionalities of smart meters are crucial for the future deployment of the full potential of the meter related services, the functionalities were the special focus of the survey.

It should be noted that a modified methodology has been used compared to the Landscape Report 2011. Therefore the graphical overview of the Landscape Report 2012 cannot be compared without constraining that of the Landscape Report 2011.

(1) The "***dynamic movers***" are characterised by a clear path towards a full rollout of smart metering. Either the mandatory rollout is already decided, or there are major pilot projects that are paving the way for a subsequent decision. Estonia, Finland, France, Ireland, Italy, Malta, The Netherlands, Norway, Portugal, Spain, Sweden and the UK come under this group.

(2) The "***market drivers***" are countries where there are no legal requirements for a rollout. Some DSOs or legally responsible metering companies nevertheless go ahead with installing electronic meters either because of internal synergetic effects or because of customer demands. We classified Denmark, Germany, Czech Republic in this group.

(3) Austria and Poland ("***ambiguous movers***") represent a situation where a legal and/or regulatory framework has been established to some extent and the issue is high on the agenda of the relevant stakeholders. However, due to lack of clarity within the framework, at this point only some DSOs have decided to install smart meters.

(4) The "**w*averers***" show some interest in smart metering from regulators, the utilities or the ministries. However, corresponding initiatives have either just started, are still in progress or have not yet resulted in a regulatory push towards smart metering implementation. We rank Belgium, Greece, Latvia and Romania in this group.

(5) Finally, "***laggards***" are countries where smart metering is not yet an issue. This group consists of Bulgaria, Cyprus, Hungary, Lithuania, Luxembourg, Slovenia and the Slovak Republic. However, since transposition of Directive 2009/72EC is ongoing, it is possible that the laggards will suddenly gain momentum.

Figure 1 provides a graphical overview of the legal and regulatory situation vis-à-vis the process of implementing smart metering enabling technologies and services with the goal of achieving energy savings and/or peak load shifting.

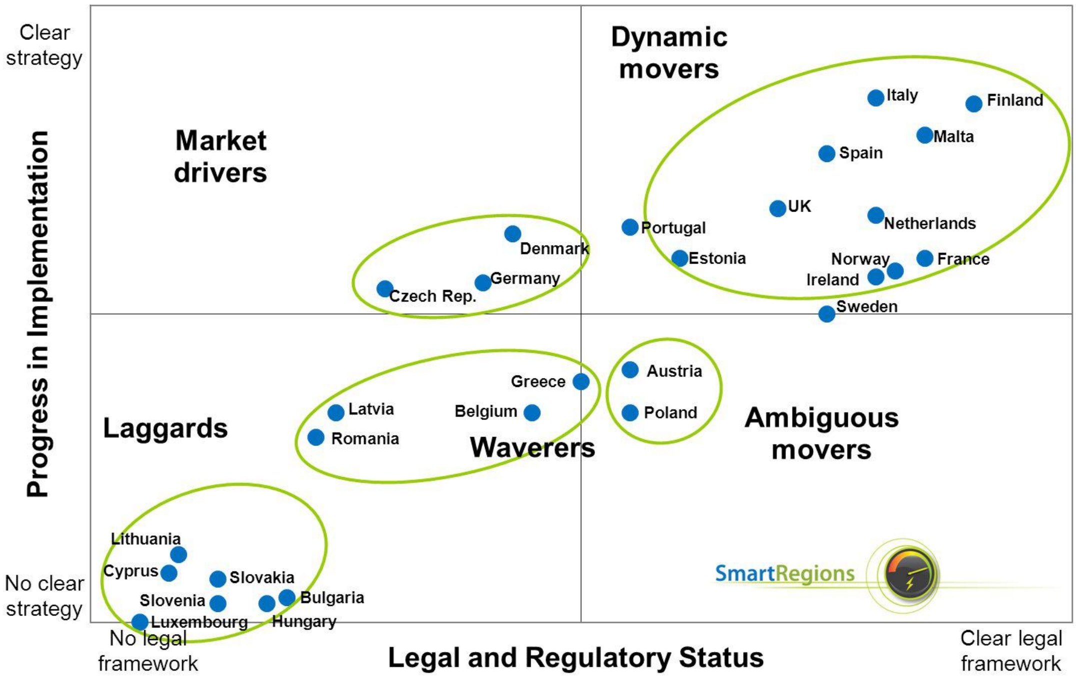

Figure 1: Regulation and implementation of smart metering in Europe

3 Legal and Regulatory Framework for Metering Services

3.1 Austria

3.1.1 Policy objectives for the introduction of smart metering

A few years ago the Austrian Energy Regulatory Authority initiated a discussion regarding the introduction of smart metering systems in Austria. At that time the authority was focused on correct billing based on actual metered data, on better information for customers and on an increase of energy efficiency. Beyond that the regulator expected more efficient data exchange and market processes (e.g. supplier switching) in the liberalised electricity market as well as more cost effective metering and billing.

The network operators, who are responsible for metering services, had a very different point of view. They raised serious concerns regarding the costs of smart metering and the feasibility of smart metering systems in general. They claimed the consideration of all costs of smart metering implementation in the regulated network charges.

Suppliers did not play an active role in the public discussion regarding smart metering and there were no suppliers, with a declared intention to offer new tariff models (e.g. time-of-use tariffs).

3.1.2 Legal foundation of smart metering services

In November 2010, the Austrian parliament passed a new national Electricity Act[4] (ElWOG) which contains general regulations for the national transposition of the 3rd energy package of the EU (Directive 2009/72/EC). Beyond that the Electricity Act authorises the responsible minister (Minister of Economy) to introduce smart metering in Austria, following a cost-benefit analysis. The objectives for the rollout of smart metering systems according to this law are customer information, billing and energy efficiency.

The key points regarding smart meters in the Electricity Act are:

- The Minister of Economic Affairs has to conduct a cost-benefit-analysis for the implementation of smart metering. Then s/he has to consult the Energy Regulatory Authority (E-Control), as well as customer protection bodies and the Austrian Data Protection Commission5. Following a cost-benefit-analysis and a consultation process, the Ministry of Economy may publish a decree for the introduction of the rollout of smart meters. Network operators will be obliged to install smart meters for final customers according to this decree.
- The Energy Regulatory Authority shall publish a decree which determines the functional requirements and the necessary data formats of the smart metering systems.

[4] Elektrizitätswirtschafts- und Organisationsgesetz (ElWOG) 2010, 86. Sitzung des Österreichischen Nationalrats am 30. November 2010.

[5] http://www.dsk.gv.at/DesktopDefault.aspx?alias=dsken

- Network operators will have to meter the consumption of the customers and will have to store these data for billing, customer information and energy efficiency reasons. The network operators will have to provide the metered data and customer information to customers on an internet platform. The data has to be provided on a daily basis at the latest one day after metering. The network operators have to ensure that the operation of the smart metering systems comply with data protection laws and customer protection laws.
- Electricity distributors are obliged to send customers information about their actual consumption and related costs on a monthly basis either electronically or on paper. However, the transfer of consumption data from the network operators to the distributors may be rejected by the customers.
- The Energy Regulatory Authority will determine the requirements for the information to the customers and the data requirements by decree.

The Austrian Regulatory Authority published a cost-benefit-analysis for the introduction of smart metering for electricity and gas in spring 2010 (PwC, 2010). According to this study, which was carried out by PriceWaterhouseCoopers (PwC), the implementation of smart metering in Austria will have strong national economic benefit. The study was very controversial and was challenged by network operators and independent institutions.

The Austrian legal framework determines that metering is a monopolistic task of the network operator. The network operator has the obligation for metering, billing of the network charges and forwarding the necessary data to suppliers and other market players involved. There are no intentions in Austria to liberalise the metering industry.

In October 2011 the Energy Regulatory Authority (E-Control (2011)) issued a decree according to the Electricity Act which determines the functional requirements of smart metering systems in Austria. As it was expected by the stakeholders, the regulator determined in this decree mainly the topics mentioned in a catalogue with minimum function requirements for smart metering systems, which was already published in June 2010 for public consultation.

According to the regulator’s decree smart meters have to comply with the following functional requirements:

- Smart meters need a bi-directional communication-connection.
- Smart meters must provide the possibility of metering and saving meter counts, average power values or energy consumption in 15-minutes-periods. They also have to provide the possibility of saving the daily energy consumption.
- Smart meters must save all metered data for at least 60 days within the meter. It has to be ensured that in case of network failures and disconnection from the grid all data is saved in the meter to ensure a reconstruction of all relevant data.
- Smart meters must provide the possibility of exporting all data via communication ports at least once a day. All the data for one day has to be transferred at the latest by 12:00 (noon) of the following day.
- Smart meters need communication ports which allow at least 4 external meters (e.g. gas, water etc.) to be able to use the communication line of the smart meter in both directions, and which support data transfer from these devices.

- Smart meters have to provide a communication port with an interface that allows unidirectional data transfer to external devices connected to the customer's installation.
- Smart meters and all communication have to be encrypted and protected to avoid unauthorised access to the data.
- Smart meters have to enable the remote disconnection of the customers system, the remote release for reconnection by the customer and a limitation of the maximum load.
- Smart meters have to be equipped with an internal clock. A calendar function must be provided by the smart metering system. There must be the possibility of remote synchronisation of the clock.
- The possibility to receive and process remote software updates has to be provided in compliance with the national weights and measures regulation.
- Smart meters have to comply with the national weights and measures regulation.

Rollout plan

On 24 April 2012 the Minister of Economy has issued a decree, which determines the mandatory timetable for the rollout of smart metering services in Austria (BMWFJ (2012)).

According to this decree the electricity network operators have to equip at least

- 10 per cent of all metering points by the end of 2015,
- 70 per cent of all metering points by the end of 2017, and
- 95 per cent[6] of all metering points by the end of 2019

with smart meters that comply with the regulator's decree mentioned above.

In the moment there are about 5,7 million electricity meters installed in Austria (metering points). For the time being only large customers with an annual consumption of more than 100,000 kWh have to be equipped with at least electronic meters which allow automated meter reading. According to the estimations by the regulatory authority there are already about 150,000 electricity customers equipped with smart meters within the different pilot projects and early rollouts.

The timetable shows that the main rollout of smart meters can be expected in 2016 and 2017.

The new decree also determines that the network operators will have to report to the Minister and to the regulator regarding rollout developments.

The mandatory annual reporting has to cover:

- Latest rollout project plans,

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[6] Within the scope of technical feasibility

- Advance of the rollout,
- Rollout costs,
- Experiences during the rollout,
- Data protection,
- Development of customers' energy consumption,
- Network situation.

3.1.3 Data protection and the concerns of different stakeholders

There are still stakeholders and interest groups in Austria who criticise a lack of privacy and data protection. Discussions regarding appropriate metering periods (daily, hourly, quarter-hourly) and the need of data aggregation are on-going. Some IT-security-experts have raised concerns regarding potential cyber-attacks against electricity networks. Especially the requirement that smart meters have to enable the remote disconnection of the customer systems, seems a critical aspect for these experts and also for customer interest groups.

The Energy Regulatory Authority is preparing a decree, which will determine the level of detail regarding the metered data and the provision of data to suppliers and customers by the network operator.

Moreover it is expected, that the Ministry of Economy will develop an amendment to the Electricity Act this year, which will clarify open issues regarding data protection and privacy.

3.1.4 Smart Metering Landscape in Austria

The new decrees according of the Electricity Act (ElWOG) in Austria will accelerate the rollout of smart metering in Austria. Many network operators were very reluctant as long as there was no clear legal framework. Many of them only have small smart metering pilot projects and some of them have completely refused to deal with the topic so far.

There were only some network operators in Austria who decided to implement smart metering systems at an earlier date. These forerunners in the Austrian market are:

Energie AG Oberösterreich, which is a regional distribution network operator in Upper Austria has installed already about 23,000 smart meters until spring 2011, when the company announced to start the rollout of a further100,000 meters. The overall plan is to install more than 400,000 smart meters until 2018.

LinzStrom, another regional distribution network operator in Upper Austria, has already decided to rollout smart meters for all of its 240,000 customers. LinzStrom deploys 20,000 smart meters a year. For the time being there are more than 60,000 meters installed and the original plan was to finalise the rollout by about 2020. The new national regulations for smart metering will now accelerate the rollout. Within its rollout LinzStrom also tested different Feedback-instruments for customers as Smartphones or internet-applications to investigate energy saving potentials and customer acceptance.

One of the most innovative early adopters of smart metering in Austria is the municipal energy supply company in Feldkirch (Stadtwerke Feldkirch) in the province of Vorarlberg. Stadtwerke Feldkrich supplies customers with electricity and also operates the municipal distribution network with about 18,400 customers (approx. 19,500 metering points). The company started a smart metering pilot project in 2006. In 2007 it decided to implement a smart metering system for all customers in the long-term. So far about 50% of all customers are already equipped with a smart meter and according to the company's schedule the rollout for all customers should be completed by 2016. The company also provides an Internet-platform with comprehensive energy consumption data and also E-mail-information to interested customers. About 500 customers are using the consumption information actively. The customers can choose the level of detail of the data metered and provided. Quarter-hourly consumption data will only be processed upon request by the customer.

3.2 Belgium

Belgium has approximately 5.3 million electricity customers and approximately 2.6 million gas customers. Not all customers also have access to a gas connection. Those who do not use gas (around 50%) heat their homes electrically or with heating oil. Electrabel (part of the major energy company GDF-Suez) is the largest energy producer and energy supplier for most customers in Belgium. Electrabel is also a shareholder in a large number of distribution system operators.

Belgium has a total of around 25 distribution system operators for electricity, and around 15 for gas. Over time, a number of operators have combined their activities and placed them into operating companies, the most important of which are *Eandis* and *Infrax* in Flanders, *Ores* in Wallonia and Sibelga in the Brussels Capital Region. Alongside these, a number of (smaller) distribution system operators also operate independently in both Flanders and Wallonia. Electricity and gas suppliers are separate entities to distribution system operators, the most important of which are *Electrabel*, EDF Luminus, *Distrigas* and *Gaz de France* (GdF). A number of smaller suppliers also exist in addition to a limited number of new arrivals (some from abroad), such as *NUON Belgium*, *Essent*, *Eneco Energie*, *E.ON Benelux* and *Endesa*.

3.2.1 Policy objectives for the introduction of smart metering

The introduction of smart meters in Belgium still is under discussion, mainly because of the complicated legal and energy market situation in Belgium. The country is divided into three regions (Flanders, Wallonia and the Brussels Region) with highly autonomous energy authorities. Although Belgium does not yet have any legislation regarding the (compulsory or otherwise) introduction of smart energy meters in place, the advantages of smart metering are becoming a relevant issue in Belgium. This theme is high on the agenda of nearly all stakeholders in the market.

In Flanders, a network operator-driven rollout decision for a phased introduction of smart meters is still subject to final political consideration. For Wallonia and the Brussels Region, similar considerations are taking place but progress is not as far along as in Flanders.

Flanders

The most important trigger for these developments in Flanders is the fact that there are many complaints about late or incorrect invoices. This turned into (excessively) high costs for the energy suppliers and ultimately also for the energy customers. By order of the Flemish regulator VREG, KU Leuven conducted a study into the communication methods that could be used to communicate with smart meters. In 2006 VREG also performed a comprehensive analysis of the market forces in Flanders, in which the subject of smart energy meters played an important role. Cost-benefit analyses have also been performed. In addition, a number of network operators are currently conducting pilots.

In 2008 a social cost-benefit analysis regarding the financial feasibility of the introduction of smart meters in Flanders was conducted by order of Flemish regulator VREG (KEMA, Schrijner et al., 2008). The objective of this analysis was to obtain an insight into the costs and benefits of a large-scale introduction of a smart metering infrastructure for the gas and electricity usage of customers in Flanders. The conclusion was that, from a social point of view, there appears to be a *negative* business case. The value of the reference alternative shows a *negative* balance of - EUR389 million. The cost-benefit analysis in Flanders took into account a potential energy savings (as a result of feedback of meter data) of 1.5%.

In 2011, the cost-benefit analysis was updated by KEMA by order of the Flemish regulator VREG. The new report, published in January 2012, now shows a positive business case of a complete rollout of + EUR144 million. This is a result of expected lower investment costs on the one hand, such as for data management and higher adjusted savings and on the other hand, such as for meter data collection, energy savings from feedback and dynamic tariffs and revenues for switching supplier and moving home contributed to the positive net result.

Brussels and Wallonia

In 2009 a comparable cost-benefit analyses for the Brussels Region –that showed similar initial negative results(CWAPE, 2009; Hujoel, 2009)- was also updated in 2011. An extensive scenario based on an economic, environmental and social impact analysis was re-worked, based on a dedicated cost-benefit tool developed by Cap Gemini. This report, presented to the Brussels regulator BRUGEL in May 2011, again tended towards a negative business case, resulting in advice to the regulator not to make a premature decision on the rollout of smart meters.

In Wallonia a similar extensive scenario based on an economic, environmental and social impact analysis is still under construction. The outcomes of this study are expected to be presented to the Walloon regulator CWAPE later in 2012.

3.2.2 Legal foundation of smart metering services

Belgium does not have any legislation regarding the introduction of smart energy meters. The introduction of smart meters is still in the research phase. The EU directive regarding energy efficiency for end users and energy services (2006/32) has not yet been fully implemented.

Recently a vision document relating to the market model in Flanders was published (VREG and Deloitte, 2009). According to the document a rollout in Flanders over the period 2012 – 2020 is feasible. The rollout of smart networks should also be completed by 2020.In Flanders, VREG has drawn up an overview of the possible functions of a smart meter (for both electricity and gas). Functionality is divided into *basic functions* which must be provided on the smart meter in all cases, and *optional functions*, that are not (yet) available on a basic meter, but which shall be deemed to be of interest in due course. Optional functions referred to include: real time and on-demand availability of quarterly values, phase-sequence control, the option to choose the phase for grid balance and Euro values on the meter display.

3.2.3 Smart Metering Landscape in Belgium

Referring to the vision document relating to the market model in Flanders mentioned above (VREG and Deloitte, 2009), there is consensus about the need to introduce smart meters for the future functioning of the energy market, where 'functioning of the market' is broadly defined so that both the technical (network management) and commercial (market processes and services) aspects are included. There is also consensus about the fact that the installation of the smart meters is a task for the network operators. However, the energy suppliers do want to have input in the (technical) specifications of the smart meters. The idea behind this is the fact that they want to offer metering services using the smart meters.

Regarding metering services, no information on existing smart metering services that have already been implemented and marketed could be obtained. Instead, the focus in Belgium is mainly on the technical tests of the meters and the communication technology. A number of different pilot projects are in progress or under preparation.

The Flemish network operator Eandis has launched the smart meters installation in three phases. An evaluation will follow each phase to decide whether the project will be continued. In the second quarter of 2010 around 4,000 meters were installed in the cities of Leest and Hombeek, near Mechelen. In the second half of 2012 the pilot project will be expanded to 40,000 households and the rest of the coverage area is expected to follow from 2014 onward. Eandis has developed a smart electricity meter communication system under its own management. For the communication between the meter and the centralised data server Eandis uses a proprietary invention for the real-time exchange of information.

In addition to these technical aspects, economic and ecological aspects are also included in the pilots. Among other things Eandis expects it will be able to resolve power outages more easily and that more accurate and correct usage invoices can be formulated when people move home. Eandis also hopes that energy fraud, which is currently estimated at around 1.5%, can be reduced considerably. Approximately EUR 135 million has been budgeted for the first two phases. The cost for the complete introduction of smart meters in the Eandis coverage area - approximately 2.5 million electricity meters and 1.5 million gas meters - is estimated at around EUR 1.5 billion. It is expected that the entire coverage area will have been provided with smart meters by around 2019.

3.3 Bulgaria

The electricity sector in Bulgaria is managed by the State Energy Regulatory Agency. Under the Agency, the Nationalna Elektricheska Kompania (NEK) was split into six independent generators, a national transmission system operator, and seven regional distribution system operators. Three distribution regions in western Bulgaria (including the Sofia region) are owned and operated by CEZ, two distribution regions in north-eastern Bulgaria are owned and operated by E.ON, and two distribution regions in southeast Bulgaria are owned and operated by EVN. Currently, most of the thermal electricity generation capacity is privatised (the hydropower and nuclear plants are still State-owned), all of the electricity distribution companies have been privatised, and the district heating companies are still primarily owned by the State or Municipal governments. (www.energymarketsgroup.com)

In line with Directive 2003/54/EC and the Energy Act, the electricity market in Bulgaria has been fully liberalised since July 2007. Since 2005, 67% of the Electricity distribution business has been owned and run by 3 non-Bulgarian companies via stakes in 7 of the 8 distribution businesses: EVN, CEZ and EON. Gas distribution and metering is owned and run by 40 companies supplying only 1% to residential customers. The dominant player with 88% of total consumption is Bulgargaz EAD. With 25% of the total energy consumption district heating is the dominant form of heating in major cities (Open Meter Consortium, 2009, 30; 60).

3.3.1 Smart Metering Landscape in Bulgaria

The energy sector in Bulgaria has undergone major restructuring in recent years. One of the most important factors for the power sector reform and for attracting private investors is achieving regulatory stability in the country. The Energy Law, adopted in December 2003, establishes the energy sector legal framework and sets the basis for the creation of a transparent and predictable regulatory environment where the key regulatory responsibilities are vested with the State Energy and Water Regulatory Commission (SEWRC). The role of the energy regulator to effectively balance the competing interests of the investors and customers is of critical importance for the success of the power sector reform. (www.bulgaria.usaid.gov)

Figure 2: Electronic meter by EVN Bulgaria

The Bulgarian Minister of Economy, Energy and Tourism announced during the Third Annual Conference on “Smart Grids for Power Transmission and Distribution” that the use of smart grids in Bulgaria is scheduled to start in 2012 and will help make companies more competitive. The so-called smart grids are in fact electricity networks that can intelligently integrate the actions of all users connected to them – generators, customers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. (www.energia-online.eu)

Smart Grid implementation is just beginning in Bulgaria. In October 2011, CEZ announced plans to have 23,500 smart energy meters installed in western Bulgaria by the end of 2012 to help modernise its power grid and boost efficiency. CEZ has already installed more than 18,000 smart meters costing some BGN 66 million ($46.5 million) since 2009. The smart meters will enable more efficient use of energy by adapting customers’ supplies to changing daily demand patterns and enabling customers to feed unused electricity back into the grid. Initially, these smart meters will only be used for remote metering of power consumption until the country fully liberalises its power market and customers start choosing between different providers. (www.energymarketsgroup.com)

According to a local press report the majority of these smart meters have been installed in Sofia, Kyustendil, Lom, Ihtiman, Dupnitsa and Blagoevgrad in the west of the country.(www.metering.com)

There are two factors that might act as drivers for electronic metering: First, non-technical losses are reported to be up to 25%. This is why a considerable number of electronic meters with remote reading have been installed since 2006. Secondly, about 22% of all complaints in the electricity sector relate to "errors in metering and bills calculation." Moreover, about 18% of total complaints to electricity distribution operators are related to disputing the calculation of interim bills caused by quarterly metering and mistakes working out the bills.

3.4 Cyprus[7]

Cyprus has a relatively small electricity market and no gas market. The electricity industry is dominated by the state owned Electricity Authority of Cyprus (EAC) that was established in 1952 as an independent semi-governmental vertically integrated electricity provider. EAC generates and supplies more than 90%of the electricity in Cyprus. Electricity is produced in three power plants owned and run by EAC and by one relatively big RES producer, some auto producers and many small RES producers. EAC also owns and operates the transmission and distribution networks. Competition in the electricity market is weak, although there are some producers that have entered the generation sector by producing electricity for their own use.

As from 1 of May 2004, 35% of the electricity market was opened to competition and this was extended to 65% (all non-domestic customers) as of 1 January 2009. Following the terms stated in the law, an independent Cyprus Energy Regulatory Authority (CERA), consisting of three members, was appointed in January 2004. The functions and responsibilities of the Energy Regulatory Authority cover the electricity and the natural gas sectors. CERA has executive duties and responsibilities in the energy sector such as recalling generation licenses, encouraging competition in order to achieve price reduction, and regulating prices and charges related to the production, transmission, distribution and supply of electricity.

In terms of Renewable Energy Sources (RES), 4% of the country's energy originates from solar energy, and is mainly used for heating water. 1% of the energy supply comes from solids, and is used for industry. 50% of the energy supply is used for transportation, whereas industrial, residential and tertiary sectors use 27%, 15% and 8% respectively. Oil products, mainly used for transportation, contribute the most to the net domestic consumption per fuel (80%), with electricity, solar and coal providing 16%, 2% and 1% respectively. The net domestic consumption per fuel, gives a total of 1.66 Mtoe (according to 2000 data). With respect to solar energy use, the EU Study "Sun in Action" ranks Cyprus first with approximately 1m² of installed solar collector per capita. Today, about 690,000 m² of solar collectors are installed in Cyprus. Approximately 90% of privately owned houses, 80% of apartments and 50% of hotels are equipped with solar water heating systems. (www.planbleu.org)

3.4.1 Policy objectives for the introduction of smart metering

The DSO of Cyprus, which is part of EAC, the vertically integrated utility of Cyprus, is currently working on a pilot project to install 3000 smart meters. This project started in July 2010 and is going to publish a cost and benefit analysis report by July 2012. The pilot project is scheduled to investigate all technologies available for achieving all the basic functions and the interoperability objectives of the European Commission using a communication architec-

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[7] Information about the situation in Cyprus was kindly provided by Katerina Piripitsi, Industrial Extensions Officer at the Ministry of Commerce, Industry and Tourism, Cyprus.

ture that will fully facilitate the evolution of smart grids on the island. The declared strategy underlines the objective of moving towards a full rollout for smart meters for all electricity customers in Cyprus that will be based on the findings of the pilot project that is currently in progress.

3.4.2 Legal foundation of smart metering services

There is no legal framework for the provision of smart metering services in Cyprus but at the same time the current legislation does not hinder the evolution of smart meters or smart grids on the island. More generally, the electricity market is regulated by a number of laws and regulations. The main element of the framework is the Cyprus Law on Regulating the Electricity Market which provides a framework of rules for the generation, transmission, distribution and supply of energy throughout the island. Following the implementation of this Law, competition in the production sector was introduced as well as in the supply for eligible customers. In addition, it enables access to electricity networks, ensures public service obligations and introduces effective and independent regulation.

3.4.3 Smart Metering Landscape in Cyprus

Cyprus is on the road of meeting the European objective of replacing the existing damp meters with smart meters which will satisfy the expected functionalities that are currently under discussion within the various working groups of the EU. A pilot project for installing 3000 smart meters with all related technologies is under way and the strategy for the full rollout will be developed on the lessons that will be learned from this pilot project. The pilot project is expected to be completed by July 2012.

3.5 Czech Republic

In the Czech Republic there are no legal obligations concerning smart metering. The metering market is regulated and unbundled. A national rollout plan is under discussion. The main progress in the smart metering landscape has until now has been made through pilot projects. Any possible rollout will depend on the information gained from these projects, specifically regarding the question of costs and benefits.

3.5.1 Policy objectives for the introduction of smart metering

The Czech energy policy is defined by the State Energy Policy. A new energy concept has been in preparation for several years but been delayed several times, and was expected to be completed in June 2012 (Ministerstvo Průmyslu a Obchodu, 2012). The current policy document dates from 2004, but has been amended several times, most recently in February 2010 (Ministerstvo Průmyslu a Obchodu, 2010).

The current version of the policy document mentions smart metering only as a measure to improve energy efficiency. Other policy objectives as described by Vasconcelos (2008) can also be assumed, however. As the Czech Republic is committed to increasing the share of renewable energy sources in the energy mix to 13% by 2020, the use of smart metering for the integration of RES can also be assumed as a motivation to introduce smart metering, as well as the compliance with EU directives (IEA, 2010, 22-25).

A first cost-benefit analysis for smart metering in the Czech Republic was conducted by the energy utility *ČEZ* and the Ministry of Industry and Trade in 2006. At that time, the costs of a smart metering rollout were considered to outweigh any potential benefits (ERGEG, 2009, 25). A new analysis was required for September 2012 - data is currently being gathered from various pilot projects for this purpose. (ESMA, 2010, 18).

3.5.2 Legal foundation of smart metering services

The main legal document regarding energy regulations and obligations is the Energy Act, which was most recently amended in June 2011 to comply with the EU 3rd Energy Package. As the Czech Republic does not yet have an official implementation plan for smart metering, the Energy Act contains no obligations on installing smart meters or offering smart metering services (ESMA, 2010; Open Meter Consortium, 2009, 31). Instead, it sees the national cost-benefit analysis as the next necessary step, and lists this as one of the responsibilities of the Minister of Industry and Trade. This is the only mention of smart metering in the current Energy Act. (Energetický Zákon, 2011, § 16k).

According to Vasconcelos (2008) the regulatory regime of electricity meters in the Czech Republic is regulated and unbundled. The DSO can outsource the installation of the smart meter to a metering company, but remains responsible for the meter (ERGEG, 2009, 19f).

Czech legislation does not define a smart meter or its functions. Nevertheless, the regulator defines a smart meter as a metering system that can measure data on consumption, collect data and support two-way communication. It also stipulates that a smart meter should be compatible with supplementary equipment such as displays (ERGEG, 2009, 11).

3.5.3 Smart Metering Landscape in the Czech Republic

In the Czech Republic a national rollout plan is still under discussion, but progress in both implementation and regulation of smart metering will depend on the results of the national cost-benefit analysis. Until the analysis is concluded and regulation is clearer, the smart metering landscape in the Czech Republic is limited to pilot projects initiated by market actors (Martin, 2011).

In 2006 *E.ON Česká Republika* installed more than 4000 smart meters in a region of South Moravia in a trial focusing on the technical feasibility and reliability of the technology being tested. The meters did not provide customers with additional feedback, and *E.ON* has not announced any further planned pilots. (Martin, 2011)

The main utility for the region of Prague, *PRE*, launched a pilot smart grid project in 2009. The trial involved the installation of 3000 meters in Prague households and was due to be completed in December 2011. Results have not yet been released, but *PRE* will base any continuance of smart meter installation on the “interests and needs of customers” as well as the results of the national cost-benefit analysis (Martin, 2011).

The company *ČEZ* began a one-and-a-half year pilot project in the east Bohemia region with just under 2000 metering points in 2009. Similar to the *E.ON* project, this pilot focused on technical issues and not on products for customers.

Unlike *E.ON* and *PRE, ČEZ* increased its involvement in smart metering after completion of the first pilot. More than 32 000 smart meters were installed in various pilots under the title “FUTUR/E/MOTION”, a smart grid pilot project in cooperation with Hewlett Packard. Part of this project, taking place in the town of Vrchlabi, is now part of the “Grid4EU” project (7th Framework Programme). The smart metering pilot will run until 2013, while the project is expected to run until 2015. CEZ announced in May 2012 that it was not planning any further smart meter installations, naming the low level of customer interest as a reason (Stabrawa, 2012).

3.6 Denmark

Since January 2005 Denmark has mandatory hourly metering of the electricity consumption for customers with a yearly consumption larger than 100.000 kWh. This represents 46,000 customers. Smaller customers are "load profile customers" (DERA, 2011). Mandatory metering of the electricity consumption of smaller customers has been suggested, but the implementation costs exceed the benefits for these customers. Nevertheless, trials have been performed focusing on electricity and heat.

3.6.1 Policy objectives for the introduction of smart metering

There are no plans at the moment to deploy smart metering technology to end customers with lower demand. In 2008 there was a proposal regarding mandatory AMR for all customers, but studies concluded that the investment was not profitable, and that the costs for implementing smart meters exceeded the gains for households (Open Meter Consortium, 2009). An analysis described in Energinet.dk (2009) concludes that there were no socio-economic reasons to reduce the limit for hourly metering of 100,000 kWh/year, because the value of a price flexible demand was lower than the required investments and management costs. This conclusion was based on high technology costs and no scarcity of power capacity for the coming 10 years. Since the technology costs are expected to decrease and the power capacity margin is expected to be reduced, the analysis is expected be repeated in a few years.

However, some DSOs have found it profitable to invest in smart meters, and approximately 50% of customers will have remote reading in 2011. Also according to ESMA (2008, 15) demand response is one of the main drivers for the introduction of smart meters in Denmark. However, if demand response alone were to pay for new meters, this would not be economically viable.

3.6.2 Legal foundation of smart metering services

3.6.2.1 Provision in the Energy Law

From first of January 2003 hourly metering was mandatory for metering points with a yearly consumption larger than 200,000 kWh (ESMA, 2008). Since 2005 hourly metering of electricity consumption has been mandatory for end customers with a yearly consumption larger than 100,000 kWh. The same requirement has been mandatory for heat metering since 1991. There are no requirements regarding gas meters(Open Meter Consortium, 2009).The lowering of the limit for hourly metering involved approx. 9,000 new customers being equipped with hourly metering (Morch, 2008).

Today Danish metering regulations allow for long intervals between manual readings of household electricity meters. Most of the DSOs in Denmark use self-reading via telephone or the online as their primary method for collecting meter data. But there is a strong and growing interest in Smart Metering technology among the Danish DSOs (Ryberg, 2009).

There are no requirements for the remote reading of the heat consumption, but many companies install remote reading meters. The market penetration of district heating is 60%.

There are no apparent initiatives concerning remote metering of gas (Open Meter Consortium, 2009).

In Denmark it is an on-going work to establish a central register for meter data from customers with smart meters. The data hub gives customers easier access to their meter data and makes it easier to change power supplier. The data hub will also simplify the data traffic in the power market, were actors today communicate many-to-many. The data hub will also improve competence in the power market[8].

The first version of the data hub will be available in October 2012.

3.6.2.2 Market model

In Denmark the EU directives for the liberalisation of the energy market were fully implemented in January 2003, when all electricity customers became eligible to choose their own suppliers. Denmark has the largest gas network in the Nordic countries, with 13% of households connected. More than 50% of households have district heating, and Denmark has the largest population of heat meters in Europe (Ryberg, 2009).

The Danish utility industry is characterised by multiple utility companies that often supply gas, heat and water as well as electricity. In Denmark approximately 115 electricity DSOs operate on a local or regional level. Many of these companies have ventures in cable TV, the Internet and other telecom-related services. With exception of the State-owned DONG,[9] the DSOs are mainly owned by customers (Ryberg, 2009).

The DSO is responsible for the metering of electricity and gas consumption. The local government is responsible for the distribution of water, and also for metering water consumption.

3.6.2.3 Minimum functional requirements

Electricity consumption should be metered on an hourly basis for larger customers (100,000 kWh/year). There are no such mandatory requirements for smaller customers but an announcement for new requirements has been presented. In January 2009 the Danish Minister for Energy and Climate established a working group to investigate the possibility for establishing some harmonised functionality requirements for the metering of electricity in Denmark (Energistyrelsen, 2009b). The working group should suggest minimum requirements for meter data that should support the spread of flexible electricity consumption.

Example of suggested requirements are (Energistyrelsen, 2009b) (Under discussion):

Mandatory:

- Remote meter reading should be possible.
- The meter should register both electricity consumption and production.
- The meter should have a display showing electricity demand.

[8] http://energinet.dk/DA/El/DataHub/Sider/Baggrund-og-krav.aspx (2012-04-13)

[9] www.dong.dk

- Consumption data should be registered and stored in the meter location. The data should be available from the meter within a period of at least 30 days after the date for settlement.
- If the settlement is based on time varying prices, it should be possible to get the historical data on a display.
- It should be possible to connected external equipment to the meter.
- Open standards should be used for connecting and communication with external equipment.
- Meter data should be available via the Web.
- The interval for collecting meter data from customers should be adjustable according to settlement and invoicing schedules and according to market regulations. The DSO should be able to collect the meter data on demand.
- The electricity demand should be registered with the frequency defined by the authorities (both 15 and 60 minutes registration frequencies are presented as possible alternatives in the report.)
- Interruptions/outages should be logged.
- The meter should have an output for remote load control.

Optional (Advisory)

- Max. and min. power for the day should be available on the meter.
- Metering of consumption and production of active and reactive power.
- Separate port for connecting external equipment used by the DSO.
- Possibility of meter data from other energy sources (heat, water and gas).
- Output for load control of external equipment.

3.6.2.4 Smart Metering Landscape in Denmark

Since January 2005 Denmark has had mandatory hourly metering of the electricity consumption for customers with a yearly consumption greater than 100,000 kWh. Mandatory metering of the electricity consumption of smaller customers has been suggested, but the implementation costs exceed the benefits for these customers.

Even if there are no mandatory requirements regarding AMR for smaller customers, several trials have been performed – focusing on electricity and heat (See Figure 3). In some trials water data are also collected. There are no apparent initiatives for gas meters.

Totally there are 3 million electricity metering points in Denmark, and about 50% of these have already had smart metering technology installed or the DSOs are planning to do this. A map of the implementation of smart metering technology in Denmark is shown in the figure below. The red areas plan to have installed or have already installed smart metering technology.

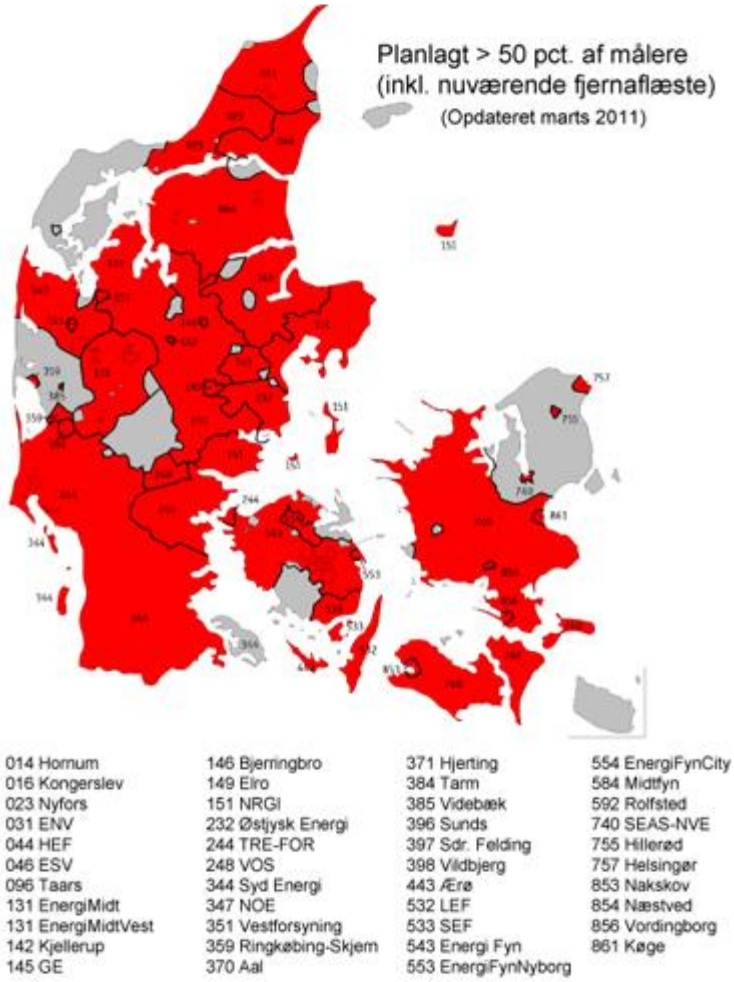

Figure 3: Danish map ofsmart metering technology (www.danskenergi.dk – March 2011)

Table 3.1 presents an overview of the number of meters installed in Denmark. In the near future approx. half of the load profile customers will have remote meter reading. The meter data will not yet be used for settlement, but several DSOs offer the customers the possibility to see their hourly consumption in graphs and tables online (Energinet.dk, 2011).

Table 3.1 Distribution of customers according to methods for metering and settlement (Energinet.dk, 2011)

Distribution of customers	**Number of customers**
Load profile customers w remote meter reading by the end of 2009	550,000
Load profile customers, w/o remote meter reading, but will get remote meter reading IN 2010	420,000
Load profile customers, w/o remote med reading, but will get remote meter reading AFTER 2010	680,000
Load profile customers, w/o remote meter reading, with NO plans for remote meter reading	1,540,000

Customers settled on an hourly basis, in total	50,000

In a document presenting the energy strategy until 2050 for the Danish Government (Danish Government, 2011), it is specified that the government in 2013 is evaluating lowering the limit for the installation of intelligent meters from 100,000 kWh/year to50,000 kWh/year. The government will also ask the DSOs to replace all electricity meters which are replaced after 2015 with intelligent electricity meters. A final decision has not been made yet.

Lowering the limit for hourly metering without changing the market model, will make it more challenging to increase the flexibility in consumption. Today, load profile customers have a subscription fee of approx. DKK 500 (EUR 67) per year, while customers with hourly settlement of their consumption have a subscription fee of approx. DKK 5,000 (EUR 672) per year. The subscription fee for hourly settlement is too large for residential customers to benefit from hourly settlement (Energinet.dk, 2011).

The increase in the number of trials for smart metering technology for different types of energy commodities, combined with initiatives for new electricity pricing systems may increase the focus on the implementation of smart metering technology. Since the Danish utility industry is characterised by multiple utility companies that often supply gas, heat and water as well as electricity, this technology will also contribute to the development of different smart metering services that will further contribute to increased energy efficiency and reduced energy consumption – for electricity, heat, and maybe even gas too.

3.7 Estonia

3.7.1 Policy objectives for the introduction of smart metering

According to the responsible Ministry (The Ministry of Economic Affairs and Communications), the plan is to replace all old meters with remotely readable meters by the end of 2017. The minimum requirements are defined and large-scale smart meter rollout begun in 2011, with 220,000 meters installed by 2013 and full rollout by 2017.

The Estonian government will exercise its policy to implement the rollout through the dominant DSO OÜ Jaotusvõrk, a subsidy of Eesti Energia, nearly 90% of which is owned by the Estonian state. The Grid Code (National legislation) states, that from 1 January 2017 the measuring system shall enable to measure active energy by a remote reading device. Also from 1 January 2013, the remote reading device must enable the data to be transferred to the service provider using a data network, at least once a day.

In addition, smart meters are discussed more in the Energy Sector Development Plan for 2030, which will be completed by the end of 2013.

Compliance with EU-directives

As a requirement of directive 2006/32/EC (ESD), Estonia issued a National Energy Efficiency Action Plan (NEEAP) that includes measures to improve energy bills. Additionally, in the list of things to do to comply with the ESD the Estonian NEEAP states: “Establish requirements for installing individual meters, if justified, in the Energy Efficiency Regulation.”

No official cost-benefit analysis (as required by Directive 2009/72/EC) has been performed yet. Still, when last reviewing the Grid Code (national legislation), the implementation of smart meters was also analysed and content concerning smart metering was added (see the previous chapter).

Support for competition in the energy market,

The privatisation of large-scale firms, such as energy, is in progress. Power production, transmission, distribution and sales are legally separated and third party access is regulated. However, the current energy market can be characterised as a State-owned monopoly. The Estonian TSO, Elering OU, is owned by the State-owned Eesti Energia AS as a vertically integrated undertaking. The unbundling would see the State buying the Elering OU shares and different ministries would manage the shareholdings of Eesti Energia AS and Elering OU. The Estonian Government is giving high priority to its energy sector in its on-going economic reform programme. Actual management of energy infrastructure is to be decentralised to the local municipal level where possible, the energy regulatory functions carried out by mostly autonomous agencies, especially in cases where monopolies continue to exist. In January 2001, new electricity tariffs were established that enable customers to choose their electricity supplier (Iklaa, 2010; Shargal, 2009).

3.7.2 Legal foundation of smart metering services

According to the responsible ministry, at the moment smart metering services only include hourly consumption readings provided to the customers, where applicable. In the future, the addition of information on grid quality, remotely controlling meters (switching on/off), error information etc. is provided for. Also, there are plans to supply customers with displays that provide information on their current and historical consumption.

3.7.3 Smart Metering Landscape in Estonia

The responsible ministry (The Ministry of Economic Affairs and Communications) has plans to replace all old meters by remote reading meters by the end of 2017. The minimum requirements have been defined and large-scale smart meter rollout begun in 2011, with 220,000 meters installed by 2013 and full rollout by 2017.

Instead of formal national regulatory requirements, the Estonian government will exercise its policy to implement smart metering rollout through the State-owned dominant DSO OÜ Jaotusvõrk. The dominant DSO OÜ Jaotusvõrk is now installing smart meters throughout its entire network (638,000 units in total) over four years between 2011 and 2015, including replacing the existing stock. OÜ Jaotusvõrk has around 55,000 remotely readable meters installed 1995 - 2010. Also other larger DSOs, including VKG Elektrivõrgud and Fortum Estonia, are having a rollout or planning to rollout smart meters respectively. When the deployments of the three largest DSOs are completed, Estonia will have approximately 97% smart metering coverage of the estimated 720,000 metering points. (Smart Grid Opinions 2011).

According to the above-mentioned plans, the DSO-led rollouts will result in high smart meter coverage by 2017. However, the current monopoly-like situation on the energy markets may not be the most encouraging context for the uptake of new and innovative smart metering services. Yet, as the market opening gradually increases the competition between energy suppliers, a more encouraging context for innovations is likely to develop.

3.8 Finland

3.8.1 Policy objectives for the introduction of smart metering

Compliance with EU-directives:

The overall responsibility for implementing the energy end-use and energy services directive (ESD) is with the Ministry of Employment and the Economy (MME).

Parts of the ESD are transposed by the following regulations:

- Electricity Market Act (386/1995) and Decrees (581/1995, 66/2009) under the law (including the new decree requiring electricity smart meter rollout)
- Natural Gas Market Act (508/2000) and Decree (622/2000) under the law.
- Law on Energy Services - obligations for energy retail sellers to give feedback and energy saving information to end-users (came into force in 2010)
- Voluntary Energy Efficiency Agreements and Action Plans for Industries, Energy Services and for Distribution of Liquid Heating and Transport Fuels
- (ESD CA Finland, 2011.)

With these legal acts, the ESD Article 13 requirements regarding electricity metering have been implemented in Finland. Moreover, the implementation is reinforced and even exceeded with the new electricity metering decree demanding at least 80% roll-out of electricity smart meters to all customers by 2014. This decree also implements the EU's 3rd energy package requirements.

In district heat metering, the ESD requirement of individual meters is implemented so that metering the consumption of an individual client, such as a house or a housing company, is considered sufficient. Thus apartment-specific metering is quite rare, in residences other than single-family houses.

In many older residential buildings, there are no apartment-specific water meters, and only the total consumption of the whole house is metered. From the beginning of 2011, the building regulations concerning water and drainage systems make installing apartment-specific water meters mandatory in new buildings.

A **cost-benefit analysis** as required by Directive 2009/72/EC has been performed in Finland. The Finnish cost-benefit analysis dealt with the evaluation of possible benefits and possible costs at a general level. The Ministry of Employment and Economy has roughly estimated that the costs of a full rollout are EUR 565 - 940 million (for 2.2 million customers who do not yet have AMR). The costs will be compensated through operating cost savings for DSOs and suppliers, customers' energy saving and more effective electricity market and network operation through demand response activities.

Support for competition in the energy market

Finland's electricity market gradually opened to competition after the passing of the Electricity Market Act (386/1995) in 1995. Since late 1998, all electricity users, including private households, have been able to choose their preferred electricity supplier.

The purpose of the electricity market reform was to increase the efficiency of market operation and to integrate Finland's electricity market into the pan-Nordic market. These liberalisation and integration actions increased productivity and environmental efficiency, as the Nordic hydropower capacity can now be utilised efficiently.

Customer protection

In Finland, the main customer issues are related to the smart meter costs versus benefits for customers and problems arising from changing flat estimated bills to real consumption-based bills (affecting mostly electricity heating bills in wintertime). Also, general concerns have arisen from the false interpretation that customers are forced to adopt hourly-based market tariffs, when the metering is hourly-based. The smart metering data safety issues are not considered to be a big problem, while the Metering Act on smart meter rollouts defines the DSO responsibilities regarding data security. The common societal trust between citizens, authorities and utilities is generally quite high, and people generally accept well new solutions and technology.

Energy efficiency and carbon reduction

Along with implementing the EU directives and energy market packages, the key policy issue stated specifically for the smart meter rollout is introducing demand response to guide the electricity market towards more economically and environmentally efficient operation.

Smart grids

Developing the energy infrastructure towards smart grids is a longer-term national objective, with smart meter rollout being one of the first steps. Considerable amounts of both public and private funding are allocated to smart grids R&D work.

Energy security

Energy security improvement through energy efficiency is an acknowledged goal, and the demand response applications of smart meters are seen as potential solutions in this. However, the public and political discussions on energy security seem to generally focus more production side solutions, such as nuclear power and renewable energy.

3.8.2 Legal foundation of smart metering services

Smart metering regulation in Finland currently only covers electricity. There are no official plans for smart district heat or water meters. However, automatically read district heat meters providing hourly-based readings are starting to be the industry standard in energy utilities.

The Electricity Market Act (66/2009) on electricity supply reporting and metering, requiring a smart metering rollout by the DSOs, came into effect 1 March 2009:

- In 2011, all connection points over 3x63A must have remotely readable hourly metering.
- By 2014, full smart metering penetration is required, although a maximum of 20% exception is accepted when: the user has max. 3x25A main fuses, or over 3x25A main fuse but the use is no more than 5000 kWh/a (and the electricity is bought from seller obliged to supply).

The Finnish market model is regulated and partly monopolised: meters belong to the regulated activities of the DSOs, who have limited obligations to offer information to the customer and other parties. The minimum functional requirements defined by the Electricity Metering Act are:

- The DSOs are responsible for arranging the metering, reading the meters, the validity of the meter data, and reporting and forwarding the meter data;
- The remotely read hourly metering data is available next day to the customer and electricity supplier. Also a 3rd party authorised by the customer has the right to receive the data. (comes into force from the beginning of 2014);
- If requested by the customer, the DSO must deliver metering equipment that has a standardised connection for real-time electricity consumption monitoring;
- Meters are able to receive and execute load control commands, or forward the commands send through a communication network (two-way communication), which can mean in practice
- The customer takes out a contract with a utility supplier for a load control at peak times when the electricity market price is high - the seller gives load control command either directly to the meter (using a mobile phone network) or through the DSO;
- The customer orders a meter from the DSO which forwards the load limiting commands to the house automation control system which controls the home applications as programmed.
- DSO must have data security to properly manage data transfer and storage;
- Log outages lasting more than 3 mins;
- Settlement based on hourly metered data is required for all customers that have meters capable of hourly metering (from the beginning of 2012);
- Remotely readable meters that have already been installed before the Act are allowed some exceptions regarding the minimum functional requirements).

3.8.3 Smart Metering Landscape in Finland

Due to the early national rollout decision and a clear regulatory push, the technological advancement of smart metering in Finland is currently one of the best in the world. In 2014, practically all end-users should have electricity smart meters installed through a DSO led-rollout. The DSOs have started implementing their rollouts swiftly, with well over 2 million meters in place and around 1 million left to install.

Through the advanced state of smart metering adoption, the possibilities for end-user services promoting energy efficiency and demand response are large. However, currently the end-user service side is still ambiguous from a technical, market model and regulatory point of view. The regulation only requires the provision of hourly information to the customer once in a day, with no obligation to offer in-home displays - but rather to just offer a possibility for a standardised connection. Thus the minimum requirements do not guarantee advanced information and feedback services or real-time data to customers, which dilutes the energy saving and demand response potential.

The DSOs are intensively implementing the rollouts and developing their energy reporting systems to fulfil the regulatory requirements on providing smart metering data to customers, mainly through web-based portals. In many cases, these portals are quite basic and not designed optimally to promote energy savings, although there are also more advanced systems available. The electricity suppliers, which operate in a liberalised market are expected to offer new and innovative services, to differentiate their products and offer new added value to their customers. Also, real-time displays and advanced smart home appliances utilising smart meters are increasingly entering the market. In short, the metering technology rollout is quite regulated and under DSO monopoly, but the end-services are expected to increasingly come from a liberalised market.

The meter data is held by the DSOs, however it is owned by the customer. From the beginning of 2014 at the latest, the DSOs are required to forward the hourly consumption data to the customer, supplier and other parties authorised by the customer. This is expected to open the door to new services and applications building on the customers' smart meter data, including new information and feedback and demand response services. At this point, the important question is how will the huge amount of metering data coming from the end-users (and stored by DSOs) be available to all relevant actors who can make innovative end-user energy efficiency services with it, and at what cost and restrictions.

For district heat, it is estimated that over 80% of meters are remotely readable. A major part of the district heat meters is capable of delivering hourly data, while the rest can deliver monthly data. Some utilities have Web-based district heat consumption reporting systems available also for domestic customers, from which the most progressive systems can deliver further information and feedback on consumption. Most utilities provide monthly district heat consumption reporting to their customers via informative bills.

Utilities have not yet adopted smart metering for water consumption, and requirements for this remain unclear. However, installing apartment specific water meters is now mandatory in new buildings.

3.9 France

France has quickly become one of the front-runners of smart metering in Europe – simple legislation, successful pilot projects, and an uncomplicated market have paved the way for a mass rollout, planned to attain 95% coverage by 2016.

3.9.1 Policy objectives for the introduction of smart metering

The general objectives of the French energy policy are described in the Energy Law of 2005, most recently updated in June 2011 (POPE, 2011). This document describes various energy policy objectives without any direct references to smart metering. There are two French policy documents dealing specifically with smart metering, however:

The first policy document is a roadmap for smart grids and smart metering, developed by the government agency ADEME[10] with the involvement of relevant stakeholders (CEER, 2011,

[10] Agence De l'Environnement et de la Maîtrise de l'Énergie

16). It was published in 2010 and sets various research and demonstration goals for smart metering development, but does not define specific objectives for the introduction of smart metering (ADEME, 2010).

The current main policy document for smart metering is a position statement from the national regulatory body, CRE[11]. In its statement from July 2011, the CRE recommended a smart metering rollout, basing its decision on the positive outcome of the ERDF pilot project (described below). The CRE cited the following expected benefits of a smart metering rollout, which can be assumed to correspond to the French policy objectives for a smart meter rollout:

- To maintain grid stability despite the increasing share of renewable resources
- To enable more accurate grid monitoring
- To benefit customers with bills based on actual use as well as the new services and tariffs offered
- To support demand-side load management and enable peak load reductions
- To increase cost-effectiveness
- To strengthen the international competitiveness of French industry

(CRE, 2011)

The national cost-benefit analysis for France was carried out in 2006. The CRE commissioned Capgemini Consulting to conduct an international benchmark study and cost-benefit analysis. The results of the analysis were presented in early 2007 and indicated positive effects for the DSO, as well as significantly decreasing the cost of electricity supply and generation. It also predicted benefits for customers, who could, for example, profit from more competition on the retail market and lower energy prices.

3.9.2 Legal foundation of smart metering services

The current version of the French Energy Act does not mention smart metering. A separate decree from September 2010 defines the legal obligations in France concerning smart metering:

- From January 2012 every new electricity meter installed must be a smart device.
- By the end of 2014, 50% of all meters must be connected to an AMM system.
- By the end of 2016, 95% of the meters must be connected to an AMM system.
- Smart meters must enable users to access data on their own energy production/consumption at least once daily.

(Décret n° 2010-1022, 2010; King, 2010)

In France, the DSO is responsible for both gas and electricity metering. As a rule, the distributor is in charge of installing the meter, maintenance, reading and data management. In

[11] Commission de Régulation de l'Énergie

some cases the customer can be in charge of the installation and the data management (Vasconcelos, 2008, 21ff). The regulator defined goals that have to be reached by implementing smart meters. These lead to a set of minimal criteria, namely a two-way communication system and compatibility with remote operations management (ERGEG, 2009). It is expected that there will be no need for guidelines on standardisation due to the dominant role of ERDF in France (Ryberg, 2009, 111).

According to a report from the Open meter consortium (2009, 56), French regulation also foresees the following functional requirements for smart meters:

- 4 registers for distributors and 10 registers for suppliers;
- Load profiles should be configurable in 30 or 60 minute intervals. Load profiles with at least 30 minute data intervals should be stored for at least two months.
- Quality of power should be measurable by the date and duration of power cuts, sags and swells, and meters must store this data for at least two years.
- Meters should be compatible with remote disconnection and distant reconnection authorisation.
- Variable tariffs should be possible, as should remote tariff configuration and scheduling.
- At least one relay must be based on the tariff and controlled by the distributor or retailer for the purposes of peak shaving.
- An interface enabling the connection of a display providing information on instant power measurements, load profile elements and maximum value of the delivery and consumption powers, the state of the breaker, and seasonal tariff periods.

For gas there is no official definition of smart meters. The industry players agreed that automated meter reading (AMR) with one-way communication should be sufficient to improve billing and to get the customers load curve history (ERGEG, 2009).

3.9.3 Smart Metering Landscape in France

On 29 September 2011 the French government announced the rollout of 35 million smart electricity meters, beginning in 2013 and being completed by 2018 (ERDF, 2011). In France the electricity market is dominated by EDF[12] and ERDF[13], and the activities concerning smart metering are therefore closely coordinated with those companies. This is also the case for the rollout. As DSO, ERDF will be responsible for the deployment. It is expected that approximately 7 million meters will be installed in households between 2013 and 2014, followed by a further 28 million between 2015 and 2018 (Bayani, 2011).

The smart meter rollout is likely to be based strongly on previous experiences with smart metering, mostly gained through ERDF's "Linky" pilot project. In this pilot, ERDF worked with Atos Origin to install 250 000 smart meters and 4600 concentrators in urban and rural areas.

[12] Électricité de France
[13] Électricité Réseau Distribution France

The project tested the installation process, the AMM system, and meter interoperability, as well as the economic feasibility of a rollout, running for one year and ending in March 2011.

As a result of the rollout plans there has been increased competition amongst meter manufacturers. Most of the meters (57%) in the ERDF pilot were Landis+Gyr products, followed by devices from Itron and Iskramenko (Mercadier, 2010; Ryberg, 2009, 145). Amongst DSOs, ERDF is expected to be the future provider of smart metering solutions for smaller DSOs as a result of its market dominance (Nabe et al., 2009, pp.94). Other DSOs have also initiated smart metering projects; however, the GAELD consortium (made up of local DSOs) began implementing the NES advanced metering system from Echelon in around 90,000 homes in 2009. The system is expected to be completed in 2013. (King, 2011)

In addition to the progress on smart electricity metering, there has also been progress in smart gas metering in France. The first smart gas meter pilot in France, led by GrDF[14], ran from April 2010 to June 2011, in which time around 18,500 smart gas meters were installed and operated. Based on the results of the pilot and following consultations by the CRE, a rollout of 11 million smart gas meters could take place between 2014 and 2020. (GrDF, 2011).

3.10 Germany

The German government has chosen the policy of relying on market forces to steer the introduction of smart metering. There has been recent progress in the development of a regulatory framework, but some regulatory documents on minimal requirements for smart meters still has to be completed before market players begin to install smart meters on a scale larger than pilot projects.

The decision to end German dependence on nuclear power after the events of March 2011 in Fukushima, Japan, is expected to contribute towards an accelerated take-up of smart metering services in Germany. The increased reliance on renewable energy sources can only be achieved with the help of smart grids – of which smart metering is a crucial component.

3.10.1 Policy objectives for the introduction of smart metering

The key executive and legislative documents for the energy sector, namely the Energy Concept and the Energy Act, offer differing definitions of the German policy objectives relating to the introduction of smart metering.

The Energy Act describes two objectives for the German energy policy which are related to smart metering:

- Ensuring a safe, low-priced, customer-friendly, efficient and environmentally-friendly supply of electricity and gas and
- Compliance with EU directives

(EnWG, 2012, § 1)

[14] Gaz réseau Distribution France

The German Energy Concept of 2010, on the other hand, describes smart metering as a central component of the smart grid, namely a technology to enable demand-side load management (BMWi, 2010, 19). This definition more accurately reflects the current energy policy objectives regarding smart metering, especially considering the change in German energy policy since 2011.

An official cost-benefit analysis according to the directive 2009/72/EC is yet to be carried out in Germany. An initial KEMA report commissioned by the Federal Ministry of Economics and Technology concluded that smart metering can contribute to energy savings, but that energy savings should be more heavily demanded by legal obligations in order to maximise this impact (KEMA, 2009, 16). The contracting process for a national cost-benefit analysis began in August 2012. The analysis is expected to be completed, and the results implemented through an amendment to the Metering Access Act, early in 2013.

3.10.2 Legal foundation of smart metering services

Legal obligations for smart metering services in Germany are defined in the Energy Act and the Metering Access Act. Several important amendments and additions to the Energy Act regarding smart metering were made in recent years to encourage the introduction of smart metering services.

Despite Germany’s market-driven policy, the following obligations regarding smart metering have been set:

- Metering operators are obliged to offer smart meters to all customers
- Metering operators are obliged to install smart meters (if technically possible):
    - In new buildings and any buildings undergoing major refurbishing
    - For end users with an annual consumption of more than 6,000 kWh
    - For customers with new energy generators with a capacity of 7 kW or more
- Utilities must offer tariffs that give “an incentive to saving energy or controlling energy consumption...especially load-variable or Time-of-Use tariffs”
- Customers with smart meters have the right to a free monthly invoice.

(EnWG, 2012)

Previous legislation made all these obligations dependent on whether the installation/offering tariffs were “technically possible and economically feasible” (Aichele, 2012, 35). The requirement of economic feasibility was removed by recent legislation. The installation is seen-as “technically possible” if there are meters available on the market that fulfil the legal requirements.

In addition to the above-mentioned regulations, the Federal Ministry of Economics and Technology can require the installation of smart meters in all other buildings, should a cost-benefit analysis show this to be economically feasible on a national level (EnWG, 2012, § 21c).

Market model and responsibilities for metering

The German energy market was liberalized in 1998, and the metering market followed in 2005 and 2008, fitting to the German smart metering policy. Accordingly, there is no rollout of smart meters planned in Germany – the current legislation has the purpose of regulating competition while providing the necessary framework for a competitive market.

The liberalisation of the metering market in 2005 and 2008 created two distinct new roles: the metering operator and the metering service provider. The DSO is the default in both roles, but the separation of roles allows customers to choose a metering service and device from different service providers according to their own preferences. The DSO must then allow the metering service provider to install their own devices, as long as these fulfil regulatory requirements. (Doleski, 2012, 118)

Minimum Functional requirements / Compatibility / Data protection

This liberalised market model allows any service provider to develop and offer metering systems, making the development of certain standards and requirements for smart meters even more important.

The initial functional requirement for smart meters as defined in the Energy Act was that of reflecting “the actual consumption of energy and the actual time of use”. This requirement was extended in amendments to the Energy Act to include the requirement of being integrated in a communications network. The section in question also foresees the development of a legal document specifying further functional requirements of smart meters, although the publication of such a document is not expected in the foreseeable future.

The Energy Act also foresees the development of standards in the areas of interoperability and data protection. The government assigned the task of developing a protection profile for gateways and security modules as well as technical guidelines for the interoperability of smart meters to the Federal Office for Information Security (BMWi, 2011). These documents should be completed and ratified in the course of 2012, as smart meters not fulfilling these requirements may only be installed until 31.12.2012. A certification system testing the fulfilment of these requirements is also foreseen.

In addition to these technical requirements, the Energy Act regulates the use of personal data for smart meters. It defines certain possible purposes of recording, using or processing metering data, and prohibits use of metering data for any other purposes. In addition, the Act names the metering operator, DSO and utility as parties allowed to access metering data, and requires a written permission from the end user for any other parties (EnWG, 2012, § 21g).

3.10.3 Smart Metering Landscape in Germany

Compared to high expectations when the question of smart metering first became well known, few smart meters have been installed in Germany.

A market survey carried out by EnCT showed that early in 2010 only 15 of about 800 utilities in Germany offered smart metering products with a time of use tariff and feedback system. (Schäffler, 2010). Due to the legislative obligations valid since January 2011, this number has risen strongly since then. In June 2011 there were 101 utilities offering time-of-use or load-variable tariffs (compared to about fifty in January 2011). Many utilities are doing the bare minimum to fulfil their obligations, however, implementing two-category tariffs like those offered in the past, using two conventional (non-smart) meters. Of the 101 variable tariffs on offer, only 25% used more than two price categories (ene't, 2011). As a result of the regulatory guidelines regarding standard load profiles, time-of-use tariffs with two price levels and a small difference between the highest and the lowest prices continue to dominate the market (Vest, 2012, pp. 210).

A simulation of smart meter tariffs for residential consumers shows that the transparency and cost control made possible by smart metering are worthwhile for customers with a medium or high annual energy consumption. Households with a consumption higher than 3400 kWh/a should be able to compensate the additional costs of a smart meter by reducing and shifting consumption. Customers with a high annual energy could even reduce their energy costs. This is due to the relatively high fixed annual costs of smart meter services – whilst the price/kWh is generally lower than for standard tariffs, the fixed costs are usually considerably higher. Customers with a low energy consumption are not generally able to compensate for the higher fixed costs by reducing and shifting consumption.

The customer take-up of smart meters has been accordingly slow. Many industrial customers use a form of registered load measurement, but private households and small and medium sized enterprises have not taken up smart metering in any large way. Approximately 500 000 smart meters are thought to have been installed in Germany – it is expected that 42 million will be needed for the smart grid.

The slow progress in smart metering can be traced back to a number of factors, on which varying progress has been made since the original *Landscape Report* was published in February 2011.

One factor was that of unclear regulation. Smart metering regulation has been developed much further, meaning that the situation is clearer. However, the utilities are still expected to hold back on their investments until the requirements resulting from the cost-benefit analysis and the reports on standards are finalised (Grandel, 2012, 225). As these results are expected in autumn 2012, the market players in Germany expect accelerated development of the smart metering landscape in 2013.

Another reason for slow progress in smart metering is that the financial cost of smart metering is not yet balanced out by financial benefit – not for the utility or for the customer, depending on which one carries the cost. This is a result of two factors: the scale of the rollout (the benefit for the utility increases and the cost for the customer decreases according to the number of smart meters installed) and the regulation of standard load profiles in Germany (Grandel, 2012, 225). As long as the purchase of energy has to be carried out according to the standard load profiles for most customers, there is no possibility for the supplier to benefit financially from demand-side management or through better knowledge of the customer's consumption. This situation has not been resolved through amendments to the Energy Act – it is hoped that new regulations expected at the end of 2012 will provide a solution (ene't, 2011).

Although large-scale rollouts and smart metering services are not yet widespread in Germany, there has been strong progress in smart metering research, especially through the large-scale demonstration projects sponsored by the state “E-Energy” programme. Energy utilities and smart meter manufacturers have therefore been able to gain important insights into technical and economical issues of smart metering, as well as different possibilities of feed-back information for users.

3.11 Greece[15]

The Greek electricity market is divided into two different systems: the grid-connected main-land and the non-interconnected islands, which refer to the islands in the Aegean Sea, as well as Crete and Rhodes. The electricity sector in Greece is largely monopolistic and it is dominated by a publicly owned company, Public Power Corporation (PPC). PPC is Greece’s largest generator and its sole distributor of electricity. It owns 93% of the installed power capacity.

The Regulatory Authority for Energy (RAE) is an independent administrative authority and the primary regulatory responsibility lies with the Ministry for Environment, Energy and Climate Change that has assigned the following activities: licensing, tariff setting, and the imposition of public service obligations. RAE will have monitoring, advisory and referral responsibilities. It will be able to impose fines, revoke licenses, and settle disputes, enjoying a certain degree of independence from the Ministry.

The Greek transmission grid is owned by PPC and managed by Hellenic Transmission Systems Operator (HTSO). Law 3426/2005 from 1 July 2007 provides that HTSO should also acquire the responsibility for the operation of the Distribution Network, with the excep-tion of the networks located on the non-interconnected islands.

3.11.1 Legal foundation of smart metering services

In Greece, a smart meter roll-out has been decided. All medium voltage (MV) customer meters have been replaced and since 2005 smart meters have also been installed at new low voltage (LV) connections ≥ 85 kVA. Every new MV and LV (≥ 85 kVA) connection is supplied with a smart meter. A rollout for all LV connections ≥ 85 kVA has also been decid-ed. For the MV level, a general meter replacement was executed from 2002 to 2005, and the Automatic Meter Reading capability will be activated for these meters throughout 2007 to 2009. On the LV level for connections ≥85 kVA, new connections have been equipped with smart meters since 2005, and a full-scale replacement roll-out as well as the activation of Automatic Meter Reading capability is planned for the years 2010-2013. (www.smartgrids-cre.fr)

Greece has defined some minimum functional requirements and has defined two-way com-munication as the minimum requirement for the communication system for smart meters in electricity. Fraud detection and self-diagnostics of the operation of the meter will also be important functions of the smart meter infrastructure in Greece (ERGEG, 2009).

[15] Information about the situation in Greece was kindly provided by Yannis Vougiouklakis, Head of Market Devel-opment at the Centre for Renewable Energy Sources and Saving (CRES).

In Greece, there is no legal framework that guarantees a mandatory reading of the customer's meter. The majority of the meters currently require onsite reading by the metering companies. Electricity is actually read every four months (bill is issued bi-monthly), while natural gas is read bi-monthly. In order to provide metering services, secondary legislation and regulations stipulate the release of information to third parties and it is also subject to data privacy legislation.

The Ministry of Environment, Energy and Climate Change (YPEKA) presented a new energy bill, which incorporates into the Greek legal order the 3d Energy Package, as regards Directives 2009/72/EC and 2009/73/EC, concerning rules on the Electricity and Natural Gas markets respectively. The Greek energy bill regulates issues regarding the liberalisation of the electricity market, which fall within the framework of the privatisations programme undertaken under the Memorandum of Understanding on specific policy conditionality. In that respect, the new bill allows independent investors to participate, up to 49%, to the electricity transmission network owned by the Public Power Corporation S.A. (www.kalaw.gr, Tina Koutsopoulou, 18/03/2011)

Law 3855/10 ("Measures to improve energy efficiency in end-use energy services and other provisions") requires additional information to end customers, such as actual consumption and actual energy prices. This Law foresees that the energy supply companies are responsible for the installation of personal meters that represent the actual consumption and give information regarding the actual use duration, when this is economically reasonable and analogous to the potential for energy saving. The afore-mentioned companies are obliged to supply such meters to any new connection of new or refurbished buildings, to replace existing old meters and to any connection taking place during grid construction or refurbishing projects. Moreover, this Law foresees that the billing of energy products should include data regarding the actual energy consumption and the respective energy price, as well as comparative assessment of the customer's energy consumption with the respective consumption of the previous year.

3.11.2 Smart Metering Landscape in Greece

Currently, all medium voltage (MV) customer meters have been replaced with electronic meters, this corresponds to about 8,000 electricity customers. A full-scale replacement rollout as well as the activation of Automatic Meter Reading capability is still under planning and not final schedule has been announced.

More specifically, PPC has planned to install 60,000 smart meters in large end customers with low voltage connections, many of which are residential. The specific programme will cost EUR 27 million and will be co-financed by European programmes. These meters will automatically send out the consumption data to a central server and will be collected and processed by PPC. The customer will be able to find out the amount of electricity consumed, while PPC will be able to apply flexible pricing rules, depending on the time of day the electricity is consumed. This scheme will start from the 60,000 large customers that together with 8,000 commercial customers comprise 30% of the total final energy consumption in Greece. Afterwards it will be extended to all customers throughout Greece. It is estimated that there will be cost savings for PPC of approximately EUR 37 million per year. PPC is currently examining the possibilities of extending the electricity metering system to include metering the water and the natural gas consumption in cooperation with the Athens Water Supply and Sewerage Company (EYDAP SA) and the Athens Gas Supply Company (EPA SA).

3.12 Hungary

3.12.1 Policy objectives for the introduction of smart metering

The Hungarian Electricity Act and the Gas Supply Act provide the Government to stipulate the rules governing the installation of smart meters as specified in the Energy Services Directive (Directive 2006/32/EC) in a decree[16]. The Hungarian Energy Office (HEO), which is the national regulatory authority, is responsible for preparing regulations for smart metering, which have to comply with the respective EU directives.

In 2010 two consultant firms (A.T. Kearney, Force Motrice) conducted a study[17] on behalf of HEO. The study contains an examination of different options for the introduction of smart metering in Hungary and recommendations for methods and a timeframe of the introduction. The political intent to implement smart meters was recognised as one of the key drivers for the related activities in Hungary. Beyond that, it was recognised that smart meters are the technical basis to provide energy customers with transparent information regarding their actual energy consumption, which is a prerequisite that customers can react with a change of their customer behaviour when prices increase. The advanced development of energy networks, enhancement of energy efficiency and sales-related potentials to promote competition were also identified as strong drivers for smart metering.

In the study different models for the implementation of smart metering were assessed and a cost-benefit analysis was performed in order to recommend a favourable smart metering model. The recommendation to HEO was to implement a model with legally separated meter operators beside the already existing utilities. To reduce the implementation risk by a higher number of competitors, there should be Area Smart Metering Operators instead of one Central Smart Metering Operator

The HEO used the findings of the study to start preparing the smart metering pilot projects with the involvement of the affected parties and the development of the related Government decree. Regarding the costs and benefits of smart metering systems the study from 2010 is just a preliminary assessment. The HEO plans to carry out a final cost and benefits analysis, which shall consider the results of some pilot projects[18].

ERGEG has published a report in 2009 in which HEO identified the following benefits of smart metering for Hungary:

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[16] Hungarian Energy Office: Annual Report to the European Commission, Budapest, August 2011

[17] A.T. Kearny, Force Motrice (2010): Assessment of Smart Metering Models: The Case of Hungary, 18 June 2010

[18] ERGEG: Summary of Member State experiences on cost benefit analysis (CBA) of smart meters, 2 February 2011, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/CUSTOMERS/Smart%20metering/CD/C11-RMC-44-03_CBA%20SM_2-Feb-2011.pdf

- Contribution to energy savings
- Secure energy supply
- Development of services based on prepayment systems
- Development of energy services based on tailored tariffs
- Peak consumption information and contribution to an accurate network management
- Support self-diagnostics for meter operation

3.12.2 Legal foundation of smart metering services

There is no binding regulation for a rollout of smart meters so far in Hungary. Nevertheless, A.T. Kearney and Force Motrice (2010) recommended a timeframe to HEO. According to this timeframe the development of the regulatory framework and the implementation of pilot projects as well as their evaluation should be finalised by 2013. The rollout of smart metering systems should start in 2014.

The probable approach will be the recommended model with some Area Smart Metering Operators. The DSO will be the owner of the smart meters and will be responsible for the installation, maintenance and inspection of the meters. The Area Smart Metering Operators will be new market participants. The operators will be under the regulation of HEO and have to be legally unbundled. This means that energy utilities can find different companies for smart metering.

The Area Smart Metering Operators will be responsible for metering, data collection and data processing in certain regions. Within these regions, the Area Smart Metering Operators will have a natural monopoly. Network losses will have to be covered by the DSOs. The Area Smart Metering Operators will provide the suppliers and DSO with relevant metered data.

If Hungary decides to implement this model, comprehensive amendments to the national laws and regulations will be necessary. Some of the important topics for regulation are:

- Status of the Area SM Operator (natural monopoly, regulation, licensing)
- Ownership of meters
- Meter readings and data transfer
- Data security

The expected minimum functional requirements for smart meters in Hungary are (AT Kearney and Force Motrice, 2010):

- Two-way data communication
- Possibility for remote control
- Remote switch-on/off possibility and possibility for consumption limitation
- Possibility for regular forwarding of metering data upon request – possibility for quarter-hourly data forwarding (15-minute measuring intervals)
- Possibility for remote programming and update, controlling software can be remotely managed

- Possibility for recording and storing data based on different parameters (e.g. consumption data and tariffs)
- Possibility for remote modification of tariffs and tariff periods
- Measurement accuracy: +/- 1% (low voltage, low capacity (current), single phase)
- Alarm messages (e.g. tampering)
- Remote display not necessary

3.12.3 Smart Metering Landscape in Hungary

In the current legal framework the electricity DSO is responsible for the installation, calibration and maintenance of the meters as well as for the invoicing. Meter readings are the responsibility of the network operators (TSO, DSO). DSO has to transfer their metered data to the TSO. There should be at least one meter reading per year for small customers, more frequent meter readings can be agreed in the network utilisation contract).

In February 2012 the distribution network operator E.ON Hungary announced the implementation of a smart metering pilot project in a real user environment. The project will be implemented in cooperation with Magyar Telekom. The first phase of the project is focussed on the testing of the technical solution and shall be finalised in the first half of 2012. After that innovative supplementary functions which may provide comprehensive information for customers and energy companies shall be examined. The project will be implemented with the supervision of the Hungarian Energy Office. It is expected, that this project will support the development of the regulatory framework for smart metering in Hungary[19].

ELMÜ/EMASZ and their key shareholder RWE are cooperating with local gas and water utilities in Budapest to carry out a joint smart metering trial for electricity, gas and water[20]. In this project RWE and ELMÜ/EMASZ will test the use of smart meters before a rollout shall be prepared. RWE's goal is to connect up to 80% of electricity customers and 90% of the gas customers in Hungary to smart grids by 2020.

3.13 Ireland

3.13.1 Policy objectives for the introduction of smart metering

Since 2007, the Irish government has had a National Smart Metering Plan in place. After a series of consultations, customer trials and cost-benefit analyses, in November 2011 the Irish regulator, the Commission for Energy Regulation (CER) proposed to rollout electricity and gas Smart Meters to all homes and many businesses across Ireland in the coming years. This national rollout will contribute to policy objectives related to lower customer bills, greater customer information and choice, lower CO2 emissions and environmental benefits for Ireland. The CER is proposing to roll-out Smart meters nationally in a manner which:

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[19] Press release from E.ON Hungaria: „Smart metering" cooperation between E.ON and Telekom, 9 February 2012, http://www.eon-hungaria.com/en/press/releases/2012/kozl_120209_2

[20] RWE: „The Energy to lead sustainability", Responsibility Report 2011, Essen, March 2012

- Includes an In-home Display screen to give customers more real-time information on both the cost and usage of electricity and gas.
- Provides customers with Smart Bills, containing detailed consumption and cost information.
- Involves suppliers offering Time-of-Use pricing for all electricity customers, facilitating a shift in electricity consumption to cheaper times of the day and giving more choice to customers.
- Provides prepayment services as standard with smart metering, i.e. energy customers will be able to automatically switch between prepay and bill pay options.

The CER has also set out proposals for the design and functionality requirements of the national Smart Meter roll-out, as well as the procurement model and high-level timelines involved. A final decision on the national rollout is expected before the end of 2012, with the process of installing meters likely to occur over the following years.

3.13.2 Legal foundation of smart metering services

Since 2007, the National Smart Metering Plan is a commitment in the Government's Energy Policy Framework. It is a central component of the strategy to radically enhance management of energy demand and to deliver greater energy efficiency. Smart metering is believed to be one method which encourages the self-regulation of energy consumption. In 2009, the Government adopted the National Energy Efficiency Action Plan 2009-2020 (NEEAP) in order to achieve Ireland’s energy efficiency targets. One of the principal measures contained within this Action Plan is the encouragement of more energy-efficient behaviour by householders through the introduction of smart meters. By the end of 2009, the Energy Services Directive (Directive 2006/32/EC) was transposed into Irish law. A series of Customer behaviour trials were started to deliver the evidence for the energy efficiency potential of smart metering.

As a result of both the Electricity and Gas Customer Behaviour Trials, the proposal mandates all electricity customers to be provided with an in-home display (IHD) device, which for dual fuel customers will also be capable of displaying gas information, and with “smart” bills containing detailed consumption and cost information. It is generally recognised that customers own their consumption data generated by smart metering and that data protection should be paramount in smart metering. Customers will have the right to provide their detailed historical consumption data to other suppliers in order to get an alternative quote for their supply. Moreover, customers can give permission to other third parties to access their detailed historical consumption data for metering services.

3.13.3 Smart Metering Landscape in Ireland

In November 2011, Ireland’s energy regulator the Commission for Energy Regulation (CER) set out proposals for the rollout of electricity and gas smart meters to homes and businesses across Ireland by 2020. These proposals followed the completion of comprehensive customer behaviour and technology trials and cost-benefit analyses. The trials showed that a national rollout of smart meters could lead to a 2.5 per cent reduction in overall electricity consumption, 2.9 per cent reduction in overall gas consumption, and 8.8 per cent reduction in peak time electricity consumption. Both trials have contributed to the cost/benefit analysis being carried out by the Regulator to enable a decision on the rollout of smart meters in

Ireland. The combination of operational savings and the ensuing benefits achievable from changes in electricity customer behaviour demonstrated in the trial indicate a positive business case.

The extensive cost-benefit analyses (CBA) were presented on 16 May for Electricity and on 11 October 2011 for Gas. Both reports have delivered the findings of a robust economic, environmental and social assessment of the long-term costs and benefits to the market, society and the individual customer (residential and small businesses) of a national electricity and gas smart metering rollout in Ireland. The cost-benefit analyses found all together a net benefit of smart metering up to €229 million over 20 years. The rollout cost is estimated to be up to €1 billion.

The CER proposes that electricity and gas smart metering should be rolled out to all residential customers and to a significant proportion of business customers, including all business electricity customers currently with non-interval meters and all business gas customers. This corresponds to a total of about 2.2 million electricity customers and 600,000 gas customers.

It is also proposed that the gas smart metering will leverage the electricity smart metering communications infrastructure, and that time-of-use electricity tariffs will be mandated for all electricity customers. Prepayment services will also be provided as standard, enabling customers to automatically switch between prepay and bill pay options.

Other aspects of the proposals include the design and functionality requirements of the electric and gas smart meters, and the wide area network (WAN) and home and area network (HAN) requirements.

The final decision following the consultation on the Proposed National Rollout of Electricity and Gas Smart Metering is expected to be taken in 2012.

3.14 Italy

In Italy, the infrastructure for remote meter reading was established even before the regulatory framework was developed. The legislator then applied a mixture of regulatory tools to support the installation of smart meters, such as rollout obligations, financial penalties for non-replacements, and the specification of minimal functional requirements. Vasconcelos (2008, 47-50) provides a good overview of the Italian case.

3.14.1 Policy objectives for the introduction of smart metering

- Compliance with EU-directives;
- Support for competition in the energy market: development of competition in supplying electricity to LV customers;
- Customer protection: transfer to customers as much as possible of the benefits afforded by conducting business remotely;
- Exact and frequent billing: lowering the interval metering (1h) to a population of LV customer for dispatching purposes;
- Debt and theft management: Smart meters are used for remote reduction of capacity made available to a bad debtor and for remote disconnection/re-connection;

- In a second level, energy efficiency and carbon reduction, smart grids, energy security, etc.

3.14.2 Legal foundation of smart metering services

- Provision in the **Energy Law**: In 2006, the Italian regulator introduced the mandatory installation of electronic meters, characterised by minimum functional requirements, for all household and non-household low voltage customers.[21] The mandatory replacement programme started in 2008, will last four years and involves all Distribution System Operators (DSOs), regardless of the number of the customers served. By 31 December 2011, 95% of smart meters should be installed.
- **Market model** and responsibilities for metering:

  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. In order to avoid creating barriers for innovation, the defined minimum functional requirements were independent from architectures used by DSOs or recommended by AMM system suppliers and from telecommunication systems.
- **Minimum functional requirements** for the metering system (Vasconcelos, 2008):
- 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 promptly signals 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 re-parameterisation; 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;

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21 Regulatory Order No. 292/06 of 18 December 2006 and modified by Regulatory Order 235/07 of 26 September 2007 introduced deadlines for the commissioning of smart meters and performance requirements of AMM Systems.

- Slow voltage variations (according to EN50160);
- Annual percentage of successful remote transaction (activation/deactivation, change of subscribed power, change of price scheme, power reduction) within 24 hours and within 48 hours;
- Failure rate in readings reported to the control centre.

3.14.3 Smart Metering Landscape in Italy

In Italy, ENEL had installed an electronic metering system in almost all houses that comprises an electronic meter that provides access to the actual parameters and contractual data of the supply through a display on the meter, a module for communicating, a switching device remotely enabling the supply connection and disconnection and the company's central systems managing processes and interfacing of the company's legacy systems.

Meters are therefore able to transmit data regarding consumptions, receive updates of the contractual parameters and remotely manage the supply connectivity. Consumption data are collected every time they are required/needed. Data from meters can easily be displayed on home screens and become part of a more complex HEMS (Home Energy Management System), currently being tested and deployed in a pilot scheme.

By 2011all 36 million electricity customers were equipped with a smart meter (ESMA, 2010). The focus of the smart metering system was initially on electricity theft prevention and the efficiency of operating processes while it is now moving towards customer engagement and energy savings being suitable to comply with these objectives in a smart grid environment. Therefore, the system is DSO-oriented but is also evolving towards advanced functionalities to manage the customer demand.

3.15 Latvia

The Latvian electricity market is dominated by the state owned AS Latvenergo, which is the main major electricity producer in Latvia and, before the implementation of Second EU Energy Market Package (Directive 2003/54/EC), was also the sole electricity transmission and distribution operator. To comply with the unbundling requirements of Directive 2003/54/EC, Latvenergo created two subsidiaries.

The transmission system is operated by AS Augstsprieguma Tikls which is a fully owned subsidiary of AS Latvenergo. The largest share of the distribution network belongs to AS Sadales Tikls, another fully owned subsidiary of AS Latvenergo. Nevertheless, the liberalisation of the electricity market has resulted in the entry into the Latvian market of SIA E.Energy, a fully owned subsidiary of Eesti Energia AS, which is becoming more active in selling electricity to Latvian corporate customers. In addition, another electricity supplier, the Swedish company Scaent AB, has announced that it intends to start operations in the Baltic states.

The Latvian natural gas market is purely monopolistic, the only entity licensed to transport, distribute, store and supply natural gas being AS Latvijas Gaze.

District heating is an important energy source with Latvia topping the Europe penetration rates at 70 per cent (Lejins and Aljens, 2010).

The current underlying technologies are:

- Residential customers have mainly ordinary electromechanical meters, which are gradually being replaced by electronic meters, but which are not necessarily connected to the AMR system.
- Customers with a permitted connected load of 100 kW and higher are connected to Automatic Meter Reading (AMR) system.
- Also independent producers of electricity are connected to the AMR system.
- For Customers with a permitted connected load of 100 kW and higher objects that are connected to AMR – the meter data is exported to AMR system on a daily basis; after that, the data is exported from AMR system to CSPS (Customer Service and Payment System). DSO (Sadales tīkls) sends a bill for distribution system services to the user once a month; at the same time, DSO forwards the load profile data to the trader, who issues a bill for the electricity consumed.

Latvenergo currently has 10,000 industrial customer meters connected to the AMR system (all customers over100 kW). The current purpose of this system is to get load data, and to make balance, billing, loss control and theft prevention. For industrial customers the DSO sends hourly load data by email (monthly report) or provides access to a web portal.

For the next two years, the DSO plans connect to the MDC customers with a permitted load of over100 A (total amount approximately 3000 - 5000 meters).

Latvenergo is planning to start a smart metering pilot for domestic customers in 2012. According to the plan, the company will install smart meters into 500 households (which are selected by different monthly consumption) and will implement a new MDC system. The main objectives of the project are:

1) Explore the technical/economic aspects of smart metering;
2) Explore how households will react to load profiling;
3) Test the latest smart meters and their functionality;
4) Test the MDC systems;
5) Test the smart metering installation procedure;
6) Test the system's security.

3.15.1 Policy objectives and legal foundation for the introduction of smart metering

There are no public plans for regulations on smart metering installation and mandatory hourly metering in Latvia. Similarly, a cost-benefit analysis as required by Directive 2009/72/EC has not been performed yet.

Regarding information on bills, the Public Utilities Commission has issued Regulations on Information for Electricity End Users, which states that the end user who pays for the electricity supplied on the basis of the bill, should have the following minimum information:

- Charges for electricity;
- Subscription fees (if applicable);
- Cost of power apparatus size (if applicable);

- Fee for the allowed time (if one is specified);
- The total amounts payable and VAT;
- At least once a year: charges for electricity (including the cost of marketing services); charges for electricity distribution services (including the cost of jet energy); charges for electricity transmission services; minimum payment for electricity purchases.
- At least once a year: information on environmental impacts resulting from the electricity production from primary energy resources used in the previous year, as a minimum the resulted carbon dioxide emissions and radioactive waste.

3.15.2 Smart Metering Landscape in Latvia

Since there is no clear direction through regulation, the adoption of smart metering technology and services relies on the activity of utilities. The dominant State-owned DSO AS Sadales Tikls has no clear plans to deploy smart metering. Also, the current monopoly situation in the energy markets is not the most encouraging context to uptake new smart metering technology and services. Currently the development of smart metering in Latvia seems to be one of the slowest of the EU Member States.

However, the dominant DSO AS Sadales Tikls, subsidiary of Latvenergo has developed a smart network concept (approved on 1 March 2011 by decision of the Latvenergo Board of Directors). Preparation of the concept forms part of the development of the distribution network. The driving forces behind the development of smart networks are green initiatives, the development of renewable energy resources and energy efficiency, as well as the assumption that well-informed customers will use less energy. Therefore the implementation of smart networks and smart meters is regarded as being an important instrument in the European 20/20/20 targets as regards reducing energy consumption. (Second National Energy Efficiency Action Plan of Latvia).

3.16 Lithuania

In Lithuania, the Ministry of Energy is in charge of the energy sector. The National Energy Strategy is the main document setting the guidelines for the energy sector. General provisions of the energy sector are regulated by the Energy Law. Sectorial requirements are set in the separate Laws (Electricity Law, Heat Law, Biofuel Law, and Law on Nuclear Power Plant).[22]

The Law on Energy, adopted in 2002, amended in 2003, 2004, 2005, 2006, 2007, regulates general energy activities, the basic principles of energy development and management, energy and energy resources efficiency.

The Law on Electricity entered into force in 2002. A revised version of the Law on Electricity entered into force in 2004. This law establishes the basic principles regulating the generation, transmission, distribution, and supply of electricity in the Republic of Lithuania, the relations between providers of electricity services and their customers as well as the condi-

[22] www.enercee.net

tions promoting competition in the electricity sector. Since July 2007 the electricity market has been fully liberalised and all customers can choose their supplier.

3.16.1 Smart Metering Landscape in Lithuania

Smart Metering is not an important issue in Lithuania. With Elgama Elektronika, Teltonika and others there are companies in the country that deliver smart metering solutions (electronic electricity meters, communication infrastructure, etc.). However, there are currently no concrete plans for a smart metering rollout (Shargal, 2009).

3.17 Luxembourg

In Luxembourg there are currently no detailed plans for a rollout of smart meters. However, trial tests of smart meters with Internet portals and in-house displays are being carried out by some DSOs. The regulator is responsible for the cost recovery surveillance. Luxembourg has not performed a cost benefit analysis yet. The DSO has the responsibility for installing the electricity meter. Luxembourg states that its definition applies to all residential and small non-residential customers although it is not a legal definition. Luxembourg has not defined the minimal technical standards or functionalities(ERGEG, 2009).

3.18 Malta

In Malta the installation of electronic meters has been decided and is moving according to plan. The rollout started in 2009 with a first pilot phase. After that first pilot project, all meters are expected to be changed within three years. While the installation of electronic meters is moving according to plan, there were some serious problems with billing actual consumption.

3.18.1 Policy objectives for the introduction of smart metering

The installation of electronic meters is part of the goal to modernise the power sector in the country and curb meter tampering which allegedly amounts to EUR 23million on evaded revenues per year[23] (7% non-technical electricity losses per year).[24] One of the objectives is to implement demand management methods and facilitate the feed-in of electricity into the low voltage network through smart metering. Moreover, with remote readable electronic meters the costs of EUR 1million per year to provide bi-monthly actual bills should be reduced.

In April 2009 the government issued a proposal for an energy policy for Malta that provided for the use of smart metering to provide customers with appropriate information in regard to inefficiencies in their consumption and enabling them to take action to mitigate them as well as to quantify energy consumption and provide appropriate information to customers (MRRA, 2009).

3.18.2 Legal foundation of smart metering services

- Provision in the Energy Law: During 2010, a nation plan for replacing traditional meters with smart meters has been initiated, led by Enemalta, the vertically integrated

[23] http://www.smartmeters.com/the-news/1381-malta-investigates-power-billing.html
[24] http://www.cipmalta.com/Uploads/Resources/2_4_Sean%20Barabara.pdf

national electricity provider. The meter is owned by the company (compulsory). No information on any provisions in the energy law could be retrieved.

- Market model and responsibilities for metering: Enemalta is the only provider of electricity to Malta's customers. Automated Revenue Management Services (ARMS) Ltd is a private limited liability company jointly owned by Enemalta Corporation and Water Services Corporation (water provider). During 2010, the company will be taking over the management of the Customer Care and Billing functions on behalf of both corporations.
- Minimum functional requirements for the metering system: the smart electricity meter is an advanced meter that can store information (such as consumption readings) and transmit the data via a network to a central system. It can also receive commands from a remote location. Power load limits can be set and changed remotely, as can consumption limits to allow prepayment services. The limits are programmed into the meter according to pre-arranged agreements. The new meters will improve the service we provide to customers (e.g. eliminate estimated billing), increase efficiency in certain operations (e.g. reduce meter reading costs substantially) and provide social and environmental benefits (e.g. reduce electricity theft and reduce CO_2 emissions).

3.18.3 Smart Metering Landscape in Malta

Enemalta Water Services Corporation Transformation is currently implementing the Integrated Utilities Business Systems (IUBS), a pilot project for electricity and water across Malta. The IUBS is a 5-year programme that started with the implementation of 5,000 meters in 2009 and is followed by a 3-year phase involving the large-scale implementation of 84,000 meters per year. The pilot project is aimed at identifying any problems ahead of the planned replacement of all electricity and water meters in a €40 million project that will enable remote, real time and accurate meter reading.

Together with the start of the pilot, utilities designed a tailored communications campaign to smoothen the implementation of the AMM system (videos, printed media, etc.). Also in 2010 Enemalta launched a massive implementation plan that will replace 270,000 electricity meters and install AMR modules for 270,000 water meters in the coming years. The meter is owned by Enemalta Corporation, the national electric company.

To date, 140,000 electric smart meters have been installed (50% of the total) by Enemalta Corporation, to allow customers to track their energy consumption in real-time and thus better control their energy bills. Also, in 2010 Enemalta launched an online portal allowing the customer to access consumption details. The overall replacement project should be completed by the end of 2013.

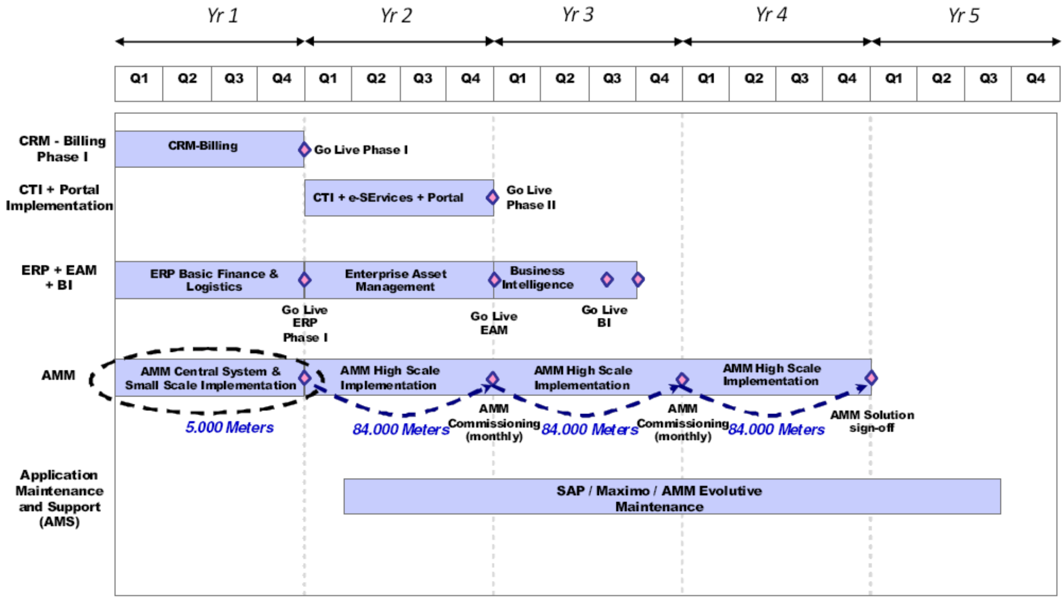

Figure 4: Timetable of Integrated Utilities Business System (IUBS) in Malta (Klatovsky, 2010)

3.19 Netherlands

The revised Dutch Electricity Act and the Gas Act, accepted by parliament in 2011 and lawful since 2012, obliges network operators (as owners of the smart meters) to offer all households (and small businesses) a smart meter. The households have a legal choice in accepting a smart meter, ranging from having no smart meter at all to a smart meter with full functionality to provide interval data to the network operator and/or a chosen service provider. When accepting a smart meter, the customer has to authorize the network operator to collect and use a minimum set of consumption data for specific regulated purposes such as bi-monthly cost statements, annual billing, switching supplier and moving home.

The revised law requires energy suppliers to provide customers with these bi-monthly cost statements. Providing customers with more detailed smart metering services for household energy management is considered to be a market responsibility. The customer will choose and authorise a commercial service provider to use (real-time) data beyond the minimum regulated level. In order to access the measurement data, the network operators set up uniform authorisation and authentication procedures. These procedures ensure that individual measurement data is only used for the specific purposes for which the customer has given its consent.

3.19.1 Policy objectives for the introduction of smart metering

The introduction of smart meters is an important part of a broader new energy market model for domestic and small business users. Important national policy objectives for the reform of the Dutch meter market were a strong desire to correct administrative problems with billing that followed the liberalisation of the Dutch energy market in 2004. Other objectives were to facilitate more energy market competition (easy switching for customers), improve operational efficiency for market parties and supporting energy savings for end-use customers.

Except for the ‘national’ drivers, the legal rollout proposal was also designed to meet the requirements of the Energy End-use and Energy Services directive (2006/32/EC). The Dutch government interpreted Article 13 as a claim for smart meters and bi-monthly bills.

Important drivers in other countries, such as limiting customer peak load demand to reduce the size of maximum demands in capacity e.g. on hot summer days, are less important drivers for smart metering in The Netherlands. The Dutch tariff system is primarily based on fixed rates. The only available tariff scheme that could be considered as a basic and static form of demand response is the option to choose a meter that allows a fixed switch between two tariffs: day and night/ weekend tariffs. It is expected that the rollout of smart metering will encourage the introduction of prepayment and flexible tariff schemes.

Prior to the original proposed changes in the Electricity Act and the Gas Act, which included a mandated rollout of the smart meter, a thorough cost-benefit analysis was conducted in 2005. This cost-benefit analysis, performed by KEMA by order of SenterNovem (now Agentschap NL), resulted in an expected positive business case of approx. EUR 1.3 billion(SenterNovem, 2005).

In 2009, the initially proposed mandated introduction of the smart meter was not approved by the Dutch Senate and the original proposal had to be changed to allow a voluntary rollout of the smart meter. As a result of that development, the Ministry of Economic Affairs instructed KEMA to perform a revised cost-benefit analysis and recalculate the consequences of the changed circumstances with respect to the business case for the introduction of smart meters in the Netherlands (Gerwen et al., 2010). The three major differences that prompted a new analysis were:

1) The smart **meter will only be read once every two months** in the standard situation. Only if express and unequivocal permission has been obtained from the customer can a detailed reading be taken. In the 2005 analysis detailed reading was still the standard situation.

2) The customer will have the **option of refusing the smart meter**. This means that the customer in question will keep their traditional meter. In the case of new construction and renovations it *is* compulsory to install a smart meter, and there is no obligation to replace it with a traditional meter at the request of the customer. In this case the customer can have the smart meter treated like a traditional meter by registering it as ‘administrative off’.

3) The need to get an understanding of the possible measures the Dutch government could take to influence the **social costs and benefits** in the direction desired by the Dutch government.

Assuming a situation of almost 100% acceptance of the smart meter as well as almost 100% standard readings, the updated cost-benefit-analysis showed a positive business case of appr. EUR 770 million. The main beneficial items (in order of positive contribution) are energy savings, savings on call centre costs, a lower cost level as a result of the market mechanism (increased switching) and savings in meter reading costs.

3.19.2 Legal foundation of smart metering services

In 2008, the Dutch government presented a legislative proposal to bring the smart meter under the responsibility of network operators in the regulated domain in combination with a mandated rollout to all households. Following consultations in the market sector, the Ministry proposed the following meter market changes:

- All small users will be given a smart meter;
- The grid operators will be responsible for rollout. The grid operators will own and maintain the smart meter and be responsible for a total distribution;
- The meters will become part of the regulated domain of the grid operator, being considered as part of the physical infrastructure;
- The cost of the hardware (meter hire) will be regulated;
- The energy retailers will be responsible for all customer-related processes and metering data management;
- The smart meters must comply with the basic functionality and technology mentioned in the smart meter industry standard NTA-8130 and technical requirements according to the DSMR.

To meet the obligation arising from the ESD to provide regular feedback to customers about energy consumption, the government stated a preference for setting a minimum frequency of 6 times per year (every two months).

The government proposed a mandated rollout as a prerequisite, because it was expected that a smart metering rollout in a liberalised market, without further regulation, would probably reach no more than about 30% penetration. In that case, several of the smart meter benefits mentioned above would not be realised.

The rollout will partly be funded from the current meter tariff. This tariff should remain unchanged or even drop. To date the meter charge has not been regulated and has increased by up to 100% since 2001. The Dutch Competition Authority has stated that it could not believe there is a relation between the increased tariffs and actual costs.

In 2009, after intense political debate and vigorous campaigning of the national customer's association *Consumentenbond* and privacy watchdog groups, the Dutch Senate declined to approve a mandated rollout of smart meters. To solve this privacy issue, the smart metering bill was revised into a voluntary rollout of smart meters and reintroduced for political consideration in September 2010. In this revised proposal the customer has the following legal options when offered a smart meter:

1) The option to refuse the installation of a smart meter and keep the traditional meter;

2) The option to have a smart meter fitted (or once it has been installed), but opt out of sending meter readings automatically (smart meter functions as a traditional meter, a meter reader is still required);

3) The option to have a smart meter fitted, but with a limited set of automatic meter reading capabilities of which the most important are: final billing in case of switching energy

supplier or moving house, once a year for annual billing and bi-monthly meter readings for interim energy advice.

4) The option to have a smart meter fitted, with full automatic smart meter reading, the preferred option for the government and energy market players.

The revised law requires energy suppliers to provide customers with a basic smart metering service: bi-monthly cost statements. Additional regulation has been developed to set out the minimum information requirements for these cost statements. More detailed smart metering services for household energy management are not part of regulation and considered to be a market responsibility. However, the customer will have to authorise a commercial service provider to use (real-time) data beyond the minimum regulated level. In order to access the measurement data, the network operators set up uniform authorisation and authentication procedures. These procedures ensure that individual measurement data is only used for the specific purposes for which the customer has given consent.

In combination with freedom of choice for the customer, the revised law proposal passed in the Dutch House of Parliament on 9 November 2010. The Senate approved the revised proposal in January 2011.

3.19.3 Smart Metering Landscape in the Netherlands

The rollout of smart meters in the Netherlands started in 2012 in line with a two-stage approach. From 2012 until 2014 a small-scale rollout will take place for experience purposes. The small-scale rollout will take place in case of regular meter replacements (e.g. malfunctioning), new meters to be placed in newly built houses/ renovated houses and new meters on request by customers. Important aspects that will extensively be monitored during the small-scale rollout are related to technical and economic matters and the level of energy savings and smart metering services market development. From 2014, the rollout will continue on a larger scale, based on the experiences mentioned above. The large scale rollout aims to have a smart meter fitted by at least 80% of households and small businesses in 2020, as mandated through the 3rd Energy Package.

3.20 Norway

In the Norwegian deregulated power system the DSO and the power supplier are two separate actors. This implies that all customers have separate tariffs for the electrical energy and the use of the power network. The design of the network tariff is strictly governed by the monopoly regulation. The energy contract is based on a contract between the power supplier/retailer and the customer.

The main actors related to the power system are presented in the following figure, grouped as monopoly actors and market participants.

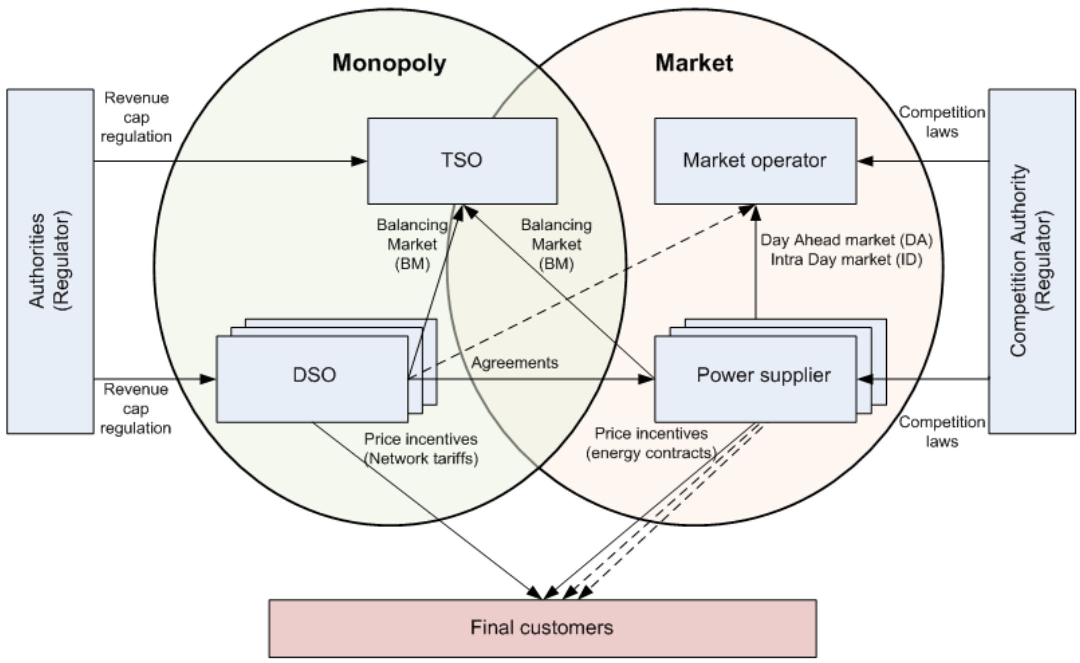

Figure 5: Monopoly actors and market players (Sæle, 2010)

For the Transmission System Operator (TSO) there is an overlap between these roles, because the TSO is under monopoly regulation, and also has a role as the organiser of the Balancing Market (BM). The market operator (NordPool) is the organiser of the Day Ahead (DA) and the Intra Day (ID) market.

The figure also indicates the network tariff and the energy contract that the end customers receive from the monopoly side and from the market side, respectively. The customers are free to choose power supplier, and they can change the power supplier weekly. The DSO is hence the only actor that has a permanent relationship with the final customers.

Self-reading of the meter has been the most common solution for smaller customers. Despite the lack of technology for Automatic Meter Reading (AMR) in the last quarter of 2011 54.9 % of household customers had an energy contract related to the market price (NVE 2011a).

In 2005/2006 a survey was conducted to determine the status concerning technology for AMR/Smart metering. This work was performed within the research project “Market-Based Demand Response” (MBDR). According to this survey 10 Distribution System Operators (DSO) had performed full-scale establishment of AMR, and 18 DSOs were planning to do so (Sæle, 2006).

For smaller customers (<100,000 kWh/year) the AMR technology was mainly used for reading the meters on a weekly or monthly basis. This metering frequency was principally chosen due to requirements in the regulations regarding change of power suppliers and periodical settlement of the consumption (Sæle, 2006).

By June 2011 there were 150 DSOs in Norway (NVE, 2011b), and of these there are only 8 DSOs with more than 100,000 customers.

3.20.1 Policy objectives for the introduction of smart metering

From the Norwegian Regulator's point of view, Smart Metering technology is evaluated as an enabler for a more efficient power market, a more optional consumption of electricity and good management of the power systems. Only Smart Metering technology regarding electricity is evaluated in Norway.

The Regulator has specified the following objectives for the implementation of Smart Metering technology (NVE, 2010a):

- Exact billing of the electricity consumption
- Easier to change power supplier
- Increased competition between the power retailers, and thereby reduced prices and new products/services
- More efficient control of the distribution system
- Increased information to the customers regarding prices and their electricity consumption.

The costs related to full-scale deployment of Smart Metering technology in Norway are estimated to be EUR 625 million.[25] This amount is valid for investing in and installation of the metering technology. Afterwards it has been commented that the costs related to internal software systems will be a further EUR 625 million(TU, 2010).

3.20.2 Legal foundation of smart metering services

The prevailing Norwegian requirements regarding metering and the settlement of the electricity consumption are specified in a regulation (FOR-1999-03-11-301).[26] The DSO is responsible for all the meter values from metering points in his power network (§3-2).

The requirements regarding metering of the electricity consumption differ according to the consumption volume in each metering point. The following requirements are specified in (FOR-1999-03-11-301):

- All metering points should be metered at least yearly.
- Household customers with a yearly consumption greater than 8,000 kWh shall be metered periodically 12, 6 or 4 times per year. The time between the readings should be approximately equal. One of the meters should be performed at the start of the year.
- All energy input (production) to the power network shall have hourly metering.
- Metering point with a yearly consumption larger than 100,000 kWh shall have hourly metering of their consumption.

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[25] 5 bill. NOK

[26] "Forskrift om måling, avregning og samordnet opptreden ved kraftomsetning og fakturering av nettjenester" ("Regulations for metering, settlement and coordinated behaviour , FOR-1999-03-11-301).

The requirement for hourly metering of the consumption for customers with a yearly consumption larger than 100,000 kWh implies that about 4% of a total of 2.5 million metering points in Norway have hourly metering (Grande et al., 2007). Over 60% of the total yearly consumption in Norway (approx. 125 TWh/year) has hourly metering.

In July 2011 new regulations regarding smart metering were introduced in Norway. The new regulations imply that all customers should have a smart meter by 1/1/2017. 80% of the customers should have a smart meter by1/1/2016.

The following functional requirements to the new smart meters are specified in §4-2:

The smart meter should…

1) Store the meter data with a registration frequency of a maximum of 60 minutes. It should be possible to change the registration frequency to a minimum of 15 minutes
2) Have standardised interfaces that adjust for communication with external equipment based on open standards
3) Be able to connect different types of meters (gas, heat, water, etc.)
4) Secure data storage at voltage outages
5) Disconnect or reduce (electrical fuse) the total load at the customer, except customers metered with a transformer (large customers)
6) Send and receive price information (energy contracts and network tariffs) and signals for load control and earth fault
7) Give security against misuse of data and unwanted access to load control functionalities
8) Meter both active and reactive power – in both directions (in/out)

Hourly meter data should be:

- Stored in the meter until transferred to the DSO
- Transferred to the DSO after the end of the day

Available for the customer and the power retailer within 09:00 the next day (the day after the consumption day)

3.20.3 Smart Metering Landscape in Norway

Smart metering has been a hot topic for several years, and it was already proposed in 2002 that all end customers should be offered technology for AMR (Dok 8:139 (2001-2002)). Even if the process for introducing smart metering technology lasted for a long time, it did not speed up until2007. Since then two hearing rounds concerning new regulations have been performed. The first suggested deadline was that AMR should be deployed full-scale until 2012, but after several delays, it has now been decided that AMR should be deployed in full-scale until 1.1.

In the beginning the development of new regulations was delayed due to uncertainty regarding costs and the quality of the technology. The latest delay is due to the standardisation work within EU. The Norwegian regulator was awaiting the results from the standardisation work – if this work comes up with results that may affect the requirements specified in the regulations.

Some Norwegian DSOs have already provided AMR technology to all their customers, but this is mainly smaller DSOs. The AMR technology is mainly used for weekly meter reading of the consumption. Larger DSOs have performed some pilot tests, but not to all their end customers.

According to the new regulations for deployment of smart metering technology all DSOs are obliged to deliver a periodical progress report to the Norwegian Regulator. The first report (NVE, 2012) was delivered on 1/1/2012, and 126 DSOs delivered a report (Representing 2,791,385 customers in total). According to this report most of the DSOs still are early in their planning process for deployment of smart meters. 38 DSOs (30.2%) have already installed smart meters to most of their customers, representing 197,621 customers. 49.2% of the DSOs expect that their plans for deployment of smart meters will be approved in 2012, and approx. 61.1% will make an agreement with the vendors in 2012 and/or 2013. 52.4% of the DSOs expected that the installation of the meters will start in 2013 and/or 2014.

In relation to new requirements for smart metering technology in Norway, work has been undertaken to evaluate the possibility for third-party access to the data and new smart metering services (Davinci, 2011). This has resulted in a request from the Regulator to the TSO to evaluate the possibilities related to a national meter database – to store all the meter data from all customers in Norway, and where the energy retailers can have access to the data from their customers. The request from the Regulator to the TSO was sent in December 2011, and the recommendation from the TSO will be provided in June 2012 (NVE, 2011c).

How to develop the network tariff is specified in the regulations, and the traditional network tariff consists of a fixed part (covering at least the customer costs) and an energy part (covering at least the network losses). The rest of the costs are divided between these parts. Some DSOs have in pilot studies offered new network tariffs based on hourly values of electricity consumption. New regulations regarding the network tariffs have not been discussed when evaluating smart metering technology.

Some power retailers offer power contracts with the spot price on an hourly basis – related to hourly metering and settlement of the electricity consumption.

The Norwegian TSO experiences bottlenecks in the transmission grid, but such experiences are not common for the DSOs in the distribution grid. If thinking locally the DSOs have therefore less incentive to introduce tariffs that stimulate demand response and energy efficiency.

Increasing the focus on the environment, energy efficiency, export of electricity produced by renewable energy and new smart metering technology have increased the focus on demand response and end-use consumption.

3.21 Poland

The drivers for the implementation of smart metering in Poland are EU directives (especially Directive 2006/32/EC, Energy Performance Directive – 2006/32 of Buildings Directive

2010/31 and 2009/72/EC, 2009/73/EC) and the so-called 20-20-20 EU-goals by 2020. Intensive preparations for the implementation of smart metering have started. An important document defining directions of development of the Polish power sector is the Polish Energy Policy until 2030.[27]

The Polish National Energy Conservation Agency (KAPE) supports activities in the joint declaration on the introduction of smart metering to the Polish electric power system of 3 June 2009, concluded by the Regulator, KAPE, Customer Federation, Association of Polish Customers and Buyers Forum Electricity and Gas.

On 19 November 2010 the Energy Regulator, the Industry Development Agency (ARP) and the National Fund of Environmental Protection and Water Management signed the "Declaration of Appointing the National Technological Platform on Energy." There are four strategic areas of this new Platform. First, support the creation of advanced control process automation of power system applied in the electricity, gas, heat and water supply sectors. It should be supported by the latest, cost-effective IT and telecommunication technologies, which improve people's quality of life. The Platform will support research in that area. Secondly, introduce knowledge about innovative solutions in the knowledge-based society development process. Thirdly, initiate the cooperation of "energy coalition" partners. The "energy coalition", which consists of individuals, social groups, customers and industry organisations, enterprises and State authorities, should cooperate especially in the field of new technologies. It would create a base for social and technological transformation and guarantee accessibility, reliability, quality and efficiency energy. Fourthly, disseminate knowledge about innovative solutions to end customers.

Additionally, the consortium "Smart Power Grids – Poland" has been established. The consortium consists of scientific and economic institutions and was established at the Wroclaw University of Technology on 3 November 2010 by the Energy Regulatory Office, the Office of Electronic Communications, the National Fund for Environmental Protection and Water Management and Bank Zachodni WBK. The organisation will work on innovative technologies for the smart grid development. The consortium members will particularly deal with smart grids development as well as tools used for its optimisation, protection and steering. They would also take steps to draw up the basic directions for networks and their technical parameters development. The consortium will conduct R&D works for the practical implementation of smart power grids concept and will draw up general rules for these networks' exploitation. The consortium will be also aimed at the commercialisation of its research and technology solutions. The consortium not only wants to cover the Polish energy market but it is going to undertake also international activities.[28]

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[27] http://www.mg.gov.pl/Gospodarka/Energetyka/Polityka+energetyczna

[28] http://www.ure.gov.pl/portal/en/1/91/Smart_Power_Grids__Poland_consortium_has_been_established.html

3.21.1 Policy objectives for the introduction of smart metering

Smart metering is one of the major subjects for the entire power sector in Poland today. Implementation of this system represents a significant financial and technological challenge with the following benefits:[29]

- Limiting increases in electricity prices for end users through the implementation of new mechanisms for a competitive electricity market, in particular the disclosure of the price elasticity of demand,
- Strengthening energy security – including improving the quality of the energy supply and power quality parameters,
- Reducing energy consumption – bringing energy to the needs and financial capabilities of the household. The experience of EU countries shows the resulting potential for increased energy efficiency at a level of 6-10%,30
- Simplifying the procedures for changing energy distributors,

In Poland the PSE-Operator is responsible for preparing the "Smart Metering" system to improve the security and reliability of the Polish power system. The scope of the project is:[31]

- Global benefits and costs analysis of Smart Metering and DSR (Demand Side Response) implementation",
  - fulfil the obligations of Directive 2009/72/EC,
  - provide guidelines to decision-makers,
- Developing a model of metering data flow on the energy market,
  - design area of responsibility,
  - design the communication rules,
  - design the financial flow,
- Developing DSR programmes,
  - incentive-based DSR programme,
  - Emergency DSR programme.

Benefits attributed to smart metering for different stakeholders:[32]

- Global economy - energy savings and efficiency targets and free market process improvement.
- End users - energy awareness allows energy use and energy cost to decrease and more efficient switching between suppliers.

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[29] http://www.piio.pl/smart_metering_w_polsce.php
[30] http://www.piio.pl/smart_metering_w_polsce.php
[31] http://www.piio.pl/prowadzone_projekty.php
[32] http://www.piio.pl/prowadzone_projekty.php

- Distribution System Operators (DSO) - decrease meter operation costs and O&M costs and cut down income losses.
- Transmission System Operator (TSO) – grid resilience improvement and decrease cost of balancing.
- Energy suppliers – new, customer-oriented services, decrease energy purchase cost and call centre costs reduction.

The following activities in the scope of energy efficiency improvement are part of the Polish energy policy:

- Use of demand management techniques stimulated by:
  - differentiation of daily distribution bids and electricity prices
  - transmission of price signals to =customers through remote two-way communication with electricity meters,
- Information and educational campaigns in order to promote rational energy consumption
- Energy Efficiency Act (of 15. April 2011)
  - Decrease energy consumption by 9% by 2016 while averaging covers the years 2011-2005
  - 2nd National Energy Efficiency Action Plan (endorsed by the Council of Ministers. May 2012)

3.21.2 Legal foundation of smart metering services

Work began to develop legal solutions, which create conditions for the gradual implementation of smart metering. The Energy Regulatory Office is responsible for preparing the legislation package for the Ministry of Economy and the Polish parliament. It is expected that the legislative work will take approximately two years. In parallel the PSE Operator works on the system, whose aim is to provide global benefits for the implementation of smart metering and to develop an optimal model for implementing such a system.[33]

The Energy Regulatory Office (ERO) is responsible for preparing the necessary regulations. During 2009-2012 the ERO has taken the following initiatives:

- Declaration concerning the introduction of smart metering into the Polish power system signed in June 2009 by Presidents / Chairmen of: Energy Regulatory Office, Customers' Federation, Polish Customers' Association, The Polish National Energy Conservation Agency, Customers' Forum for Electricity and Gas. Many other bodies (administrative, academic and business) have confirmed their readiness to cooperate and support this initiative.
- Education:
  - The Energy Regulatory Office (ERO) website,

[33] The role of the PSE Operator S.A. activity is to provide the services of electricity transmission in compliance with the required criteria of the security of the Polish Power System operation.

- Press releases and press conferences,
- Content-related conferences,
- ERO personnel activity on many other conferences and workshops. e.g. Workshop on Regulatory Aspects of the Smart Grid, Including Smart Metering 16 February 2012 Gdansk, Poland Co-Hosted by the Energy Regulatory Office (ERO), Energa-Operator SA, Energy Regulators Regional Association (ERRA)

■ Co-operation related to :

- Transmission System Operator,
- Distribution System Operators,
- Branch Chambers of Commerce,
- Universities of Technology.

Moreover, the Energy Efficiency Act was approved by the Parliament.34

3.21.3 Smart Metering Landscape in Poland

The government and parliament has started to work on the preparation of the comprehensive revision of the energy law. In order to start a dialogue on this topic the PSE Operator initiated an information platform in June 2010.[35] Smart meters are also regarded to be the first step towards the implementation of intelligent networks in Poland.

In December 2008, the Energy Regulatory Office (URE) presented a feasibility study of smart metering in Poland. The study provides an analysis of all aspects of the implementation of smart metering costs, technical, legal and socio-economic issues. It also outlines the scope of work and sets out a timetable for full implementation of the system in Poland. It is assumed that implementation of the system will take up to 10 years.[36]

An analysis of the PSE Operator shows the basic conditions for the implementation of Demand Side Response (DSR) mechanisms in Poland.[37] The preparation of the project is supported by the National Fund for Environmental Protection and Water Management "Smart energy networks." The basis for DSR implementation is the ability to record energy consumption within stipulated deadlines.

In December 2011 the ERO finished public consultations on Koncepcja modelu rynku opomiarowania w Polsce, ze szczególnym uwzględnieniem wymagań wobec Niezależnego Operatora Pomiarów.

In the Ministry of Economy a Group on energy market development is being put together. Its scope also covers issues related to the Smart Grid.

Broad business initiatives in the coming years are:

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[34] Law on energy efficiency in Poland **Dz. U**. nr 94, poz. 551
[35] www.piio.pl
[36] www.ure.gov.pl/download.php?s=1&id=2736
[37] http://www.piio.pl/bszpre_produkty.php

- Transmission System Operator (Electricity)
  - Feasibility Study for Measures and Smart Grid Operation Market Structure
  - Smart Region Platform Initiative
  - Parallel studies for smarter system management and control
- Distribution System Operators Association (Electricity)
  - Pilot scale installations
  - Feasibility Study
  - Information exchange: General Conference and local Workshops
- Chamber of Commerce, Gas Industry
  - Smart Metering Analysis and Preparation Team

At present the Polish distributor Energa is a leader in smart metering innovation pilot testing. By the end of the exchange counters procedure Energa will cover 70%percent of the energy transmitted to customers. The entire project is valued at PLN 1 billion it will cover three million customers and will be completed in seven years. An expected outcome of the project is to reduce the price of energy distribution, reduce technical losses by 4% and to reduce the theft of energy by 60%. As shown in the operator's first experience, the system allows for the rapid identification of faults and reduces repair times.

The other energy distributors are a few steps behind Energa. The operator RWE Stoen has launched a pilot programme for individuals and develops them in a device designed to further modernise the network measurement. Already at this time all counters that are installed in the operator RWE Stoen are set up for the remote reading of electronic meters. However, the supplier does not have an action plan and it makes further decisions from the regulator in Poland (ERO – Energy Regulatory Office). President of RWE Stoen Operator stresses that for the moment the programme is already used widely by industrial customers.

A similar programme runs EnergiaPro. The project will cost PLN 10 million and cover 20,000 customers by the end of next year. The company is considering extending the project to 20% of their customers by 2015. The operator sees another advantage of this approach. The intelligent supply network will permit the calculation of the real value of deductions for interruptions in the supply of electricity; the absence of current flow is automatically recorded in the system. As a result, customers will receive higher compensation for an interruption to the supply.

Another company to check the technological capabilities of the smart meters system on the Polish energy market is Enea Operator. On the pilot testing experiments 1000 smart meters will be installed in Poznań I Szczecin. Enea operator is another player waiting for the traffic regulation. At present the development plan is under negotiation with the ERO, which determines the size of the investment in the smart meters development programme.

Enion, operating in the south of the country, does not have an implementation plan for remote meter reading. The distributor is still waiting for final arrangements. The company has introduced a device for its largest industrial customers.

The exchange of almost the entire measurement system is not a simple operation with suppliers. In addition to financial resources, distributors will need highly skilled workers, particularly to manage data. Parts of the operators are expected to support the financial investment by EU funding. Most of the energy suppliers are waiting for developments on the market.

3.22 Portugal

3.22.1 Policy objectives for the introduction of smart metering

The policy objectives related to the installation of smart meters are mainly to implement European legislation. The Regulatory Compatibility Plan agreed by the Portuguese and Spanish governments on the 8^{h} March 2007 foresees a timeline for the establishment of homogeneous meter specifications and minimum functional requirements.[38]

3.22.2 Legal foundation of smart metering services

- **Provision in Energy Law**: In December 2007 a proposal was presented for the minimum requirements and a substitution plan for energy meters by the National Energy Services Entity (Entidade Reguladora dos Servicos Energéticos), establishing the period of 2010 to 2015 to replace energy meters. A pilot project should be performed prior to that. At present, there are no regulations related to a rollout of smart meters.
- **Responsibilities for metering**: Distribution companies (operadores de redes de ditribuição) are currently responsible for metering issues.
- **Minimum functional requirements**:[39]
  - Active and Reactive measurement in any direction (bi-directional),
  - 15 minutes maximum demand,
  - 15 minutes load profile for a minimum of 3 months,
  - Up to 6 programmable energy registers with at least 3 periods per day,
  - Possibility of prepayment,
  - Open protocols for communication,
  - Recording of service interruptions longer than 3 minutes and voltage out of the rated limits,
  - Demand management,
  - Load control, disconnection and reconnection,
  - Interface for end user services.

3.22.3 Smart Metering Landscape in Portugal

The proposed replacement plan is included in the framework of the Regulatory Compatibility Plan agreed with the government of Spain in March 2007 for more than 6 million low voltage

[38] Entidade Reguladora dos Servicos Energéticos.

[39] Entidade Reguladora dos Servicos Energéticos, December 2007

customers including the domestic sector and small companies (99% of customers). The plan is involving distribution companies and smart metering manufacturers, supported by the public consultation prepared for this issue. It includes a pilot action for 2010 that is in progress at present.

A consortium led by EDP Distribuição (with support from national partners in industry, technology and research such as INESC Porto, Efacec, Lógica, Janz and Contar) is implementing the pilot project InovGrid. The project aims to provide the electricity grid with information and devices to automate grid management, improve service quality, reduce operating costs, promote energy efficiency and environmental sustainability, and increase the penetration of renewable energies. It will be possible to monitor and manage the state of the entire electricity distribution grid in real time, significantly reducing the duration of any service interruptions.

Using this technological platform, suppliers will be able to offer price plans that are constantly adapted to customers' consumption profiles and requirements. Energy services companies will also provide access to integrated home automation solutions which interact with appliances in the home.

Within that project around 50,000 smart meters will be installed in several points of the country (not concentration), with an investment of EUR 15 million. On 6 April 2010, EDP unveiled the InovCity concept for the city of Évora, a World Heritage City celebrating the centenary of its electrification. New functionalities will allow to the domestic customer to know, in real time, the cost of energy in their home, to know where they can save energy and opt for a more efficient consumption. To date, around 100,000 low-voltage customers (residential, small businesses and industry) are connected in Portugal. The integrated and intelligent electricity system, that started in the municipality of Évora, will be developed in another 7 regions in Portugal with the additional installation of 100,000 smart meters..

3.23 Romania

In Romania, a decision on a nationwide rollout of intelligent metering systems as demanded by Directive 2009/72/EC is expected in 2012.

ANRE (the Romanian Electricity, Heat and Gas Regulatory Authority) was established by the Government in 1998 as an independent regulator for the electricity and heat sector. Since 2007, ANRE has also been the regulator for the gas sector (ANRGN). It is an autonomous public body coordinated by the Ministry of Economy and Finance. It is in charge of Secondary Legislation in the field of electricity, gas and heat. Any activity in the field of electricity is subject to ANRE’s prior authorisation/licensing procedure.

The energy market is regulated and refers to the ANRE Metering Code. The installation and maintenance of the metering system could be carried out by any ANRE certified metering operator. The installation, maintenance and reading are the responsibility of the utilities or subcontracted independent metering service providers. In the case of electricity, the customer and metering operators may also read the meter. The metering data is managed by the metering operators and the utilities.

In Romania there are two types of customers (for electricity): (a) independents and (b) “bound to a provider;” the first category can choose their energy provider and the contracts are individual, based on various grounds, some maybe including efficiency. The second category is mostly represented by individual customers with low voltage, low power (households) and comprises approximately 8 million metering units. These customers count for 17% from the total electricity consumed and 24% of the total installed power. The smart metering procedures in Romania can only be implemented to these (b) customers.

3.23.1 Policy objectives for the introduction of smart metering

Currently there is no official policy statement that calls for the introduction of smart metering in Romania. Additionally, a cost-benefit analysis as required by Directive 2009/72/EC has not been carried out yet. However, in a publication by the European Regulators (ERGEG, 2009, 24) Romania stated that energy efficiency is one of the expected benefits from a nationwide and standardised rollout of smart meters for all domestic household customers. Additionally, Ryberg (2009, 124) suggests that Romania has an outdated meter park that has to be modernised, a high ratio of customers on double tariffs with dynamic schedules and a high incidence of energy theft are also arguments for the introduction of electronic meters.

3.23.2 Legal foundation of smart metering services

The legal framework for metering services in general is the Romanian Energy Law (Legea energiei electrice). The electricity measurement is described in Art. 60.

1) Electricity sold on the market is measured by the metering service providers/operators using measurement chains, according to the “measuring code” issued by the authority in charge.

2) Instrument transformers in the energy measurements chains for billing purposes are provided by one of the following: a) TSOs; b) producers; c) DSOs; d) customers.

3) Metering services providers/operators can be: a) TSO; b) energy producers; c) DSO; d) independent metering service operator/provider.

4) The transport and system operator (TSO), as well as the distribution operator (DSO) have the obligation to provide the electricity measurement service for users of the electricity network directly or by using an independent measurement operator named by them, on the condition that they match the costs agreed by the authority in charge.

5) In certain situations, when the transport and system operator (TSO) or distribution operator (DSO) do not meet the deadline for the instalment of the measurement unit according to the terms agreed, providers or customers may choose an independent metering operator to provide this operation at their own expense, and after previous notification from the authority in charge.

Energy Law defines the metering operators for each category of points of measurements. The authority names one or more metering operators for each category of points of measurements, through the present Code or through distinct rules. The metering operators could be economic agents that have a producing, transportation, distribution or electric power providing license or, according to the provider agreement, these could be industrial customers that agree to follow the provisions of the present Code.

In Romania, the government has set out a preliminary roadmap towards a smart grid in the form of an Action Plan published by the Ministry for the Economy, Commerce and the Business Environment in November 2010. This stops short of setting out a detailed timetable – but it does set out the preliminary feasibility studies that need to be carried out along with changes to legislation. Beyond this there are no formal plans for a rollout of smart metering;

a cost-benefit analysis has not been conducted; and the country's Electricity Act does not refer to smart metering. The government's strategy and the legislative position are expected to be clarified in 2012 (www.smartgridopinions.com).

Romania is relatively advanced in implementing some of the requirements of the Third Energy Package, such as, for example, the unbundling system and the independence of the National Energy Regulatory Authority (ANRE). This legislative package will have significant effects in Romania, in terms of the increased transparency of grid operations, a stricter monitoring of the market and the opening up of borders as regards interconnection capabilities. Moreover, it is expected that this legislative package will trigger the elimination of the main irregularities of the Romanian energy market including the maintenance of regulated prices for non-residential customers. (Roadmap for innovative smart metering end user services Romania, www.smartregions.net)

There are 8 Regions in Romania operated by 7 DSOs (Electrica Muntenia N., Electrica Muntenia S., Electrica Transilvania N., Electrica Transilvania S, ENEL (Muntenia Sud, Banat, Dobrogea), CEZ (Oltenia), EON (Moldova)).

Three of these regions are operated by Electrica S.A. The company confirms the rollout of 59,000 AMI–supporting energy meters. Electrica has around 10% of the customers covered by Smart Meters and 1% integrated in AMI systems. Since 2008 most AMI information is integrated in advanced billing systems. The following table presents the number of Smart Meters bought and integrated in AMI systems compared to other types of meters and the total number of customers. This table refers to Electrica's customers only. However, at the beginning of 2003, this DSO served more than 80% of the customers in Romania.

The gas market in Romania was fully opened up on 1 July 2007, while natural gas customers are able to choose their own supplier. The gas market contains 1 TSO, 7 producers, 3 operators of underground storage facilities, 39 DSOs and 90 suppliers on wholesale market. Currently, there is no official smart metering policy, legal obligation or special strategy adopted in the field of natural gas and DHS. Romania is going through an approval period of the new electricity and gas laws for the implementation of Directives 2009/72/EC and 2009/73/EC requirements. To date, the Ministry of Economy, Trade and Business Environment has launched new electricity and gas legislation for public analysis according to Directive 2009/72/EC and Directive 2009/73/EC. These documents have a chapter dedicated to the implementation of smart metering system and deciding on the specific steps to be taken to develop these services:

First step – ANRE has to evaluate the effects of the implementation of smart metering systems on the electricity /natural gas market (cost-benefits analyses) - deadline 3 September 2012;

Second step – If the results of these cost-benefit analyses are positive, ANRE will draft a timetable for smart metering implementation taking into consideration the best practices, latest technology, appropriate standards and the importance of the electricity/natural gas market development.

(Roadmap for innovative smart metering end-user services Romania, www.smartregions.net)

3.23.3 Smart Metering Landscape in Romania

Currently, there are no plans for a nationwide rollout of smart meters. However, it is expected that a decision regarding “massive deployment“ of smart meters in Romania will be made until 2012..

There are 8 Regions in Romania operated by 7 DSOs (Electrica Muntenia N., Electrica Muntenia S., Electrica Transilvania N., Electrica Transilvania S, ENEL (Muntenia Sud, Banat, Dobrogea), CEZ (Oltenia), EON (Moldova)).

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Table 2: Smart Metering/AMI evolution in Electrica

Year	Customers	One phase meters			
		Classical	SMART	Stepper	AMR/AMI
2003	8,000,000	386,702	29,676	38,538	470
2004	8,000,000	353,500	46,645	41,000	500
2005	8,000,000	300,718	60,807	67,880	1,000
2006	5,000,000	105,349	75,696	57,255	3,000
2007	5,000,000	247,216	62,430	62,130	6,500
2008	3,000,000	189,440	30,090	54,730	12,000
Total		1,582,925	305,344	321,533	23,470

Source: *From AMR to AMI – Romanian Case,*Conference on Electricity Distribution of Serbia and Montenegro, September 26 - October 1, 2010.

Requirements for A-class meters, AMR - Central measurement level

- Art. 78 The central measurements point equipment provide data acquisitions and synchronised recording, at least once in a day, of the hour by indices on the electric meter in a direct way through concentrators.
- Art. 79 (1) The indices are kept in the database for a minimum period of 400 days.
- Requirements for B-class metering, AMR - **Central measurements level**
- Art. 136 The indices are preserved in a database for 400 days minimum.
- Requirements for C-class metering, AMR - **Central measurements level**
- Art. 180 The acquired data values are kept in a local database on the central point, for 400 days minimum.

- Art. 181 It is admitted the remote reading through electric impulses generated by the electric induction meters.
- Pre-payment energy meters
- Art. 193 The provider must ensure at least one top-up terminal for each 1000 prepay electric meters installed and at least one top-up centre for 10,000 installed prepay electric meters, but not less than one centre for each urban area, and one centre for three neighbouring villages in rural area.

Table 3: Smart meter integration to AMI/AMR – 2008

Subsidiary	Center	producer	Communication	local server	meters read	working	direct billing
Transilvania Sud	Mures	1	dial up	8	362	yes	yes
	Mures	2	PLC	35	92	yes	no
	Alba	3	dial up	200	921	yes	no
	Brasov	3	dial up	44-99	120	80%	test
Muntenia Sud	Bucuresti	1	dial up		4,231	yes	no
	Bucuresti	3	dial up		920	no	no
	Ilfov (Sintesti)	3	GPRS	3-16		n	no
Muntenia Nord	Ploiesti	1	dial up	23	1,722	yes	yes
	Ploiesti	x	PLC UNB		34	teste	no
		1	GPRS		1,219	yes	no
	Braila	2	PLC	100	2,344	yes	test
	Buzau	1	GPRS		1,057	yes	test
		3	dial up		1,000	no	no
	Targoviste	1	GPRS		1,047	yes	yes
	Focsani	1	GPRS		753	yes	test
	Galati	1	dial up	23	2,079	yes	test
Transilvania Nord	Baia Mare	3	PDA or dial up	3-90	1,868	yes	test
	Bistrita	3			271	teste	no
	Cluj	3			913	no	no
	Oradea	3			1,115	no	no
	Satu Mare	3			1,032	test	no
	Zalau	3		47	370	test	no

Source: *Update on Electrica's smart meter implementation plan,* Conference on Electricity Distribution of Serbia and Montenegro, 26 September –1 October 2010

Promoting investments based only on financials (most of the economics leads to favourable effects) is tricky in a fast-changing environment. Despite the fact that overall pressure on smart metering/AMI development increases, lack of standardisation leads to uncertainties that are difficult to handle. Looking at the meter in the AMI context as a hardware platform with intensive upstream and downstream communication capabilities may solve investment sharing between DSO, supplier and customer.[40]

[40] Dan Apetrei, Mihaela Albu, Ioan Silvas, Dumitru Federenciuc. *From AMR to AMI – Romanian Case,* Conference on Electricity Distribution of Serbia and Montenegro, 26 September–1 October 2010.

3.24 Slovak Republic[41]

In the Slovak Republic the Ministry of Economy (MH SR) is responsible for policy-making in the energy sector. The Regulatory Office for Network Industries (ÚRSO) is responsible for the technical and financial regulation of the energy sector. The Nuclear Regulatory Authority (UJD) is in charge of supervision of nuclear safety.[42]

Electricity generation in the Slovak Republic is dominated by Slovenske elektrarne, a.s. (SE) which makes up for 80% of Slovakia's annual electricity production, operating two nuclear plants, two coal fired plants and 34 hydro plants. SE is responsible also for the trade and sale of electricity. The transmission network is operated by Slovenska elektrizacna prenosova sustava, a.s. (SEPS) (Slovak electricity transmission system, Plc.).[43]

Three regional distribution utilities covering the whole territory of the Slovak Republic are responsible for the distribution of electricity to end customers.

- ZSE Distribucia, a.s. provides electricity distribution within the Bratislava, Nitra, and Trnava region.
- Stredoslovenska energetika – distribucia, a.s. provides electricity distribution within the area of the Banska Bystrica, Trencin, and Zilina region.
- Vychodoslovenska distribucna, a.s. provides electricity distribution within the area of the Kosice, Presov, and a part of the Banska Bystrica region.

3.24.1 Policy objectives for the introduction of smart metering

Slovakia does not have any special goals or targets in the field of smart metering services at the moment. The rollout of smart metering is still in a discussion phase.

3.24.2 Legal foundation of smart metering services

There are no specific legal requirements for smart metering. The energy sector in general is regulated by Act No. 656/2004 Coll. on Energy and Act No. 657/2004 Coll. on Heat Energy. Directive 2009/72/EC and other directives and regulations from the so-called “Third Energy Market Package” is currently in the implementation process. Examples of the legislation and other documents related to implementation of the ”third energy package” in Slovakia are as follows:

- Act No. 656/2004 Coll. on Energy as amended
- Act No. 657/2004 Coll. on Heat Energy as amended
- Act No. 276/2001 Coll. on Regulation in Network Industries as amended
- Act No. 309/2009 Coll. on Promotion of the Renewable Energy Sources and highly efficient cogeneration

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[41] The chapter on the Slovak Republic was drafted by Pavel Starinsky with inputs by Jan Magyar (both Slovak Innovation and Energy Agency).

[42] www.enercee.net

[43] www.enercee.net

- Act No. 476/2008 Coll. on Energy Efficiency
- Related secondary legislation to the previous acts
- Studies on the effectiveness of the smart metering services by utilities (internal studies of individual utilities)

In Slovakia, two-tariff meters and other metering devices for billing purposes are also used. Meters obligatory are to be read once a year or less than a year (e.g. on monthly basis) as well as when tariffs change, depending on type of customer and its consumption. Regulations on the metering of energy apply as follows for different sources of energy:

Electricity:

- Measurement in the transmission system is provided by the transmission system operator and measurement in the distribution system by the distribution system operator.
- The installation of energy measurement equipment is provided by the transmission system operator, the distribution system operator and the owner of direct line on their own spending's.
- If the customer has doubts about the accuracy of the measured data or faults on measurement equipment, they can request its examination within 30 days.
- The electricity producer or customer is obliged to allow the operator to access the energy measurement equipment for different purposes.

Gas:

- The distribution network provider is obliged to measure a gas supply, install energy measurement equipment and verify the accuracy of the measurement.
- If a customer or gas supplier has doubts about the measurements, they both have a right to request a distribution network operator to check the designated meter. It has to be replaced and checked within 15 days from the written request.

Heat:

- The heat supplier has to measure the amount of supplied heat on each agreed delivery point.
- The contractor is supposed to ensure the verification of the designated meter, ensure it against tampering, inform the customer about the replacement of meter, record the data of the exchanged meter, perform monthly readings of the designed meter and provide a monthly balance of heat production and supply.
- If the customer has doubts about the accuracy of the measured data or measurement equipment, they can ask the heat supplier for testing. This is required within 30 days from the official written request.
- The supplier who supplies heat from combined heat and power is obliged to provide an extra measurement for the amount of heat produced and the amount of electricity produced.

3.24.3 Smart Metering Landscape in the Slovak Republic

Currently, there are no existing plans for the introduction of smart metering. The rollout of smart metering is in the discussion phase. DSOs gradually install smart meters on a voluntary basis preferably for delivery points with high consumption e.g. in the industry sector or where it is suitable for potential energy savings. There is no central registration of installed smart meters at state level.

3.25 Slovenia

3.25.1 Policy objectives for the introduction of smart metering

So far there is no binding legislation in Slovenia regarding the introduction of smart metering systems.

The already existing legal framework does not exclude the rollout of smart meters by distribution network operators. All activities for network operators regarding smart metering are based mainly on business cases and not on regulation.

In May 2011 the Energy Agency of the Republic of Slovenia (AGEN), which is the national energy regulatory authority issued a consultation paper about the deployment of advanced metering systems in Slovenia. After that the Agency collected comments from the stakeholders and held a public hearing. As a result of the public consultation the Agency published "Guidelines for the introduction of advanced metering in Slovenia"[44] in July 2011. As one of the outcomes of the public consultation the Agency determined topics that need to be clarified before the introduction of smart metering systems and suggestions for an assessment of the costs and benefits.

One of the positions of the Energy Agency of the Republic of Slovenia is that the introduction of smart metering systems alone will not ensure that key objectives regarding energy efficiency will be met. According to the Energy Agency's findings there is a need of programmes, services and incentive mechanisms to influence the energy consumption of customers.

Therefore the Energy Agency has developed another consultation paper[45] with a focus on Demand Side Management (DSM), Demand Response (DR), Time-of-use-tariffs as well as on balancing and other measures. This document was published in March 2012 and a public consultation of this document was initiated by the Agency.

Moreover the Agency has published a tender regarding the development of a cost -benefit analysis for the electricity and gas smart metering rollout in Slovenia in February 2012[46].

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[44] SMERNICE ZA UVAJANJE SISTEMA NAPREDNEGA MERJENJA V SLOVENIJI, Energy Agency of the Republic of Slovenia, Maribor, July 2011

[45] Prilagajanje odjema - POSVETOVALNI DOKUMENT, Energy Agency of the Republic of Slovenia, Maribor, March 2011

[46] http://www.agen-rs.si/en/informacija.asp?id_informacija=1206&id_meta_type=41&type_informacij= (

The cost -benefits analysis shall cover electricity and gas markets and should also consider the integration of other measurement systems such as systems for water and district heating. The Analysis has to be based on smart metering models, which were developed and proposed by the Energy Agency. The analysis shall cover economic aspects of a smart metering rollout in more detail than the analysis which was done in 2008, by EIMV[47] (Milan Vidmar Electric Power Research Institute). In this analysis EIMV evaluated the costs and benefits of smart metering systems for domestic and small business customers[48]. The analysis was made for all 890,000 measuring sites in Slovenia with the assumption that the systems of all five Slovenian distribution network operators will be harmonised. The total investment costs were assessed to be about EUR 235 million, which is EUR 266 per consumption site.

3.25.2 Legal foundation of smart metering services

In the current legal framework, the electricity distribution system operator is responsible for the installation, calibration and maintenance of the meters as well as for the invoicing. There is at least one meter reading per year for domestic and small business customers (customers with less than 41 kW of contracted power).

Industrial customers and other customers with a contracted power of more than 41 kW are equipped with AMR-systems. The deadline for the installation of the AMR-systems was 1 Jan 2008. These meters measure the daily load profiles of the customers in 15-minuteintervals.

The Ministry of Economy is responsible for the preparation of the draft law for the national implementation of the 3rd EU energy market package. The implementation of the package in the Electricity Act is delayed. It is expected, that the new Electricity Act, which shall also cover smart metering will be enacted by the end of 2012.

3.25.3 Smart Metering Landscape in Slovenia

So far, only Elektro Gorenjska, one of the five Slovenian Distribution Companies, has decided to start a full-scale rollout of smart metering systems. The company has plans to start the rollout for all of it's about 80,000 customers in 2011. The decision for the rollout was based on the first cost-benefit analysis of EIMV in 2008, after a successful small scale pilot project. Other companies have not yet decided about a rollout, but some of them are also running pilot projects.

The network operators are encouraged by the authorities to consider smart metering also in their network development plans. One of the obstacles to the rollout of smart metering systems could be problems financing the investment costs. In general the costs for the rollout shall be covered by the network charges, but there are strong concerns regarding the costs and a possible increase of network charges.

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[47] EIMV: Elektroinstitut Milan Vidmar, Ljubljana

[48] Omahen, Souvent, Luskovec: „Advanced meter infrastructure for Slovenia“, CIRED, 20th International Conference on Electricity Distribution, Prague, 8–11 June 2009.

3.26 Spain

Spain is a country with 46 million inhabitants and approximately 26 million electricity customers. Three major energy players act in the country, Endesa, Iberdrola and Gas Natural-Unión Fenosa, with a market share of almost 95%. ESMA (2010, 26-28) provides a good overview of the situation in Spain.

3.26.1 Policy objectives for the introduction of smart metering

The national objectives to introduce smart meters are:

- Compliance with EU directives (2006/32/EC, 2009/72/EC, 2010/31/EC).
- Customer protection: exact and frequent billing; Energy meters replacement plan, an obligation to install smart meters in all customers under 15 kW by 2018 (in steps).
- Smart grids: to allow hourly energy control through remote management.
- Support for competition in the energy market: more and better information to design pricing options for retailers.
- Energy efficiency: to reach energy saving by means consumption feedback to the end customer.

3.26.2 Legal foundation of smart metering services

- Provision in the Energy Law: establishment of the meter replacement plan in those users up to 15 kW with the aim of supporting remote management systems. Deadline is 31 December 2018.[49]
- Regulation existing in Spain related to smart meters implementation:
  - RD 1634/2006: Order to the Regulator (Comisión Nacional de Energía, CNE) about the Replacement Plan including the Replacement Plan for all Spanish residential meters, criteria for the replacement and number of meters to install every year: percentage of the total equipment.
  - ORDEN ITC/3860/2007: publication of the criteria for the Replacement Plan, including every distributor having to present its own plan and AMM system design.
  - ORDEN IET/290/2012: publication which modifies the previous order to adjust the Replacement Plan to the current deployment status.
  - The meter Replacement Plans established with an obligation to install smart meters for all customers under 15 kW in the following quantities and periods: by 31 December 2014, 35% of the contracts from each distribution company should have been installed. Between 1 January 2015 and 31 December 2016, distribution companies must have replaced another 35%, and between 1 January 2017 and 31 December 2018 the remaining 30%. Distribution companies are responsible for the installation of the meters. The new timetable for the plan is as follows:

[49] Ministry of Industry, Tourism and Trade, December 2007

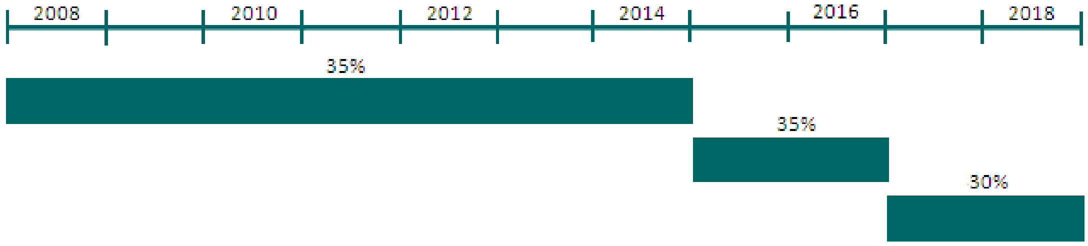

Figure 6: Timeline of Spanish Meter Substitution Plan

- **Market model and responsibilities for metering**: still under discussion at present. Distribution companies are responsible for metering equipment but it seems that energy suppliers will be the interested party responsible for the smart metering services. There will be a monthly fee for the meters.
- Minimum functional requirements for the metering system:[50]
  - Electronic meters with remote control available for the residential sector. Hourly metering and option for hourly tariff selection.
  - The remote management system is defined as the metering and bi-directional system between meters and distribution companies, with the availability of remote access to electricity meters for reading, energy management, control on the power demand and contract, supply (dis-)connectivity management and others.
  - Update of the previous definition:
    - An electricity meter is a device that measures sparely and at the same time active and reactive energy in a circuit
    - The hourly discrimination system is defined as the device or devices that allow consumption to be registered in different periods depending on the consumption time and date
    - Remote management: as the metering and bi-directional system between meters and distribution companies that, with the maximum guarantees of security, allows the availability of remote access to electricity meters for reading, energy management, control on the power demand and contract, supply (dis-)connectivity management and anti-fraud mechanisms.
    - The metering equipment is designed to: measure active energy and reactive energy, measure maximum demanded power (15-minute intervals), hourly metering with a capacity to store data for 3 months, able to manage flexible tariffs with 6 tariff periods and the capacity to store data for 3 bills.

[50] Ministry of Industry, Tourism and Trade, December 2007

- Metering system (AMM) should be able to offer the following:
  - AMR: remote reading of energy and power for billing
  - Remote reading of quality parameters
  - Change tariffs, periods, contracted power, etc.
  - Remote synchronisation (at least every reading cycle)
  - Meter software update
  - Remote reading of events
  - Remote disconnection and reconnection
  - Management of registration and cancellation of household customer
  - Rollout Demand Control Plan
  - Ability to manage demand: load reductions in peak demand
  - Ability to send different messages to customer

3.26.3 Smart Metering Landscape in Spain

The Smart Metering obligations were established in December 2007 with the national meter replacement plan for end-users up to 15 kW. The aim is to support remote energy management systems. The plan is managed by the Ministry of Industry, with a deadline for the completion of the plan by 31 December 2018. All DSOs had to submit their substitution plans to the regional governments. A binding target of 30% of all customers was set for 2010. However, this initial target could not be reached by any of the DSOs due to a late approval of the replacement plan (in May 2009), technological uncertainties in terms of system communication, alleged supply problems of certified meters that were available only in June 2010 and on-going negotiations with the regulators about the level of cost acceptance.

The latest developments are basically related to the introduction of the first set of smart meters in pilot and intensive projects by the five main electric companies operating in Spain in order to start the requirements of the national plan.

- Endesa (Enel group) had installed 1.000.000 million meters by the end of 2011 as well as 9.000 concentrators. In 2012 it is scheduled to have 2.7 million meters installed while the target is to install 13 million units by the end of 2015. The investment cost is around EUR142permeter. Endesa estimates that a monthly fee of around EUR 2.14 per meter would cover the costs of the project. In October 2010 it opened its smart metering operation centre in Seville. In Malaga they are developing the Smart City project, where a smart grid is being tested.
- Iberdrola has installed 400000 smart meters, 100.000 of which are deployed in the .city of Castellón, and the remaining 300.000 are deployed in different areas of the distribution network. Recently up to seven meter manufacturers have been awarded contracts to supply 1 million meters that will be deployed in 2012 and 2013. The complete project involves 11.000.000 smart meters.
- Gas Natural Fenosa has started several pilot projects in order to check different available solutions. In 2011 it implemented 200.000 units and by 2012 it is expected that 500,000 units will be installed. The SCALA project, as a Smart Grid Demonstra-

tion project, installed 80.000 meters in the Region of Madrid, specifically in Alcala and Aranjuez.

- E.ON has installed 340.000 smart meters to date, while they plan to reach 100% of their customers (750.000) by 2015. E.ON has developed a tool for real-time feedback to their customers as well as peak management programmes.
- Hidrocantábrico (EDP group) has installed 80.000 at present including a pilot action (550 units) while they are testing different solutions for the system. 35.000 units are now remotely monitored.

In Spain the meters are owned by the DSOs or by customers. The second option needs the meter chosen by the customer to be among those approved by the local DSO. The choice for the customer to either accept a rented meter by the DSO at a regulated monthly fee or install their own meter is a legal right in Spain.

3.27 Sweden

In Sweden monthly meter reading is required for smaller customers with a fuse description less than 63 A (since 1 July 2009), and technology for AMR is installed to fulfil this requirement.

3.27.1 Policy objectives for the introduction of smart metering

The Swedish Parliament approved monthly reading of all electricity meters from 1 July 2009, supported by the findings of the Swedish Energy Agency that more frequent meter reading would generate economic net benefit (Ryberg, 2009). Dependent on the different services, automatic meter reading on a monthly basis can give incentives for energy efficiency and energy reduction, but hourly meter reading is necessary to give the customers incentives for demand response.

Sweden has about 15,000 kWh per capita of electricity consumption. This represents almost 6 times the world average and twice the OECD average. By requiring monthly readings of all electricity meters, the legislators wanted to ensure that customers would get more understandable energy bills based on actual consumption and be able to get immediate financial rewards for energy saving efforts. The policy objective is that smart meters, providing more accurate consumption information and enabling new contractual arrangements, can contribute to energy conservation, thus facilitating national policy objectives related to energy efficiency and greenhouse gas emissions in Sweden (Vasconcelos, 2008).

3.27.2 Legal foundation of smart metering services

3.27.2.1 Provision in the Energy Law

In 2003 Sweden became the first EU country to indirectly mandate automatic meter reading (AMR) by legislating the following national regulations.

From 1 July 2006 the limit for hourly metering for all metering points was lowered from a fuse subscription of 200 A to 63 A. This was expected to increase the number of hourly metered customers by 50,000 – 70.000 (Morch et al., 2007, 196; Pykälä et al., 2008, 27ff).

The regulations are only mandatory for electricity meters.

The government mandated monthly invoicing from 1 July 2009, and this encouraged the widespread deployment of remotely readable kWh meters (Vasconcelos, 2008). All metering points should be read monthly and the end customers should be invoiced based on their real monthly consumption. This will bring an end to the preliminary estimates and annual correction bills that have been a source of many customer-perceived problems (Mannikoff and Nilsson, 2009). The meter points should also be read when the end customer switches to another power supplier (Mät, 2008).

The new requirements were initiated by customers' organisations, demanding a better billing from DSOs.

The new legislation has encouraged the widespread deployment of smart meters, which in practice means that by summer 2009 nearly all end customers in Sweden had remotely readable kWh-meters installed. Even though the legislation requires monthly reading, several DSOs have already indicated that they would prefer hourly metering and reading.

According to SwedEnergy (2009) about 750,000 meters can perform hourly metering of the consumption and handle the data related to this. This functionality is mainly available for larger final customers (e.g. industry). A further 3.9 million meters will also have hourly metering, but large investments are required before these meter values can be used for settlement.

The total costs for the installing new meters in Sweden is estimated to be EUR 1.0 – 1.5 billion (SwedEnergy 2009).There are no mandatory requirements for the remote meter reading of gas, heat and water (Open Meter Consortium, 2009).

3.27.2.2 Market model and responsibilities for metering

In 2007 the Swedish power market had about 5.2million end customers (Badano et al., 2007). About 4 million of these were domestic customers and holiday homes. At this time there were about 170 DSOs, 100 power retailers and 35 balance responsible companies in Sweden.

The end customer has a contract with the DSO to be connected to and make use of the power distribution network. The end customer pays for this service through a grid tariff. This gives the final customer access to all the power retailers participating in the common Nordic power market. In addition to the network tariff, the end customer has a contract with the power retailer for buying electricity (SEHB 09A-2009).[51]

The power retailers participate in the common electricity market – in competition with the other power retailers. There is no price regulation, and it is assumed that the end customers change to another power retailer if they are not satisfied with their existing power retailer (SEHB 09A-2009).

[51] Svensk Elmarknadshandbok rutiner och informationsstruktur för handel och avräkning ("Swedish Power market handbook. Routines and information structure for business and settlement" – In Swedish), Edition 09A rev 1 2009-04-27, http://www.elmarknadshandboken.se/

In Sweden the metering services is a monopoly business carried out by the DSOs. It is also the DSOs that own the electricity meters. The end customers pay for the metering either by regulated metering tariffs or as part of the grid tariffs (Vasconcelos, 2008).

Examples of benefits regarding hourly metering are discussed by Badano et al. (2007) for the power supplier, DSO and end customer:

Power supplier:

- Reduced risks – more stable income
- New products

DSO:

- Increased demand response and reduced peak load
- Offering new services to power retailers or end customers
- Reduced administrative costs

End customer:

- Better price products – possibility of saving money
- More detailed information about their own energy consumption gives better control and the possibility to reduce consumption
- Possibility for analyses and advice on energy saving
- Equality in different network areas
- Environmental benefits through energy efficiency

For electricity, gas and heat it is the utility (distributor) that owns the meter. For the measurement of the water consumption it is the municipality that owns the meter (Open Meter Consortium, 2009).

3.27.2.3 Minimum functional requirements

The functional requirements for end customers with a fuse description > 63 A (Commercial and industrial customers) are:

- 60 min. load profiles must be collected from the customers on a daily basis (Open Meter Consortium, 2009). The active import and export of energy should be registered. The data collection must be performed as soon as possible after 00:00 on the day following the day to be measured. The DSO has to deliver preliminary data to the national settlement daily at 08:00. Final data must be delivered within 5 working days from the measurement day.

The functional requirements for end customers with a fuse description < 63 A (domestic customers) are:

- These meters should be read on a monthly basis, and the data collected must at least be the register readings, i.e. the total active energy consumption. The meter data should be registered exactly at 00:00 on the first day of the month, and then collected as soon as possible. If the registration cannot be performed at 00:00, the value should be calculated and not estimated. The calculation should be based on the registered values before and after the end of the month. The DSO has to deliver the data within 5 working days from the measurement month(Open Meter Consortium, 2009).

- All power cuts due to supply interruptions should be registered by the grid company. Start and duration time of the power cuts should be registered. The electricity customer can apply for compensation for power cuts of a certain duration.

3.27.3 Smart Metering Landscape in Sweden

Sweden has performed full-scale deployment during the last years, and by 1 July 2009 all customers had had technology for AMR installed. The requirements are hourly metering of the consumption for larger customers with a fuse description larger than 63 A (Commercial and industrial customers), and monthly metering of the consumption for smaller customers (households) with a fuse description smaller than 63 A.

With full-scale deployment of smart metering technology, Sweden has a large potential of new smart metering services. One obstacle is the required reading frequency – smart metering services based on monthly meter readings can give incentives for energy efficiency and energy reduction, but only smart metering services based on hourly metering can give incentives for demand response and load shifting.

In a proposal from the government to the Parliament (Prop. 2011/12:98) it is suggested that all customers should have the possibility of entering into agreements that require hourly metering of electricity consumption. This should be possible without any extra costs. This will give the customers the incentive to reduce their consumption and change their consumption pattern for electricity. This also opens up a market for new services and products related to electricity consumption for customers. This proposal will require a change in the Swedish Electricity Law, and it is suggested that this change should come into force on 1 October 2012. This proposal will be discussed in the Parliament on 13 June 2012.

Despite this requirement several DSOs have implemented smart metering technology that can handle hourly metering of consumption. According to a survey performed in 2007 (Badano et al., 2007) 90% of the installed meters have the possibility for hourly metering of consumption, but they cannot fulfil requirements related to hourly settlement because of problems with the daily collection and reporting of the hourly values.

3.28 United Kingdom

3.28.1 Policy objectives for the introduction of smart metering

The policy and regulatory framework for smart metering rollout in the UK is defined under the major central programme called Smart Metering Implementation Programme, to design and implement new cross-industry arrangements for smart metering in coordination with industry participants.

In March 2011, the Government set out its conclusions on the policy design for the implementation of smart metering. This design set out the overall strategy and timetable for the rollout of smart metering across Great Britain, the plan for establishing the data and communications services and the programme’s approach to customer engagement and protection. The completion of the policy design phase also marked the start of the Foundation Stage for the programme, during which industry, the Government (DECC, Department of Energy and

Climate Change) and the regulator Ofgem (Office of the Gas and the Electricity Markets) will make the preparations needed for the start of the mass rollout in 2014. (DECC 2012).

Approximately 53 million meters will be replaced, involving 28 million homes and 2 million small businesses. The mandatory requirements for Electricity and Gas smart meters are as follows (DECC 2012; Open Meter Project, 2009):

- Electricity
  - Residential meters, installation from 2014, by 2019 around 27 million meters replaced.
  - Small/Medium-sized businesses, installation from 2014, by 2019 2.2 million meters.
  - C&I meters from 2009 to 2014, 168.000 meters.
- Gas
  - Residential meters, installation from 2014 by 2019 with 22 million meters.
  - C&I meters, installation from 2014 by 2019 with 400.000 meters:

The mass rollout is envisaged to start in the second quarter of 2014, and suppliers are required to take all reasonable steps to install only compliant smart meters. The rollout should be completed in 2019. Along with setting obligations for the mass rollout and technical requirements for the smart meters, the Government will also develop a strategy for promoting customer engagement. As part of this, there is a strong case for some elements of customer engagement to be carried out centrally or on a coordinated basis. (DECC & Ofgem 2011.)

Compliance with EU-directives: as regards the cost-benefit analysis required by Directive 2009/72/EC, in December 2009 the Government published an impact assessment of a nationwide smart meter rollout for the domestic sector. The government published an updated assessment in the consultation stage in August 2011.

In April 2012, the government published revised impact assessments again, taking into account the latest Programme assumptions, for a supplier-led rollout with a centralised data and communications model. For the domestic sector's mandated replacement of 50 million residential gas and electricity meters in the UK the costs are estimated as follows: Metering equipment, its installation and operation amount to £6.10bn. Communications equipment costs amount to £2.46bn. IT systems costs amount to £1.06bn. Industry set-up, marketing, disposal, energy and pavement reading inefficiency costs amount to £1.23bn. On the other hand, the benefits are estimated: total customer benefits amount to £4.43bn and include savings from reduced energy consumption (£4.39bn), and micro generation (£36m). Total supplier benefits amount to £8.47bn and include avoided site visits (£3.08bn), and reduced inquiries and customer overheads (£1.04bn). Total network benefits amount to £884m and generation benefits to £738m. Carbon-related benefits amount to £1.2bn.

For the non-domestic sector's mandated replacement of 3.6 million non-residential gas and electricity meters in the UKare estimated as follows: metering equipment, its installation and operation amounts to £394m. Communications equipment costs amount to £190m. Disposal, energy and pavement reading inefficiency costs amount to £24m. The following numbers are estimated for the benefits: total customer benefits amount to £1.76bn and include savings from reduced energy consumption (£1.75bn), and micro generation (£7m). Total supplier benefits amount to £452m and include avoided site visits (£251m), and reduced inquiries and customer overheads (£61m). Total network benefits amount to £110m and generation benefits to £47m. Carbon-related benefits amount to £582m.

Furthermore, the Government's impact assessments estimate that the total cost of the rollout programme for the domestic and the small/medium non-domestic sector will reach £11.3 bn. Benefits are estimated to be £18.6 bn. over the next twenty years, implying a net benefit of £7.3 bn. (DECC 2012.)

Customer protection: in general the UK customer body Customer Focus has been in support of smart metering. However, there still remains some concerns: how much the rollout will cost customers, whether the smart meters will pay for themselves, through smaller energy bills, are utility benefits passed on to customers, and how the interests of vulnerable and low income customers are being protected. Also, the issue of how the use and benefits of smart meters are communicated to customers to maximise their benefits, and the need to minimise doorstep selling during installation are seen as important.

After criticism from the Public Accounts Committee, DECC released in April 2012 clarifications targeted to further protect the customer benefits in the UK smart metering programme. (http://www.decc.gov.uk/en/content/cms/news/pn12_044/pn12_044.aspx). These included the following conclusions and proposals:

- There should be no sales during the installation visit, unless the customer permits this
- Installers must provide energy efficiency advice as part of the visit
- All households will be offered an in-home display allowing them to see what energy is being used and how much it is costing
- Customers will have a choice about who has access to their data, except for billing and meeting other regulatory obligations, typically on a monthly basis
- A model for centralised communications activity to help all customers understand how to use smart meters to better manage their energy consumption and expenditure;
- Proposals to ensure that vulnerable and low income customers can benefit from the rollout

Exact and frequent billing: as regards Article 13 (ESD), domestic, public sector and business premises in Great Britain and Northern Ireland that are served by licensed gas and electricity suppliers are already provided with individual, competitively priced gas and electricity meters which can accurately record the customer’s actual consumption. These meters, which may be electronic or mechanical, are required to measure accurately and arrangements are in place to maintain the accuracy of the meter population and to test meters if customers dispute the accuracy of the meter.

Energy efficiency and carbon reduction: the latest April 2012 government estimates suggest that smart meters could save around 20.4 million tonnes (Mt) of CO_2 emissions for the domestic sector and 13.9 Mt$CO_2$for the non-domestic sector over a 20-year period, as people become more aware of the energy they are using. (DECC, 2012.)

3.28.2 Legal foundation and functional requirements

The main energy suppliers, rather than distribution utilities, will be responsible for the rollout of the meters. They will be able to recoup the cost from customers through higher bills or upfront fees, but competition between suppliers is expected to ensure only some of the expense is passed on.[52]

The UK Government has concluded that the preferred rollout option is the central communications model, where energy suppliers are responsible for the installation and maintenance of the smart meter but the communication to and from the device is provided by a central data and communications entity (DCC) across the whole of the UK.[53]The DECC has begun tendering for the DCC service. The new central data and communications function will provide a two-way communications channel between smart meters and a central communications hub to which smart meter data users (suppliers, network companies and other authorised third parties) will have access for specified purposes (Figure 7).

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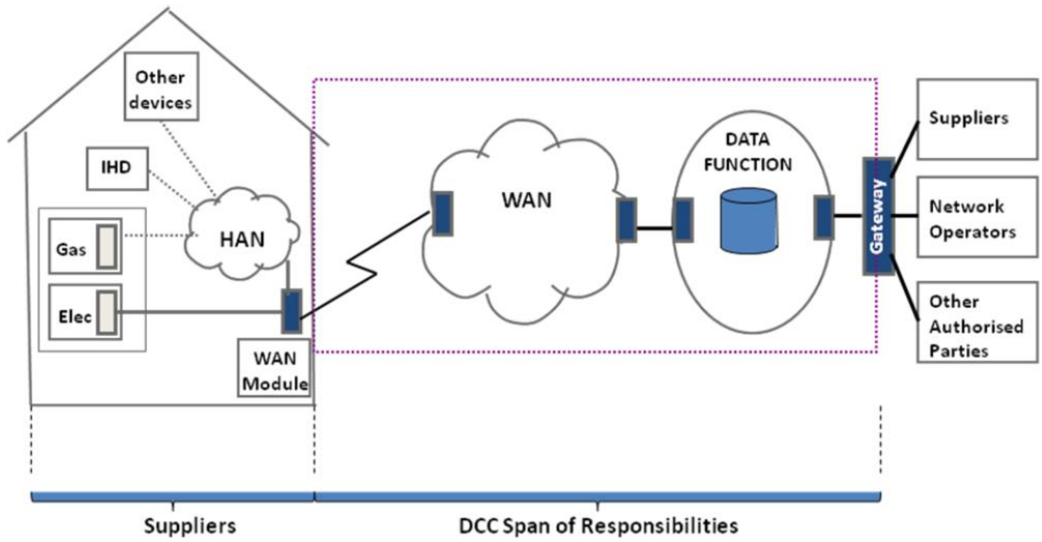

Figure 7: Proposed smart metering system responsibilities (DECC, 2010, 25)

In the mass rollout envisaged to start in the second quarter of 2014, suppliers should rollout smart metering equipment that meets a set of minimum technical specifications. The suppliers should also provide domestic customers with an IHD that meets the technical specifications. DECC has defined two operating phases; the Foundation Phase, covering the installa-

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[52] BBC News 2 Dec 2009 (http://news.bbc.co.uk/2/hi/business/8389880.stm)

[53]http://www.decc.gov.uk/assets/decc/Consultations/smart-meter-imp-prospectus/1481-central-communications-data-management.pdf

tion and operation of smart meters before the DCC communications route is available and the Enduring Phase, covering the main rollout period expected to begin in 2014,from when meters are expected to use the DCC communications network and be fully interoperable. The minimum requirements for the Foundation Phase have been published in SMETS1, which has been forwarded to the Commission for notification as required under the Technical Standards Directive. The definition of the minimum requirements for the Enduring Phase will be developed in 2012 and is expected to be published as SMETS2 in September 2012. (DECC, 2012.)

These technical specifications are based on the functional design requirements defined in the policy design phase in March 2011. The national implementation programme will facilitate the process of converting the functional requirements into technical specifications so that compliant meters should be available in volume during 2012. (DECC, 2011.)

The design requirements cover gas and electricity meters, the home area network (HAN), wide area network (WAN) module and in-home display (IHD). Requirements also set out the programme's approach to security of the smart metering system and the work to date on this issue.(DECC, 2011.)

The key consultation documents, including the SMETS, can be found on the DECC web page http://www.decc.gov.uk/en/content/cms/consultations/cons_smip/cons_smip.aspx

3.28.3 Smart Metering Landscape in United Kingdom

The UK's major central programme to define the policy and regulatory framework (Smart Metering Implementation Programme) has concluded its policy design phase, and the national rollout is envisaged to start in 2014 and to be completed in 2019. Currently the programme is in its Foundation Stage, during which industry, the Government and the regulator Ofgem will make the preparations needed for the start of the mass rollout.

The detailed and cooperative manner of the programme has a good potential to deliver a clear and efficient regulatory framework, resulting in a successful large scale rollout and bringing interoperability and smart metering benefits for the end-users and society. Developing a strategy and communications for promoting customer engagement as well as the requirement for suppliers to offer In-House Displays (IHDs) to all households certainly increases the potential for the smart meters to actually affect customer behaviour - something all the other European countries could use as an example when designing their rollout schemes. The massive size of the over 53 million meters rollout causes the completion to be only until 2019, which sets the UK back a little from the most progressed countries. Thus in the short-run, smart metering and related end-user energy efficiency services are notable to cover the whole mass of UK customers, although some early implementations are already under way.

Few utilities are already implementing their rollouts, ahead of the national rollout programme schedule, and starting to offer end-user services using smart metering technology. First Utility and Spark Energy are currently the only companies offering nationwide smart meter rollouts. Of the "big six", British Gas and Scottish Power are upgrading customers who need their old "dumb" meter replaced, and also E.ON UK has started installing smart meters. (Public Accounts Committee 2011).

- In October 2010 the independent energy company First Utility became the first UK energy supplier to provide free smart meters to customers across the nation, without an in-house display but with an online reporting service.
- Spark Energy currently offers only the smart meter and information via its display.
- British Gas, the largest UK energy supplier, will be installing 2 million smart meters with in-home displays by 2012.

In addition to rollouts, a number of utilities have been testing metering smart technology for several years or have currently large pilots.

- Four suppliers (EDF, Scottish and Southern Energy, Scottish Power and E.ON) piloted smart meters and in-home displays in households as part of the large-scale national pilot project Energy Demand Research Project (EDRP)54 which also functioned as an important source of information for the national Smart Metering Implementation Programme.
- British Gas has carried out its own trials.
- EDF is currently part of the Low Carbon London trial, testing how much energy can be saved with smart meters
- Npower has been carrying out independent trials in the Midlands and in late 2010 it carried out further trials in Yorkshire and the North-East.
- Of the smaller energy companies, Good Energy plan to start a trial at the end of 2011/early 2012.

[54] http://www.ofgem.gov.uk/sustainability/edrp/Pages/EDRP.aspx

4 Smart Metering Services in Europe

The last couple of years have seen considerable developments in smart metering technology and services in the form of displays, websites, information on moving devices and TV, informative bills etc. With the publication and the start of transposition of the internal market package for electricity and natural gas (Directives 2009/72/EC and 2009/73/EC) there is growing confidence in the market opportunity of smart metering services. As was mentioned in detail in Chapter 2.2 above, the European Commission commits Member States to rollout smart meters to at least 80% of customers by 2020 who are deemed to have a positive cost/benefit ratio. In many EU Member States this energy market package is the major driver for infrastructure pilots, cost-benefit analyses and the development of new businesses for smart metering services.

The developments within the metering service market are key to achieving actual energy savings from the alleged saving potential. Even though it is contested by the literature to what extent these services in fact achieve energy savings, it is at the same time clear that **without these feedback tools and additional metering services there is no benefit for the end customer**. It will be difficult to convince customers about the added value of new metering technology and the modernisation of the European electricity grids, if metering data is only of use for operational changes within utilities (to reduce non-technical losses, for remote reading and switching or the simplification of billing procedures, etc.). This is particularly important because the real advantages of smart metering will and have to be compared with the related costs that will be borne by customers (in monetary terms, but also in terms of privacy intervention and other non-monetary issues). Only services based on metering data will provide added value to customers.

Only metering services will provide added value to the customers.

Besides feedback tools that enable customers to regulate their energy consumption, a number of utilities test and operate **demand response and direct load control programmes** in order to limit the peak load that has to be provided in the market. Nordic countries in particular have trialled demand response programmes that give customers economic incentives to achieve a certain behaviour or apply direct load curtailment with the contractual framework with promising results. While these programmes are small-scale research projects, some of the programmes show promising results with very little intervention.

This section gives an overview of innovative services based on smart metering technologies and data in EU Member States. **It is by no means a complete picture of all the different technologies available at the moment.** This section should rather be a starting point for interesting stakeholders to explore innovative feedback systems, demand response and direct load control programmes that are in use in EU member states and Norway.

4.1 Information and direct/indirect feedback systems

In this chapter different forms of direct and indirect feedback systems such as frequent billing options, Internet-portals, in-house displays, mobile solutions, etc. are presented. The focus is on innovative solutions that help the customer to save energy.

There is a growing number of websites being provided by energy suppliers to allow consumption feedback of remotely read data. However, there seems little development and innovation in these sites. The greatest growth over the last years can be observed in the area of displays. Since 2009 there was a steady improvement and refinement of displays with the development of a basic entry level display and, at the same time, the development of higher specification models providing greater levels of functionality. The display-market received a particular push by regulatory decisions to create an obligation to supply displays to customers, such as in the UK. ESMA (2010, 63-75) provides an overview of prevalent displays in the market.

- Energy Demand Research Project (EDRP) trials | UK

Target group: around 58,000 households. The EDRP trials involve a range of different domestic customer types, e.g. those likely to be in fuel poverty; and a range of different billing types, e.g. those using prepayment meters.

Some trials are specifically targeted at particular groups, aiming to determine whether certain interventions are particularly effective for those groups. However, even in those trials that are not targeted at particular groups, information about income levels, payment methods, etc. is being gathered and will allow for studies of the effects of different interventions on different customer groups. (Ofgem 2011)

Objective of the services: the EDRP is a suite of large-scale trials across Great Britain between 2007 and 2010. It seeks to better understand how customers react to improved information about their energy consumption over the long term, covering electricity and gas.

The trials are different combinations of *interventions* and explore the responses of the households. Four energy suppliers are running trials: EDF Energy, E.ON, Scottish Power and Scottish and Southern Energy. Ofgem oversees the trials on behalf of the Government.

Nearly all the trialled services (or interventions) can be described as information and feed-back related.

Description of the services:

The trials included a variety *of* interventions, assessed either individually or in combination with each other:

- Energy efficiency advice.
- Historic energy consumption information (such as comparison of energy consumption with earlier periods).
- Benchmarking of the customer’s consumption against the consumption of comparable households.
- Customer engagement using targets (commitment to reduce consumption).
- Smart electricity and gas meters.
- Real-time display (RTD) devices that show energy use (including audible usage reduction alarms).
- Control of heating and hot water integrated with RTD.
- Financial incentives (including variable tariffs) to either reduce consumption or shift energy demand from periods of peak demand.

- Other digital media for delivering information (Web, TV). These interventions are sometimes used in combination, so it can be useful to consider themes, rather than trying to draw conclusions about individual interventions.

Customer response and results:

The following conclusions and are summarised from the EDRP Final Analysis report (Ofgem 2011).

When comparing the changes in energy consumption between different interventions, smart metering was demonstrated generally as a necessary enabling platform for behaviour change measures. While the savings were sometimes small in percentage terms, the absolute savings scaled up to national level would be substantial.

- The positive savings from smart meters depended on providing customers with appropriate additional interventions
- The provision of a real-time display (RTD) was particularly important for achieving savings in electricity consumption.
- Gas savings could be achieved through the installation of a smart meter without further intervention, although evidence of persistence was not as strong as for electricity savings with RTDs.
- Advice and historic feedback on consumption can promote energy savings, but they cannot be relied upon on their own and should be combined with smart meters
- Savings were found in combination with benchmarking against the consumption of a peer group, without smart meters.
- Financial incentives and commitment to reduce consumption, in contrast had either no effect or a very short-term effect.
- Delivery of information through the web or customers’ TVs was also not successful in reducing consumption.
- Savings were generally persistent where the trial was long enough to test this, especially electricity savings from the combination of RTDs and smart meters. In contrast, any savings from financial incentives rapidly dissipated when the incentive was withdrawn.
- Real-time feedback is more relevant to electricity consumption than to gas. Applications of gas tend to be subject to occasional adjustments having long-term effects, which are less amenable to influence by real-time feedback. (This can be also considered with other heat sources such as oil or district heat).

All in all, these results point towards the fact that just providing smart meters does not save energy and the effect of RTDs (or in-home displays) can and should be supported by other services. To gain behaviour change, attention must be paid to advice and communication - the interaction with customers and how the meters, displays and other services are explained to customers. Also, the savings seem to be persistent when the feedback (or intervention) is persistent, yielding long-lasting behaviour changes.

Savings are not guaranteed simply by implementing a particular type of intervention or service, and the EDRP results list the following points that need to be considered when designing smart metering schemes.

- To maximise the impact of smart meter and RTD, further information, advice and prompts are likely to be required.
- RTDs should be installed ready for the customer, and also guidance should be provided on how to access and use the information they provide
- Customers need to know what to do: what means should be deployed to save energy.
- Quality matters: information needs to be clear, easily seen amongst other material sent, presented in an attractive way, relevant and timely and kept up-to-date as the options for action change.
- Quantity matters: provide sufficient information and avoid information overload. For example, regular small nuggets of information appear to be more effective.
- Tailored information can be the most effective: the literature suggests that the more closely an intervention can be tailored to particular households or individuals, the more effective it is likely to be. Web portals, for example, have potential in this.
- Quality, quantity and tailoring of interventions are relevant to all points in the customer journey: from engaging the customer to the intervention (e.g. reading advice or installing an RTD), to the initial impact of the intervention and sustaining actions over a longer period.

In addition to the above lessons, the EDRP progress report (March 2010) presented an interesting concept of *a cycle of learning and action* to reduce customer energy consumption, which should be taken account when designing smart metering schemes:

- feedback to customers about energy consumption
- advice to customers about how make savings
- and motivation for customers to implement savings.

Data requirements: differing, as depending on the trialled intervention. In the case of smart meters, the meter readings were sent in daily to monthly intervals. The RTD received its real-time data from the smart meter or via clip-on connection to electricity supply.

Your assessment of the service: the EDRP provided a large-scale, versatile and long-term set of trials, and its results can be used across Europe. It provided knowledge on implementing large-scale rollouts, and more importantly, gave significant information on how domestic customers react to different kind of information and feedback on their energy consumption over the long-term.

4.1.1 Smart Metering Customer Behaviour Trials | Ireland

Target group: residential customers and SMEs

Objective of the services: Collect information on the benefits of various feedback mechanisms to the customers.

Description of the services: following the National Smart Metering Plan, the Irish regulator (CER) established a Smart Metering Project: a major pilot project coordinated with the network operators to ascertain the potential for smart meters to be rolled out nationally. More specifically, this project had the objective of setting up and running Smart Metering Trials and assessing their costs and benefits, to inform decisions relating to the full rollout of an optimally designed universal National Smart Metering Plan. In four test groups different forms of feedback to the end customer were tested (monthly billing, bi-monthly billing, in-house displays and overall load reduction).

Customer response

In 2011, an extensive Smart Meter Electricity Customer Behaviour Trial among approx. 5,500 households was completed. The trials ran from 1 January 2009 to 31 December 2010. The year 2009 acted as a benchmark period, where daily half-hourly profile data was collected from all customers but with no changes in their tariffs or billing that they received from their electricity supplier. From the start of 2010, the customers were grouped into test and control groups providing statistically valid customer samples. The test groups trialled four different time-of-use tariffs from their electricity supplier. In addition four DSM information stimuli packages, including bi-monthly and monthly bills combined with energy statements, and an overall load reduction incentive were trialled in support of the ToU tariffs. The new “smart bills” contained enhanced information on electricity consumption and costs, including hints and tips on how to improve energy efficiency and save money, average daily usage graphs and tables displaying costs of running the main appliances at different times of the day (e.g. washing machine, dishwasher, tumble drier, immersion heater). Over 1,200 customers were provided with an in-home display to provide real-time consumption and cost information to the customer. Interviews were conducted with all participants at the start of the trial with a follow-up interview at the end of the trial.

The Electricity Trial showed that ToU tariffs, in conjunction with other DSM stimuli resulted in a significant change in energy consumption. Some of the main conclusions are:

- The overall impact of ToU tariffs and DSM stimuli are found to reduce overall electricity usage by 2.5% and peak usage by 8.8%
- Customers with an in-home display showed increased load management resulting in a peak shift of 11.3% (2.5% greater than average)
- Overall energy reduction is linked with the level of usage: households with higher consumption tended to deliver greater reductions
- Analysis of the load distribution suggests shifting of load from peak to the post-peak period and in general to night usage from peak
- There is no single tariff group that stands out as being more effective than the other, but the trial showed that ToU tariffs do encourage significant demand shifting
- Of the four DSM stimuli none is statistically better than any of the others in reducing overall electricity usage; moreover, the bi-monthly bill was not shown to be statistically significant in delivering overall energy reduction
- Demand for peak usage estimated as being highly inelastic in relation to the level of the peak price incentive.

Demographic and behavioural results showed that participants adapted usage to take advantage of the savings that were achievable through the ToU tariffs on their bills. 82% of participants made some change in their electricity use with74% stating major changes were made by their households. Simple information turned out to be effective as well: the fridge magnet and stickers achieved 80% recall with 75% finding the magnet useful and 63% finding the sticker useful.

Figure 8: Sticker showing different timebands

The in-home display was deemed to be effective as a support to those achieving peak reduction (91% rated it as an important support) and shifting to night rates (87% deemed it an important support).

The electricity trial also contained 764 SMEs who have time-of-use tariffs, an Internet portal and displays. A key aspect is how these influence the Time-of-Use tariffs.[55] For the SMEs, the results were not nearly as good, with only a subset of SMEs making positive reductions.

Irish gas customer behaviour trial

The Irish gas customer behaviour trial looked at the measureable reduction in customer demand achievable through the use of smart meters in combination with a number of information stimuli (i.e. detailed billing on a bi-monthly and monthly basis, in-home displays) and a variable seasonal tariff. A representative sample of approx..2,000 residential gas customers throughout Ireland participated in the gas residential customer behaviour trial. These participants were allocated across different test groups and a control group by the statistical advisors to ensure a robust experimental trial design. Recruitment for the trials began in June 2009 and all smart meters were installed by end of November 2009. A six-month benchmark period was conducted between December 2009 and May 2010 which allowed gas usage profiles of participants to be recorded before the introduction of the test measures on 1 June 2010. The test period ended on 31May 2011. Statisticians then analysed the consumption data collated from the trial to determine the customer response to the smart

[55] http://www.cer.ie/GetAttachment.aspx?id=04816845-2202-42eb-96b5-0df76be1e9b4

metering enabled measures tested in terms of the impact on their overall gas usage. Pre-trial and post-trial surveys of trial participants were also conducted to help inform demographic, behavioural and experiential conclusions from the trials. The statistical evidence from the residential gas CBT is that the deployment of smart metering enabled informational stimuli results in a reduction in overall gas consumption by a statistically significant average of 2.9%. Each of the four stimuli combinations tested was found to reduce usage by a statistically significant amount. These gas CBT results were inputted into the gas cost-benefit analysis to derive customer usage-related benefit values.

Assessment of the service

All of the ToU pricing and DSM stimuli in the Customer Behaviour Trial (the time of use tariffs, the energy usage statement, the electricity monitor and the overall load reduction incentive) were designed specifically for the Trial using lessons learnt from other international trials and customer feedback. The ToU pricing and DSM stimuli were initially developed by the Customer Behaviour Work stream Group based on their combined experience in the electricity industry and using lessons learnt from international trials. Consideration was also given to the requirements of EU Directive 2006/32/EC which states where technically possible and financially reasonable, energy metering should record the time of use and customer billing should be sufficiently comprehensive so as to enable the self-regulation of energy consumption.

Energy Usage Statements

During the Trial all participants in the stimulus test groups received a bill, combined with an energy usage statement. See the figure below. The first page (the bill) was similar to the existing supplier’s bill (with additional lines for time of use tariffs). The second page, the energy usage statement, provided additional detail on usage and tips on energy reduction.

ESB Customer Supply

National Smart Meter Plan

Your usage statement

Your account details

Account Number:
MPRN:
Billing Period: 01-JUL-10 To 31-AUG-10

Energy awareness

Typical cost of running various appliances over a full year*

Main household appliances (excl. Electric Oven)	NIGHT RATE	DAY RATE	PEAK RATE
Washing machine	€41	€57	€174
Tumble dryer	€137	€191	€579
Dishwasher	€55	€76	€232
Immersion - 6 months only	€152	€211	€641

*Average usage 1 cycle per day, 5 days a week for a full year. Immersion: 1 tank per day 6 months only.

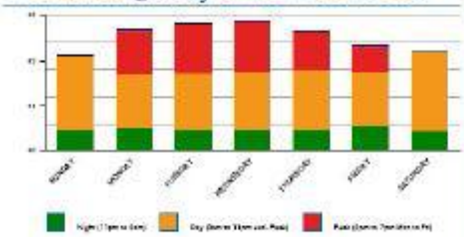
Hints and Tips

- Money Down the Drain - During the peak period (5pm to 7pm) an instantaneous electric shower running for 15 minutes costs you €217.17 per year. At day rates it would cost you €71.44 per year.
- Off peak costs less, but it still costs you. Remember it is important to be energy efficient outside of peak hours.
- Beat the Peak. Machine washing a full load on peak rate will cost you €173.74 per year; on the day rate it would cost you €57.15 per year.

Has your electricity usage changed?

- Last month the amount of electricity you used during the peak time has increased compared to the previous month. This has cost you €0.63 more. Is there anything you can do?
- Last month 227 customers on your tariff have reduced the amount of electricity they use. Is there more that you could do?

Your average day of the week costs



Further information

Values given above may be slightly different to Page 1 due to rounding impacts. The correct final values are those displayed on Page 1 of the Bill.

Learn More

Visit www.esb.ie/home to view:

✓ Energy Efficiency tips

✓ Ways to Save money

✓ Energy Challenge

Figure9: Energy Usage Statement

Electricity Monitor

The electricity monitor was designed by industry and members of the Customer Behaviour Work stream Group and developed specifically by ESB Networks for the Customer Behaviour Trial. Its aim was to help customers be more energy efficient by providing additional information on how much electricity they were using and how much it was costing them. The electricity monitor also included a budget setting mechanism, where customers could decide the maximum they wanted to spend on electricity per day. A usage gauges on the home screen, showed customers their usage against their daily budget. On installation of the electricity monitor participants were provided with a default budget from Electric Ireland which could be adopted or replaced by the participant.

Figure10: Electricity Monitor

Prior to deployment of the electricity monitor, the historical daily consumption of each participant was calculated and converted to a monetary value based on the new tariffs. Upon installation of the electricity monitor, participants were advised of this daily budget estimate and given the option to use this figure or an alternative for budget setting in the monitor.

Main behavioural and experiential conclusions to the smart metering services are that trial showed that:

- the deployment of ToU tariffs and DSM stimuli are found to reduce overall electricity usage by 2.5% and peak usage by 8.8%;The combination of bi-monthly billing, energy usage statement and electricity monitor is found to be more effective than the other DSM stimuli in reducing peak usage with a peak shift; of the tested DSM stimuli none proved statistically better than any of the others in reducing overall electricity usage; moreover, the bi-monthly bill was not shown to be statistically significant in delivering overall energy reduction;
- The electricity monitor was deemed to be effective as a support to those achieving peak reduction (91% rated it as an important support) and shifting to night rates (87% deemed it an important support);

- Participants adapted usage to realise the potentially positive impact of the tariffs on their bills. 82% of participants made some change to the way they use electricity due to the Trial with 74% stating major changes were made by their households;
- Simple information can also be effective: the fridge magnet and stickers achieved 80% recall with 75% finding the magnet useful and 63% finding the sticker useful;
- Participants were not able to accurately estimate actual reduction with 40% of those who believed they reduced their usage stating the bill reduction was not to the degree expected;
- The Trial succeeded in making participants more aware of energy usage (54% agreed) which is in keeping with the reduction in usage recorded. Only 18% stated that there had been no impact on the way their household uses electricity;
- Households headed by individuals with greater educational achievement or social grade achieved higher levels of reduction than those with lower levels. This was in part related to the typically higher level of usage associated with these households. Therefore, the impact of education or social grade on the ability to benefit from the tariffs is limited.

4.1.2 Smart Metering Trials | Netherlands

Following similar national customer trial programs in the UK (EDRP) and Ireland (CBT) as described in the previous sections, the Netherlands is the third EU-Member State to perform a series of smart metering services trials to deliver evidence for the energy efficiency potential of smart metering and to contribute to balanced decisions on the actual rollout of smart meters.

The Dutch smart meter rollout will take place in a two-stage approach. From 2012 until 2014, a small scale experience phase will provide insights in determining technical, economical and societal consequences of the smart meter rollout. In this period approx. 450,000 traditional electricity meters will be replaced by smart meters. From 2014, the rollout will continue on a larger scale, eventually taking advantage of the results from the small-scale experience phase. The large-scale rollout aims to have a smart meter fitted by at least 80% of all households and small businesses in 2020, as mandated through the third Energy Package.

Part of the small-scale experience phase is a national monitoring programme to provide future insights in the energy saving effects that can, potentially, be expected following the introduction of smart metering. By order of the Ministry of Economic Affairs, Agriculture and Innovation, NL Agency is now setting up a Smart Metering Acceptation and Response Trials (SMART) programme to assess the effects in household energy consumption and support the upcoming decision for an optimally designed universal full smart metering rollout. In order to draw practical lessons on the experience and expertise of relevant (market) actors, a suite of large and scientific designed trials across the country is now being assembled in close cooperation with the Dutch network operators.

The Dutch SMART-program is designed to investigate and better understand customer responses to a range of methods of providing improved feedback on energy consumption and associated costs over the longer term. The SMART-program will cover the largest and statistically most robust smart metering behavioural trials conducted nationally to date and is expected to provide a wealth of insightful information on the impact of smart metering enabled initiatives on Dutch electricity and gas customers. The programme distinguishes two types of informational stimuli for dual fuel metering (electricity meters and gas smart metering leveraging the electricity smart metering communications infrastructure).

1) Effect of monitoring bi-monthly cost statements

On the one hand, the programme will focus on the actual measureable reduction effects in customers' electricity and gas demand achievable through the use of smart meters in combination with bi-monthly cost statements. As mentioned earlier in this document, Dutch suppliers are legally mandated to issue six extra cost statements per annum. The statements will be required to give a comprehensive account of the customer's energy usage. Part of this will be a comparison of the customer's consumption with the equivalent period in the previous year, and a comparison with the consumption of their peer group. These comparisons should be provided in graphical format where practicable. This is similar with the informative billing requirements in the EU Energy Efficiency Directive (2006/ 73) although the informative statement need not necessarily be paper-based.

For the effect monitoring of the bimonthly cost statements, a representative sample of over 10,000 anonymous residential electricity and gas customers throughout the country will be involved in the trial. A control group, made up of customers that will not be provided with any information above their 'business as usual', will be included by the statistical advisors to ensure a robust experimental trial design. Their energy consumption will be recorded to enable comparisons with the households that have received interventions und the SMART-programme.

2) Monitoring potential effects of additional information stimuli

On the other hand, a combined suite of additional metering services systems is programmed to investigate the behavioural and potential measurable reduction effects in customer electricity and gas demand achievable through the use of smart meters (and possibly bi-monthly cost statements) in combination with a number of free market energy monitoring and managements systems. These interventions include in-home displays, Web-based information systems and community-based concepts.

This way the SMART-programme is intended to provide a robust, fact-based information set to inform the Ministry of Economic Affairs, Agriculture and Innovation and other stakeholders of the possible energy saving merits of smart metering services for residential (and SME) customers in the Netherlands. In addition, the impact of different services on customer behaviour and attitude help cast light on the relative attractiveness of various media, function and design options for specific metering service concepts.

In total over 1,000 residential customers throughout the country will participate in additional metering services trials. The participants are allocated across different population groups and connected to control groups by the statistical advisors to ensure a robust experimental trial design. Unlike the effect monitoring of the bi-monthly cost statements, sample sizes in this programme category will not appear large enough to ensure statistical soundness. Therefore, the results in this Program category should not be qualified as fully representative and reliable from a statistical point of view.

Examples of trials in this category include the provision of smart meters in combination with prototype-interfaces, such as Quby and PowerPlayer (see pictures below).

PowerPlayer

Quby

All trials in the SMART-Programme will be performed by or in cooperation with the three largest Dutch network operators Liander, Enexis and Stedin (representing approx. 90% of all meter connections in the Netherlands) under the scientific supervision of an academic statistical advisor and the results submitted to NL Agency. The statisticians will analyse the consumption data collated from the trials to determine the customer response to the smart metering enabled measures tested in terms of the impact on their overall electricity and gas usage. Pre-trial and post-trial surveys of trial participants will also be conducted to help inform demographic, behavioural and experiential conclusions from the trials. Due to the different nature of the trials, technical issues and other issues, most pilots have taken place at different times.

NL Agency oversees these pilots and is responsible for undertaking the design and coordination of the SMART-program on behalf of the Department Energy and Sustainability, part of the Directorate-General Energy, Telecom and Markets from the Ministry of Economic Affairs, Agriculture and Innovation. As part of this work, NLA is also responsible for monitoring market developments of smart metering services. Finally NLA will arrange a series of stakeholder meetings with representatives of customer associations, academic institutions, metering and/ or service providers, etc.

The key trial findings related to the actual, behavioural and attitude effects on household electricity and gas consumption, are expected to be an important source of information for parliamentary evaluation in the second half of 2013. The statistical evidence from the trials will also provide relevant customer information for the commercialising and/ or deployment of these smart metering enabled informational stimuli by free market players. If so desired, the results can also be inputted into future cost-benefit analysis to derive customer usage-related benefit values.

4.1.3 British Gas and First Utility smart meters | UK

Target group: residential and commercial buildings

Objective of the services: energy savings through information and feedback, (better customer care), and once the rollout has been fully completed and the meters operational, possibility for new variable tariffs.

Description of the services: Both utilities offer:

- Free smart meters for customers,
- Promise of accurate billing through AMR, with the ability to estimate bills with smart meters. Also switch between credit and pre-pay arrangements, without changing the meter,
- Electricity usage is metered every half an hour and gas daily. Under normal circumstances, the data is retrieved once a day and the customer can then see it on his/hers online account.

Figure 11: British Gas in-home display monitors

British Gas:

For its smart meter customers, British Gas offers an in-home display showing energy usage and cost in real-time. The display is provided free of charge.

The in-home display functionalities also include

- The “traffic lights”: show the level of use - from green and yellow to red, in real-time,
- Past energy use: in half-hour, daily, weekly, monthly, seasonal and annual timeslots, so you can track your usage and see how you you're reducing it over time,
- Tariff information: including the current tariff and energy cost,
- Utility messages: text alerts, e.g. on tariffs.

The technology utilised is Landis+Gyr smart meters and displays, using Zigbee Global Alliance wireless standards to link up in-home devices. The GPRS GSM network enables two-way communication with British Gas.

For the business clients, there are no display monitors, but the service includes online management as a free automatic monitoring and targeting (aM&T) service. The aM&T interface from Energy360™ gives a real-time overview of the site’s energy use showing consumption in simple graphs and tables:

- Allows electricity and gas consumption to be monitored, reported and analysed via your portfolio online,
- Ranks best and worst performing sites by consumption or CO2 emissions.

Energy360 from British Gas is a suite of products to reduce energy consumption, and promises to help reduce energy costs by at least 10%.

In addition, at British Gas'website britishgas.co.uk/ee customers will find an entire section devoted to saving energy – with hints and tips, a free personalised Energy Savers Report, Energy Savers Store and more. They also have a "dedicated energy efficiency hotline".

First Utility:

For the information and feedback method, First Utility offers its smart meter customers the possibility of monitoring electricity and gas usage with a First Utility online account:

- Bar charts or line graphs showing monthly, weekly and daily usage,
- Half-hourly electricity usage and daily gas usage, refreshed once a day,
- Comparing electricity and gas over months, weeks, or days,
- Viewing current and previous bills,
- The possibility downloading the usage data,
- Access to help and advice.

The utility offers also 15% annual dual fuel discount with "The Smart" as Standard tariff (15% of the amount you paid for energy over 12 months credited back).

First Utility smart metering services are based on a set of functionalities - accurate billing, load profiles, etc. - not on a particular technology. They are using several different communication technologies including PLC (Power Line Carrier), GPRS, GSM, SMS, PSTN and 868Mhz low power radio, and the utility is currently assessing several other radio options. Depending on the individual geographical location it is likely they will deploy either SMS or GPRS enabled electricity meters.

For business clients, First Utility offers:

- Online portal to review energy use across the day to identify where energy is wasted and how to save.
- Comparisons day to day, week to week and month to month, showing how changes have reduced your usage and saved you monthly.
- The monthly bill will also highlight reductions in energy consumption.
- Once the smart meter has been installed for a 12-month period the utility helps to identify areas where the business client would benefit from a change in tariff: single-rate, two-rate or three-rate tariffs to businesses. The utility says that changing to a different tariff can save 10% of the customer's annual energy bill.

Furthermore, in July 2011 First Utility announced that they will enhance their smart meter offer by partnering with Opower (US smart grid software firm) to use their home energy management platform. In 2012, Opower and First Utility are going to conduct, as they say, the first large-scale information-based energy efficiency programme in the UK, to inform the Cabinet Office and DECC on smart meter policy-making. Deployed to all UK households, the programme has the potential to save customers as much as £400 million on energy bills each year.

First Utility will use Opower's software platform to translate its customer's smart meter data into a range of new energy-saving tools, including the following:

- Reports that offer comparative consumption,
- Information and a household-specific analysis of consumption patterns,
- Access to an online portal with detailed usage information, and
- High bill alerts designed to help customers avoid excessive bills while they still have time to change their usage.

> Customers will be engaged via mailed reports, a Web portal, email and SMS messages, as well as social media. This multi-channel engagement approach is designed to reach all demographic segments, including the most vulnerable, and drive a high level of customer engagement and energy savings. (First Utility, 2011)

Customer response: After installing nearly 400,000 smart meters, British Gas commissioned a survey on 700 smart meter users. The survey discovered that 48% use their smart energy monitors on a daily basis, while 78% said that they used it at least once a week. Furthermore, 73% stated smart meters have made them think about ways they could reduce their usage and save money while 64% of the customers surveyed had made improvements to energy efficiency. The survey also revealed that 80 per cent of respondents had changed the way they think about energy consumption after the devices were installed. (British Gas 2012.)

According to a survey conducted by First Utility in 2010 for its smart metering customers, 56% of customers found that the ability to access energy usage online had led to a change in their behaviour. Furthermore, 89% of the people surveyed would recommend the smart meter to others. (First Utility 2010.)

Data requirements: electricity meter readings are recorded every 30 minutes and gas once every 24 hours. E.g. in First Utility, under normal circumstances the data is retrieved once a day and the customer can then see it on their online account.

Expected and/or delivered results: the expected energy savings depending on the service offered. British Gas states that smart meters with in-home displays can save up to 10%in energy (as the previous studies have found). For First Utility, according to the recent studies, the savings are bound to be lower, because their offer is currently based on non-real-time Web reporting. However, the new future services offered with Opower will probably increase the savings potential significantly.

When the utilities start introducing new tariffs, peak load reductions can also occur.

Your assessment of the service: these are the first larger scale commercial implementations of smart metering end-user services in the UK right now, representing quite elementary information and feedback services. Other utilities and market actors are bound to follow as the rollout progresses, and more versatile services with higher customer engagement will be seen in the near future. In this respect, these two are important and interesting cases to follow and to learn from, especially how the customers react.

4.1.4 Visible energy trial and Green Energy Options Ltd | UK

Target group: residential and commercial customers.

Objective of the services: energy savings through information and feedback.

Description of the service: the “Visible Energy Trial” (VET) is a study by Green Energy Options Ltd and the University of East Anglia on 282 homes in Eastern England who receive three different types of energy display systems(Hargreaves, 2010, 3):

- The Solo: a real-time energy display that connects wirelessly to a ZigBee smart meter (electricity or gas) or a self-installed ‘clip on’ transmitter. Users can manage their energy budget and the unit alerts them to unusual levels of consumption,.
- The Ensemble: an energy display extending the functionality of a push display, adding the ability to monitor and control up to six appliances. It works with an internet bridge so users can control the device and attached appliances via a web portal or using an iPhone app,
- The Trio: high level display providing a flexible platform with a colour-touchscreen and infinitely variable graphical user interface. The system includes websites, mobile applications and TVs. To trigger people to look at it, it works best combined with a simple push display,
- Control group: the control group had the Trio device installed in their home, which monitors their heating, hot water and all appliances; however they have not received the display unit.

Along with fulfilling the UK regulator’s (Ofgem) minimum specifications the display includes:

- 4.3” WQVGA backlit colour LCD with touch screen; portrait or landscape orientation,
- Mains and rechargeable battery powered (short term),
- Audio output,
- ZigBee SE/868 radio output,
- 6 months data storage for analysis,
- In-built temperature sensor,
- Ability to integrate to Internet bridge, plug devices, heating controllers & temperature sensors,
- Can support Micro generation and display import/export/generated visuals.

All products are designed to work pre-smart (independent & without a smart meter) or in a smart meter environment. Pre-smart meter displays provide an opportunity to build engagement amongst customers since preliminary studies show that customers with pre-smart meter displays tend to look more favourably on smart meters themselves.

Data acquisition: pre-smart clip on CT sensors: self-install sensors that clip onto the power cable going into the meter. There is an optional LED detector for meters that have a built-in pulse LED. The CT clip (or LED detector) senses the current load at the meter. Load and consumption values are re-calculated in the transmitter unit.

Smart meter IR reader: aZigBee SE sensor that connects to the IR port on existing meters. The IR reader collects all available data from the smart meter, using the IEC 1107 protocol. The transmitter unit converts the data into ZigBee SE for further processing.

Customer response and expected results: Green Energy Options Ltd works with the University of East Anglia to study the customer response to displays. 282 homes take part in the visible energy trial. Both quantitative (surveys) and qualitative (15 semi-structured interviews) social science methods are used to study the customer reaction. The qualitative interviews were transcribed and analysed using a grounded theory approach(Glaser and Strauss, 1967). Preliminary results show that the installation of the system is not straightforward and simpler systems are more successful. However, there is a general high level of satisfaction and the displays are used frequently.

Participants in the trial had heard about the trial through a variety of sources (local newspaper, local energy fairs, housing authority representatives, etc.) and had four distinct motives for participating: cutting costs, cutting emissions, gaining information, and interest in technology. Most participants expressed several overlapping motivations (Hargreaves, 2010, 8).

Some results of what people say they do (Caiger-Smith and Burgess, 2010; Hargreaves, 2010):

- Turn things off more than they did 65-89%,
- Switch off at wall 50-54%,
- Turn off lights more 71-88%,
- Use appliances more efficiently 51-75%.

How people feel:

- Believe they use less energy 52-68%,
- Are more confident on energy 69-78%,
- Have or plan low energy purchase 31-52%,
- Considering insulation 30-58%.

The results from qualitative research show that the displays had an effect on the behaviour of the customers. In particular with regard to develop new habits and routines, reducing waste and buying new more efficient appliances. Although the sample size of the qualitative study is too small to draw generalised conclusions, interviewees were extremely positive about the devices themselves and about how they had helped to reduce their energy consumption. Reflecting on the kinds of changes the devices have brought about suggests that these positive effects will be long-lasting.

Assessment: the displays may prove to have a significant effect on the behaviour of the customers. However, the remarkable aspect of the visible energy trials is that it goes with thorough scientific research that studies the reactions of customers. Since there is still a lack of research on how customers react to additional feedback on their energy consumption, this is a noteworthy approach that focuses on the customers and combines a scientific desiderate with the economic interest of a metering service and display provider.

4.1.5 Financial rewards for energy savings: Oxxio Online Information | The Netherlands

Target group: Households

Description: MijnOxxio is an online self-service platform provided by Oxxio (a subsidiary of Eneco Energie in Rotterdam) to their customer since 2009. Customers with a smart meter can enter a personal website to view their actual energy use and energy costs. Among other things, the customer gets a connection with “Energy Monitor”, an online energy management system that uses consumption information from the smart meter via GPRS.

Through a personalized web page, the customer can monitor the actual electricity and gas consumption and compare with his historical consumption data on a PC, lap-top/ tablet or smart phone (iOS as well as Android). Further possibilities are related to programming of consumption target, benchmarking and receiving tips as well as tariff- and consumption costs.

Data requirements: Customers with a smart meter send their data via P3 automatically. The system and service is also available for customers with a conventional meter by self-service input of meter data via the web.

Assessment of the service: Independent consumer research among more than 2.500 households in 2009 and 2010 showed small but consistent energy saving effects (average 1,5 % for electricity and 1,8% for gas) by the users and new users of the online platform. Other research in 2012 showed strong willingness to continue using the online platform, during the legal based transfer process of smart meters from the retailer to the network operator.

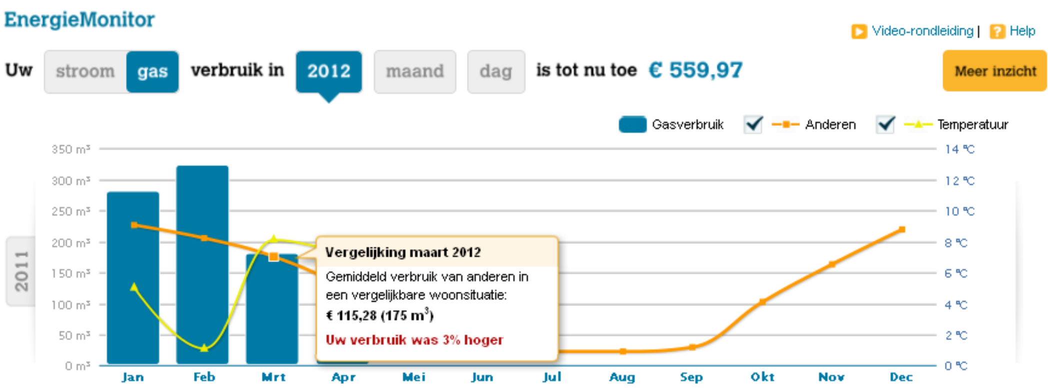


Figure MijnOxxio website

4.1.6 Environmental benefits from full-scale establishment of smart metering | Norway

Starting time: 2009

Target group: Residential customers

Main aim of the project

The objective of the research project ”Environmental benefits from full-scale implementation of Smart Metering”[56] at SINTEF Energy Research is to realise environmental benefits related to the full-scale implementation of Smart Metering (Sæle, 2010). This will be achieved through the following targets, as illustrated in the figure below;

Part 1: increase the efficiency of the data manipulation related to full scale implementation of Smart Metering. The project will contribute to a rational handling of new Smart Metering data, and that this data will be available for relevant tasks.

Part 2: establish a basis to release the environmental benefits in the form of reduced energy and power demand by making customers more conscious of their own consumption. Increased customer awareness will be increased with the use of a local exchange of information, load control and in-home display.

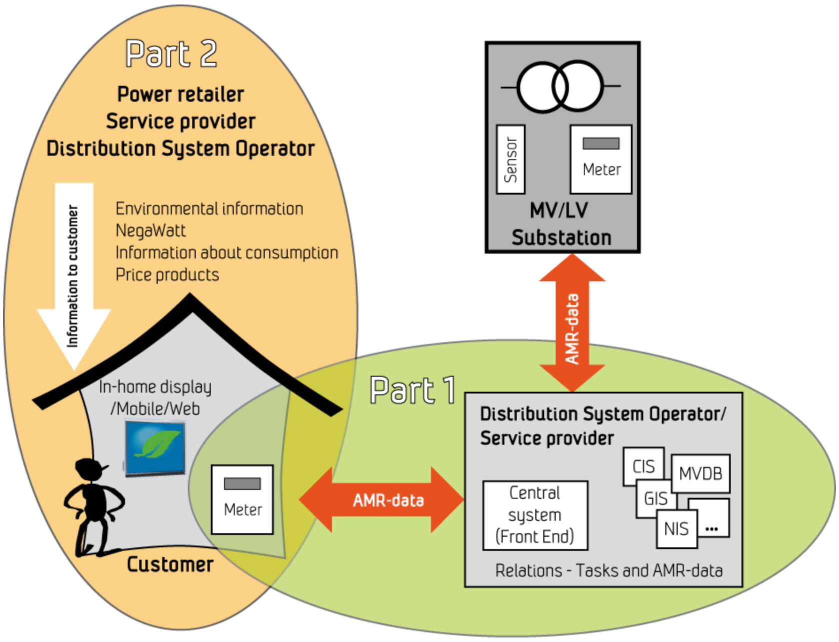


Figure 12: Technical focus within the research project

The research project is funded by the Norwegian Research Council, Energy Norway, Enova, Norwegian DSOs and Power retailers.

Description of the services: within the second part of the research project, two pilot studies have been established in cooperation with a power retailer. The main objectives of the different studies are to contribute to energy efficiency as a consequence of making customers more conscious regarding their own electricity consumption.

[56] www.sintef.no/m-ams (in Norwegian)

As illustrated in *Figure 12*: Technical focus within the research project

Increased awareness will be achieved through different types of information to the customers.

Pictures of the in-home displays installed at residential customers are presented in Figure 13.

Figure13: in-home display (eWave – Miljøvakt)

The pilot studies started in autumn 2010. The duration of the pilot study is for one year.

In total in-home displays are installed in47 households in Askøy (Western Norway) and 44 households in Follo (Eastern Norway). Three surveys will be performed during the pilot period lasting one year.

Customer response: based on new and updated information about their own electricity consumption, the retail customers should be inspired to change their consumption of electricity, and thereby increase the amount of energy efficiency and reduce their electricity consumption.

Based on the results from the first survey, households are motivated to perform energy efficiency actions, and they think the energy efficiency is important in relation to the environmental aspects. They have registered for the pilot to reduce electricity consumption, reduce energy costs and to get more information regarding their energy consumption.

Based on the results from the second survey, 81%of the households use the in-home display often – from several times during a week and up to several times during a day. The most interesting information is the real-time consumption. (The display can also present other types of information such as the historical consumption and energy costs.) The display helps the households to take environmental friendly actions during the day.

Technology used: in-home display

Data requirements: metering of electricity demand in real-time, for exchange of information between meter and in-home display.

Expected results: the expected results from this pilot study are increased energy efficiency and reduced electricity consumption as a result of making the residential customers more conscious of their own electricity consumption. The environmental benefits are based on reduced electricity consumption and increased energy efficiency. Customer surveys will be performed in relation to this pilot study, and they will hopefully give a description of different categories of residential customers and their attitude regarding electricity consumption and energy efficiency. The third and last survey will be performed during summer 2012. An analysis of consumption data will also be performed.

Customer acceptance: the customers are positive about the display and think that this helps them to reduce their energy consumption and energy costs, and to make environmental friendly actions during the day.

Empirical evidence for changing behaviour (if available); How has it been measured? n/a

Energy savings achieved (incl. date of evaluation): n/a

Lessons learnt: the service with an in-home display is not directly related to the smart metering service, since it is the technology related to the in-home displays that performs the metering of the electricity consumption. For settlement of the electricity consumption the customers perform self-reading of their meter and report this information to the Distribution System Operator. With smart metering technology installed, the customers get better initiatives for reducing and changing their electricity consumption, for example due to price incentives on an hourly basis.

4.1.7 EnBW Cockpit by EnBW AG | Germany

Target Group: the EnBW *Cockpit, iCockpit* and *StromRadar* are designed for private customers, and are offered as part of a product bundle ("Intelligenter Stromzähler®") in combination with a variable tariff and a smart meter. The product bundle has been available since 2008 in EnBW's supply areas.

Description: the three systems are all methods of providing the customer with feedback on their electricity consumption.

EnBW Cockpit is an online application where the customer can log in and view statistics on total consumption, current and past electricity consumption, cost structures for usage, and their personal carbon footprint (see Figure 11). The smart meter data is transmitted and updated in 15-minute intervals. The application allows customers to view different statistics in the form of tables and charts, as well as comparing the consumption from different time periods. The visualisation of the 15-minute values can be displayed in days, weeks, months and years. A "bullseye" function allows a comparison of the current day's consumption in reference to the price levels. All data can also be exported to a CSV data file for further analysis. The data for the online application is transmitted from the smart meter to the central EnBW server via the customer's DSL router. In addition to viewing consumption data on the Cockpit, the custom-

er can set reminders and alarms in the form of text messages and e-mails.

Figure 14: EnBW Cockpit – Screenshot (Heeg 2008)

StromRadar is a stand-alone software tool that can be installed on the customer's home PC. The software analyses data transmitted from the smart meter directly through the local network. The data can therefore be transmitted in one-second intervals and analysed almost instantaneously. The *StromRadar* allows customers to recognise the consumption of different appliances, calculate costs and estimate annual consumption. It can be downloaded by "Intelligenter Stromzähler®" customers from the *EnBW Cockpit.*

The *iCockpit* is available for free from the iTunes store for customers with the "Intelligenter Stromzähler®" tariff. It includes several functions provided by the afore-mentioned systems, but has the advantage of being an App and is therefore available for mobile devices.

Data requirements: the *EnBW Cockpit* uses metering data in 15-minute intervals, provided by the EnBW smart meter device. The *StromRadar* and *iCockpit* use almost real-time metering data for certain functions, transmitted directly through the customer's home network and not recorded or received by the utility.

Customer response: the three systems described above are expected to contribute to both energy saving (the real-time function is intended to help customers identify appliances with a high consumption) and load-shifting (the feedback systems are only available in combination with a variable tariff).

Results: EnBW AG carried out a smart meter pilot with 1000 customers using smart meters and the three systems described above. Results on the load-shifting and reduction that took place were not published, but feedback from the participants showed a high level of satisfaction. Individual participants explained that they were able to identify appliances with a high consumption as well as recognising times of high consumption in the household.

All three systems are currently being tested in MeRegio - a project from the state-sponsored "E-Energy" programme.

Assessment of services: the EnBW AG services provide customers with detailed information in a simple and understandable layout. The possibility of viewing consumption in terms of cost and carbon emissions is important factors that will lead to the customer adjusting consumption on the long-term. The options of sending text messages and e-mails or of accessing data using a smart phone also contribute to the sustainability of the system. There is still room for improvement; however, - the services are currently only offered in combination with a variable tariff with just two price categories.

4.1.8 Display trio smartbox by EWE AG | Germany

Target group and objective: the "trio *smart*box" display was developed by EWE and has been available for purchase since February 2011. The display is included in a product package including a smart meter, an Internet portal and variable tariff with two price categories. The target group are private customers. The display is marketed as increasing the transparency of household energy consumption. The product bundle is available in two variations – a bundle for electricity tariffs and a bundle for electricity and gas combined.

Description: The “trio *smart*box” display has a colour screen with 320*240 pixel resolution and integrated system software. It communicates with the gateway via M-Bus. The display can visualise the load in watts as well as the energy consumed within the last 15 minutes in kWh. It also shows the real-time consumption, the costs of energy consumption and CO_2 emissions for hourly, daily or monthly periods. The consumption data is visualised using a bar chart subdivided by the different price levels. The daily average consumption and the average weekly consumption can also be viewed. A separate online portal allows customers to compare annual consumption data with reference households or previous values.

Figure 15: “trio *smart*box” display (Harms, 2010)

Data requirements: The “trio *smart*box” is provided together with a smart meter which provides real-time data for electricity and hourly data for gas.

Customer response: the customer can respond to feedback from the display by shifting (the costs for the relevant time category are illustrated on the display) or reducing (the real-time feedback allows users to identify appliances with high levels of consumption) loads.

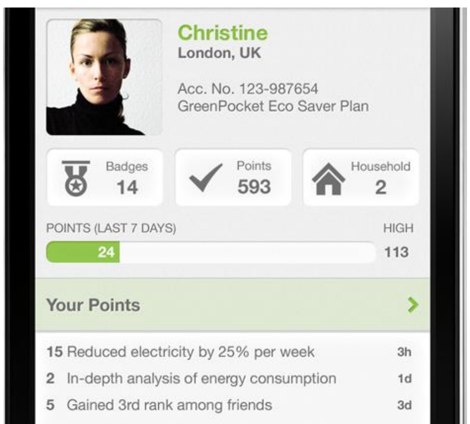
Results: before the product was released, EWE carried out a field test with 400 households. According to EWE, the increased transparency of the electricity and gas consumption led to a 10% average reduction in consumption.

Assessment of service: the “trio smartbox” is an easy to use display offering many possible ways of analysing energy consumption. It not only covers electricity consumption but also gas consumption. Therefore it seems to provide strong incentives to save energy or to shift loads. The portable display would seem to lend the product particular additional sustainability and serve as a more present reminder to customers to shift or reduce loads. The disadvantage of the “trio smartbox” would appear to be the price (the display costs €79 and the installation of the smart meter costs €99), which could be a reason why only about 200 customers ordered the product in its first year on the market.

4.1.9 GreenPocket Mobile by GreenPocket | Germany

Target group and objective: GreenPocket develops white label products for energy suppliers. The objective of the product is to maintain customer interest in load reduction and shifting by enabling customers to share their energy behaviour within their circle of friends. Since September 2011 customers can download a test version of the App from iTunes – a working application depends on a utility offering the product to their customers.

Description: the GreenPocket App is an application for Apple’s iPhone, iPod touch or iPad that allows smart metering services to be connected to the social web through integration in Facebook. The application motivates customers to continue energy management in the long term through “push” messages and competitions with



their friends. The app can list consumption and savings for all energy carriers and for water. Results can be shown in terms of carbon emissions, kWh, or cost. The customer can share successes of failures in energy saving with other users and take part in regular competitions, for which utilities can provide “virtual” or “real” prizes, such as concert tickets.

Figure 16: Screenshot 1, GreenPocket App

Data requirements: metering data in the form of 15-minute values is required to use all of the options offered by the GreenPocket App. Before the data is displayed, the programme tests it for quality and plausibility.

Customer response: the customer can respond to the feedback by increasing measures to shift or reduce loads.

Results: the product is not yet available – a working application depends on a utility offering the product to their customers.

Assessment of service: the GreenPocket App is a very innovative product and addresses a common problem of smart metering services – maintaining customer interest. Combining smart metering and energy saving with the social web is likely to lead to an increased use of smart metering services as well as encouraging other customers to order a smart metering service. It remains in doubt, however, whether interest can be maintained indefinitely using the social web.

4.1.10 District heating AMR |Latvia

Target group: residential, public, commercial buildings, the residents/users and building managers.

The objective is to achieve energy and money savings (and to reduce heat peak demand) through information, feedback, better indoor temperature control and better forecast heating needs.

Description of the services: displays in apartments / houses showing energy consumption and historical consumption and historical benchmarking on a monthly basis. Also residents are given information on how to save (e.g. temperature control – a one degree change means a 6% change in heating costs)

The novelty is that heat consumption is metered for every single apartment, instead of being metered for the whole building. In many cases, the metering installations and services are joined with renovations of the building envelope and the savings in heat consumption are measured afterwards.

Data requirements: monthly heat energy consumption

Customer response: end-user reaction is not known.

Expected and/or delivered results on energy consumption: not known for the metering only renovation savings were reported.

Assessment of the service: quite elementary technology and services, but for district heat intensive countries (Finland, Sweden, Latvia, etc.) heat AMR or smart metering for individual customer is important.

4.1.11 Ecore Action | Finland

Ecore is a Finnish AMR end-user service developer company offering consumption information management systems to utilities. These systems can be mostly categorised as information and feedback systems that display smart meter data for the end-users. Their self-service portal Ecore Action is a tailored Web-based information and feedback system for utility customers. The solution is supplied as an integrated part of the utility's own web pages, and tailored to match the utility's own visual look.

Ecore Action has already been deployed by a few of the Finland's largest energy utilities, such as Helsingin Energia and E.ON Finland. The Ecore Action based services are available for 500,000 households in Finland, making it the most extensive information and feedback system in the country.

- **Target groups**: the service covers households, commercial and public buildings, depending on the utility
- **Objective of the services:** save energy by helping utility customers to gain a better understanding of their personal consumption behaviour (information and feedback), and help utilities to offer better customer service. Features designed for peak load reduction will also be included in the future.

Figure 17: EcoreAction website

Description of the services offered: Ecore Action is a Web-based service portal where utility customers can view, compare and set goals for their electricity, district heat, gas and water consumption.

The system uses the utility smart metering data, and the exact features depend on the solution tailored for each utility. The key features usually are:

Electricity:

- A graphic view showing consumption and emission levels in a meter from green to red,
- Monitoring energy consumption from one hour to years, in different time scales,
- Comparing energy use to other users and own historic use,
- Energy costs and forecasts of consumption and energy bills,
- Planning energy goals and tracking them,
- Testing how turning on different home appliances affects consumption (virtually),
- A calendar to mark down actions affecting energy use,
- Tips and advice how to save energy.

District heat:

- 24/7 self-service online portal,
- A pointer shows in a meter, from green to red, the consumption and emission levels,
- Monthly or annual monitoring, showing comparisons to others and previous use,
- Shows district heat costs, and forecasts own consumption and bills,
- How the heating system is operating - temperatures for coming and leaving water, outside temp, and DH water stream.

Ecore is currently developing new, even more effective energy saving features, including automation and social media among others.

Data requirements: the data utilised is based on the utility's AMR solution. Usually the data is hourly-based and refreshed once a day, as the metering regulation demands. The service can be also adjusted to use for real-time or near real-time data. According to Ecore, the data quality is also important in order to create reliable services from the huge amount of data.

Customer response: no significant research to study the customer responses or energy saving effects has been done yet. Only responses known are individual opinions on the system and its possible potential in energy saving.

Expected and/or delivered results on energy consumption patterns: based on some recent studies (e.g. Ofgem EDRP), information and feedback based only on Web portals with no real-time information can only offer modest to no energy savings, although this depends heavily on the design of the system. In general, good design, strong marketing (done by the utilities to their customers) and future improvements will probably result in energy savings.

Your assessment of the service: the Ecore Action is the most advanced end-user information and feedback service implemented on a large scale in Finland to date. Also at European level, the features are quite advanced and the user base is probably at least one of the largest. The real benefit is that the service can be introduced to a large number of end-users cost-effectively, and that it can be tailored to different utilities and needs. Also, new features are being constantly developed to enable more effective energy savings. However, the customer engagement in Web portals may turn out low, as perceived in some pilots, diluting the energy saving effect. More incentives, automation as well as real-time information would be beneficial to enhance the energy saving effects and customer engagement.

4.1.12 Energiakolmio EnerControl reporting service | Finland

For over 10 years, independent of the utilities, Finnish energy Service Company Energiakolmio has offered its EnerControl energy reporting service, based on multi-utility AMR metering, to public a commercial buildings.

- **Target group:** public and commercial buildings, usually for the use of building users and managers who make decisions regarding building energy use and management.
- **Objective of the services**: energy savings through information & feedback, supporting building management through monitoring and perceiving abnormal situations (such as water leaks, etc.)
- **Description of the services offered:** EnerControl is a Web-based reporting service which gives building owners and managers information on energy use (heat, electricity, gas, water, cooling) in their buildings, based on hourly remote metering. Also more detailed facility and appliance specific electricity consumption with sub-meters is possible.

The service supports better building energy management through information and feedback, and perceiving abnormal situations (such as water leaks, etc.).

The meters used are either utility main meters, where AMR meters are available, or bought and owned by the building owner and a monthly fee is paid for the services. For larger commercial buildings, there are usually many meters (up to 20 or so), municipal buildings usually use one for heat, water and electricity.

The energy reporting service is operated via a Web-based interface, and has the following features:

- Monitoring consumption (hour, day, month, year, kWh and kWh/m3), including heat, electricity, gas, water, cooling,
- Comparing consumption to previous periods, day/night consumption (to see “Sunday” loads and consumption), max, min and average consumptions, long-term consumption trend,
- Also expert services in analysing energy consumption and operating with building automation (energy advisory services),
- Automatic surveillance of consumption changes, alarms automatically via email to find out unwanted consumption changes,
- Also energy performance certificates through the system,
- Can be combined with invoice handling, energy acquisition (mostly electricity portfolios in the Nordic stock market), balance handling.

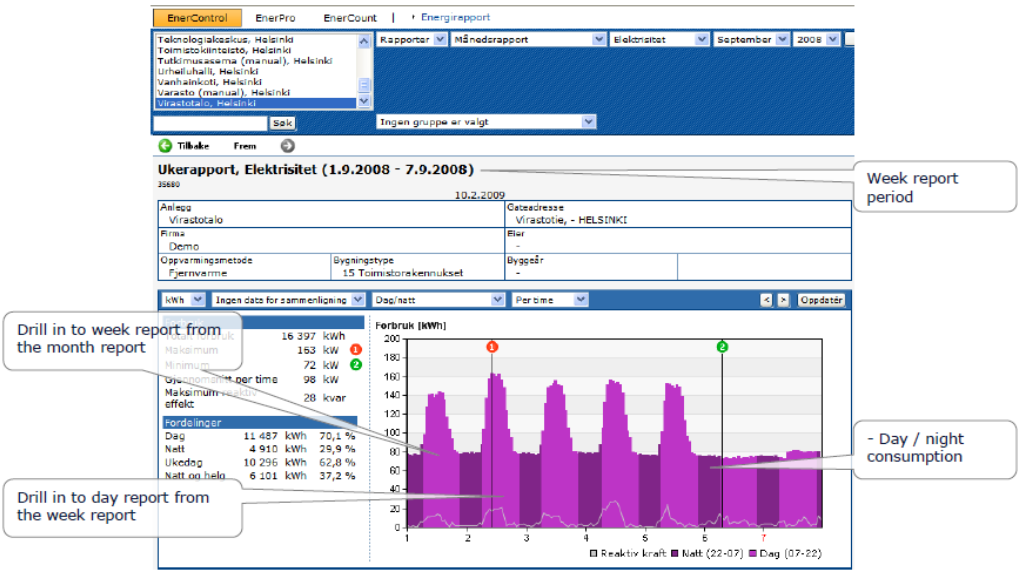


Figure 18: EnerControl website

- **Data requirements:** the system utilises hourly metered AMR data, usually refreshed once a day, and also manually typed data, including electricity, gas, heat and water (depending on needs). The metering and communication technology varies, usually hourly-based meters sending to a hub via a cable or wireless connection (e.g.GPRS), and then via GPRS to the service provider.
- **Customer response:** the system utilises hourly metered AMR data, usually refreshed once a day, and also manually typed data, including electricity, gas, heat and water (depending on needs). The metering and communication technology varies, usually hourly-based meters sending to a hub via a cable or wireless connection (e.g.GPRS), and then via GPRS to the service provider.
- **Expected and/or delivered results on energy consumption patterns:** several customers, e.g. 2nd largest retail sales chain in Finland and numerous cities and municipalities, have reported that better energy management brought by the service has resulted in significant energy and cost savings. However, the amounts cannot be specified as also many other factors affect energy consumption and savings are usually a result of several actions.
- **Your assessment of the service:** easy-to-use system, with quite basic energy monitoring information and comparison reports. The multi-utility aspect to monitor several different energy forms and water gives real added value for building energy management. The services would benefit from more energy advice aspects integrated to the system. However, this may be difficult because the end-users and their sites differ greatly, and the separate tailored advice service the company is offering might be more feasible. New feedback and information features such as benchmarking to other users, setting and tracking energy saving goals, real-time data and displays might be beneficial to increase energy savings. Also, including different variable tariffs and consumption/peak load controlling services would be a new way to increase customer benefit, energy savings and peak load reductions.

4.1.13 Vattenfall energy reporting services | Finland

Vattenfall has already been the pioneer in Finland with electricity meter AMR installations since2005 for all their 390,000 DSO customers. Since early 2010,they have also offered aWeb-based hourly electricity consumption reporting system for their residential customers.

- **Target group** residential, public, commercial buildings,
- **Objective of the services:** energy savings through information and feedback, to support their customer service and to reduce energy use and emissions. They also have very active energy advisory services through their Web pages.
- **Description of the services offered**:

The Vattenfall energy reporting service contains the following features:

- Hourly and daily electricity consumption monitoring in day, month and year intervals in bar charts, in kWh or Euros. The information updates once in a day.
- The daily energy use is also broken down to night and daytime electricity (when 2-time tariff is used), and monetary costs are broken down to energy, distribution and taxes.
- Also monitoring outdoor temperature data and comparison data of other similar users' data is available.

In addition to their energy reporting service, an ample amount of energy efficiency advice is available on their website, and the utility also has an energy advisor dedicated to answering customers' questions on home energy use and saving.

- **Data requirements:** hour-based AMR, read once a day.
- **Customer response:** not known yet.
- **Expected and/or delivered results on energy consumption patterns:** not known yet.
- **Your assessment of the service**: the reporting service contains the basic hourly data provision through visualisation, with added value by showing monetary costs, outdoor temperature and benchmarking to other similar users. For non-experts, interpreting the consumption data, and understanding to what affects the consumption might be challenging, as always in consumption information and feedback systems. Further features, such as goal settings and tracking, innovative visualisations, as well as energy advice and explanations for the consumption changes integrated directly into the reporting system would enhance the potential for energy saving. Also providing real-time data to the customers would potentially increase the energy saving effect.

4.1.14 Asema E Smart home centre | Finland

- **Objective of the services:** delivering energy savings and demand response capabilities through information on electricity consumption and automated home appliance control.
- **Target group:** residential buildings, primary focus on detached houses.
- **Description of the services offered**:

Asema smart home system combines information, control and automation to increase home energy efficiency and enable demand response. The system consists of Asema E touch-screen display, operating as a smart central home unit, and adapters, switches, modules, and sensors that connect to the central unit.

The system enables real-time monitoring of home electricity consumption and costs both through a smart meter and with independent sensors. Through switches, one can wirelessly monitor appliance specific consumption, and connected appliances can be controlled as well as programmed to automatically to react to changes in electricity price. Tariff controls can use data from utilities or directly from Nord Pool Spot.

The device also offers energy saving tips, consumption alerts and extended energy saving and other applications over the Internet (e.g. home consumption comparisons to similar users as well as different appliances comparisons). Through the use of customisable applications calleds screenlets, it can also function as a direct in-home communication channel between the utility and the user.

Asema E also has mobile phone, tablet, PC and Internet access built-in, expanding the interfaces to monitor and control home energy use. (Asema Electronics, 2012.)

- **Data requirements:** the system uses real-time data from a direct local connection to the smart meter and switches connected to appliances. The smart meter is usually provided by the utility, as the Finnish regulation demands.
- **Customer response:** see the answer below.
- **Expected and/or delivered results on energy consumption patterns:**

According to Finland based VaasaETT Global Energy Think-Tank “Response 2010” report, by combining smart meters with smart home automation in existing homes, householders can realistically expect to reduce their electricity consumption by tens of per cent, depending on the nature of the technology used and the customer’s own consumption behaviour. Also the report finds that such savings are possible with relatively affordable existing technology. More specifically, the greatest savings, up to 33% are possible at peak consumption times, by using substantially higher ‘critical-peak’ pricing in combination with the use of home automation and appliance controlling.

http://www.vaasaett.com/2010/06/respond2010launch/

- **Your assessment of the service**:

The specific real-time information, control and automation possibilities of the system have a large potential forenergy saving and demand response, especially in houses heated by electricity. The extensibility offered through applications, different interfaces and remote operability for the system is good. Including other functionalities and information besides energy (such as news and weather forecasts), is likely to increase the use of the central display unit and customer engagement. The downside is, while the system delivers higher potential energy savings and customer engagement in demand response, the price to be paid by the customer is much higher compared to e.g. Web-based information and feedback systems. Thus they are not so easily adopted by the masses, although still very potential to reach their own group of customers.

4.1.15 There Tonttu smart home system for holiday homes

- **Objective of the services:** energy saving, and remote controlling and monitoring of indoor temperature and energy use for holiday homes,
- **Target group:** mainly holiday homes, can be applied to other sites with a need for remote monitoring and controlling,.
- **Description of the services offered**:

There Corporation provides a ThereGate platform for Home Energy Management solutions, based on smart metering. The platform is compatible with appliances and applications provided by different companies.

The ThereGate platform provides the following features as building blocks for different kinds of solutions: data acquisition and processing, device and system control, as well as information presentation to the end-user via interfaces.

Tonttu (a Nordic equivalent of an Elf) is a product package for electrically-heated holiday homes owners, based on the ThereGate platform. The system consist of the central unit (ThereGate), home/away switch, wireless inside temperature meter and electricity meter reader. Through the system, the holiday home can be monitored and controlled in real-time, via Web interface with a mobile phone or PC.

- Monitoring and setting limits for energy consumption and inside temperature,
- Notification messages of unusual events (e.g. temperature or energy consumption values exceeding certain limits),
- Through the remotely controllable home/away switch, the indoor temperature can be lowered while people are away, providing considerable savings in energy consumption. The temperature can be raised before coming to the house, allowing the house to warm up and providing comfort.

The system can be expanded to cover many other features, such as outdoor temperature metering, appliance specific metering and controlling, as well as motion sensors and theft alarms. The open ThereGate platform enables the service to cover a wide variety of functions through different applications and appliances. (ThereCorporation 2012.)

- **Data requirements:** the system uses real-time data from a direct local connection to the smart meter and switches connected to appliances (socket switches).
- **Customer response:** see the answer below.
- **Expected and/or delivered results on energy consumption patterns:**

The system was piloted in 20 holiday homes in winter 2010 - 2011. The average saving in electricity consumption was 16%, and the resulting annual monetary savings are estimated to be around €154. The Tonttu system costs €1190, including installation. The average payback time for the investment is around 8 years (not taking account the interest rate or time value of money). (HS, 2012.)

If this average saving is elaborated to all 120,000 holiday homes with year-round heating (consumption averagely 8000 kWh/a), the energy savings would amount to 154,000 megawatt hours (MWh) with €20 million monetary savings and 61,000 tons of CO_2 savings. (HS, 2012.)

- **Your assessment of the service**:

The remote monitoring, control and automation possibilities based on real-time data have a large potential to reach considerable energy savings, especially as the number of electricity-heated holiday homes increases quite rapidly. The system also features well-thought out extensibility through further information and feedback and controlling options and new applications. The downside is, while the system delivers advanced possibilities for energy savings and customer engagement, the price might be still too high for many of the customers, especially for the ones with smaller electricity bills. Thus the system is not so easily adopted by the masses, although still very potential to reach its own group of customers.

4.1.16 Load profile management by AVU AG | Germany

Target group and objective: AVU's target group for this service are industry customers, ranging from small businesses to large enterprises. The goal of the service is to help industrial customers to reduce peak demand.

Description: in Germany the kWh charge for large customers is calculated using the highest load (measured at 15-minute intervals). Therefore the daily prices for energy are determined by the highest load during one period, and customers can save on energy costs by reducing maximum loads. AVU offers devices and software for customers to analyse the load profile of their operations. Using this information, customers can switch appliances on or off to reduce peak loads. In addition to assisting technology, customers can view the consumption data online using an AVU application.

Data requirements: in order to analyse the load profile, metering data must be delivered at least in 15-minute intervals. This data is collected by special smart meters which are mandatory by law for customers with an annual consumption of more than 100,000 kWh.

Customer response: the load profile analysis allows customers to recognise peak loads and reduce peak demand by shifting or reducing loads at certain times.

Results: load profile analysis is normal practice for industry customers in Germany and is a service offered by many utilities. It can be assumed that customers using this service shift large load in order to lower energy costs.

Assessment of service: load profile analysis is a standard tool in Germany to support industry customers to reduce their energy bills. It is one of the most effective forms of feedback. The service can be expected to be taken up and to contribute to regional and national peak load reduction in countries with relevant regulation for industry customers.

4.1.17 Wattcher – Electeicity information with conventional meters | The Netherlands

Target group: Households

Description: The Wattcher, since 2009 on the Dutch customer market, is a design display that shows the electricity consumption in a clear and visual way. When a customer turns on an electrical device, the Wattcher shows the extra power consumption. By switching between 5 functions, people get insight into their energy behaviour, and see directly how much they are saving:

- Current power consumption (Watts): how much energy you're using at this moment.

- Day consumption (kiloWattday): your total electricity consumption in the last 24 hours.
- Mean day consumption (mean kiloWattday): shows the average day consumption over the last 2 months.
- Energy cost savings (Euros): shows the annual energy savings in Euros, compared to last year.
- Realised savings (%): shows the realised savings as a percentage, compared to last year.

The Wattcher comes with Wattcher Online, a web based saving program that provides additional help and insights into energy saving. In Wattcher Online people can see their own history and compare with other households, and even can do an energy battle. The Wattcher itself uses very little energy. The combined consumption of all Wattcher components (sensor, sending unit and display) is less than 1 Watt.

Data requirements: The Wattcher consists of a sensor, a sending unit and a display. The sensor can be placed on any electricity meter (analogue meters, digital meters with LED pulse). The sensor is connected to the sending unit. The sending unit sends a radio signal to the display unit, which can be placed in any (euro standard) electricity socket. The Wattcher can be self-installed by the customer. In the course of 2012 a data logger for data transmission to internet and a smart meter sensor will be available.

Assessment of product and service: An independent evaluation of customer responses and achieved energy savings was executed by TU Delft. The Wattcher was nominated for the Dutch Design Award 2009 and has won the ICT Environment Award 2010. The Wattcher is a design object and communicates as ‘the ticking heart of the home’ (see figure).

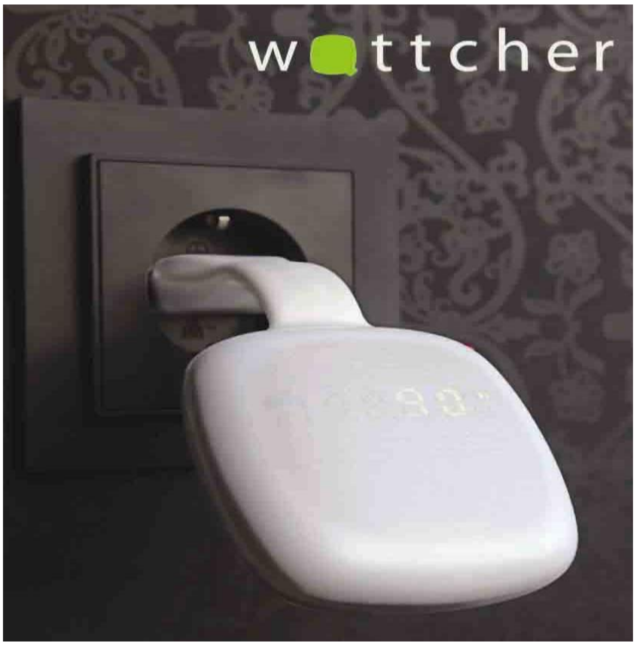


Figure 19: Regulation and implementatin of smart metertin in Europe: Wattcher the Netherlands

4.1.18 Zjools | Netherlands

Target group: households and small businesses

Description: Zjools is an independent provider offering a wireless energy display that gives households and small business users real-time financial insight into their whole house electricity consumption. The display provides information about the costs in euros per kilowatt hour, consumption levels and CO2 emissions.

Data requirements: The Zjools electricity display consists of an optical meter sensor (depending on the type of kWh meter), a transmitter and an energy display. The sensor is placed on the electricity meter and the transmitter sends the data wirelessly to the battery powered display. The customer receives the data in real-time in energy units, euros and CO2-emissions as well as the total per day. The display also provides historic consumption information (yesterday and the day before yesterday), comparison with target use and insight into cumulative consumption and costs on an monthly and annual basis. The display does not provide any information on gas consumption. It can be assembled quickly and without a professional electrician.

It is expected that the Zjools display will be available for smart meter households and businesses by the end of 2012.

Assessment of service: an independent evaluation of achieved energy savings is not yet available.

Figure 20: Zjools energy display Netherlands

4.1.19 Power Player | Netherlands

Target group: vulnerable population groups (low income households, immigrants, elderly people, computer illiterates, etc.)

Description: The Dutch PowerPlayer is a functional simple but eye-catching and colour rich touchscreen energy monitor, especially developed for vulnerable population groups such as low income households, immigrants, elderly people and people without internet connection or computer skills. By displaying energy consumption in a way similar to familiar experiences such as a car dashboard or a kitchen stove, the PowerPlayer turns meaningless data into comprehensive information, amenable to understanding and control, in energy units for electricity and gas as well as in true consumption costs. This way the easy-to-read Power-Player display also helps vulnerable population groups to discover the benefits of monitoring and controlling whole house electricity and gas consumption, without necessarily reducing the comfort of living.

The most appealing characteristic of the PowerPlayer display is without any doubt the use of the dashboard analogy, light mimics and dramatizing analogue (instead of numerical) indicators to show customers how the various aspects of their current electricity behaviour also shape their annual energy bills. By transforming the smart meter into a dashboard, including a dramatic moving speedometer and virtual fuel gauge and by providing an impression rather than accurate reading, the PowerPlayer draws attention and activates a pre-existing drive to control base load consumption and/or immediate surges in consumption when appliances are switched on. The PowerPlayer provides whole house gas consumption information in a similar self-explaining but less dynamic way, through the analogy of a kitchen gas cooker.

The wall mounted or desk/ table top monitor is also provided with dedicated programmable benchmarking, tariff setting and budgeting feature to improve a customer's 'energy performance', based on a customer's own historical consumption. This is achieved by challenging the user to set an annual energy saving target. In the case of electricity, the display subsequently automatically converses the self-set target into 'tailor-made' monthly consumption budgets, presented in analogy with a full fuel tank (in gas, presented in analogy with a gas cylinder). The challenge for the user is to get by with this virtual load of 'fuel' for the month, turns the system into an engaging and reinforcing 'energy player'. The display also gradually changes backlight colour as an additional prognosis signal for the user, to indicate from a distance and single glance whether the cumulative actual spend (energy performance) is on track to meet the self-set monthly scheme and annual saving target (green is on schedule, red is behind schedule). Historical consumption results will be stored in the display to allow comparison with different periods of historical consumption related to previous months and years. Finally, the display provides a button functionality to check the surge in power consumption of individual appliances such as a dryer, a freezer or water cooler. This way the display informs the user how much an appliance costs to run.

The display is mains powered and does not require a contract with an energy retailer or the need for online connection with the Internet, implying that the display is 100% private and security proof.

Data requirements: the PowerPlayer will only be available for smart meters.

Assessment of the display: an independent pilot evaluation of achieved energy savings of the actual display is expected by the end of 2013. Previous scientific research among 40 voluntary cooperating households in 2009 and 2010 showed significant average energy saving effects of 11% on electricity and 14% on gas against controls.

Figure 21: Familiar energy dashboard design, PowerPlayer Netherlands

4.1.20 E-manager, Nuon | Netherlands

Target groups: households

Description:

In November 2011, the Dutch energy retailer Nuon, a subsidiary of the Swedish Vattenfall, introduced the E-Manager. This online feedback service allows household customers to gain a real-time insight into their energy consumption and that of their appliances. This product was developed building on successful previous pilots with energy displays conducted in Amsterdam in previous years. With this remote control tool, customers can manage their electricity and gas use online in real-time and compare energy consumption or CO2 emissions over a period of time, via their PC at home or anywhere with a tablet and smart phone.

The E-manager instantly shows how much energy (and money) a customer is saving when specific appliances are not in use. The E-manager also provides comparisons of energy usage with previous periods and with similar households and information details such as outside temperature. For these optional smart plugs for power check and remote monitoring and control of individual appliances are available. If a customer wants to control the in-house temperature as well, s/he needs to add an additional remote controlled thermostat as well.

The E-manager (excl. thermostat) is free of charge on a 3 year contract and an additional monthly fee to see historical data. The E-Manager also provides a remote control App for Android and iOS. Following its market introduction in the Netherlands, Vattenfall will roll out the E-Manager in Germany and Sweden as well.

Data requirements: the E-manager is in the first place designed to display usage and to control electrical appliances in the house. The system comes as standard with a wall-mounted console to display historical energy usage and control electric appliances, the E-manager gateway, a meter reader for traditional meters and an active account for a personal E-manager website. In the second half of 2012, the E-manager will also be available for smart meter households.

Customer response and assessment: the system has only recently become available. Evaluation of customer experiences and consumption effects is not yet available.

Figure 22: E-manager Nuon Netherlands

4.1.21 Sweden's largest energy saving experiment | Sweden

http://experimentet.eon.se/experimentet

Start time: 2012

Target Group(s): residential customers

Main aim of the project: in Sweden's largest energy saving experiment it will be investigated how much energy the households will save when the electricity is displayed, and also if this experiment can result in behavioural changes in energy consumption. 10,000 residential customers located all over Sweden are participating in the pilot test.

Description of the services (functionalities): the electricity consumption in real-time is displayed via the Web, mobile phones and/or on an in-home display.

Costumer response: n/a

Technology used: the concept "100koll" is used in the saving experiment. The objective of this concept is to present electricity consumption in real-time, via the Internet, mobile phones and an in-home display. See Figure 23.

Figure 23 Illustration of the concept "100koll", delivered by E.ON (Source: www.eon.se/privatkund/Energiradgivning/100koll/)

Data requirements: real-time data on electricity consumption

Expected results: energy savings and behavioural changes related to electricity consumption.

Customer acceptance (if empirical findings are already available):n/a

Empirical evidence for changing behaviour (if available); How has it been measured? n/a

Energy savings achieved (incl. date of evaluation): on the website of the experiment energy savings achieved are presented (http://experimentet.eon.se/).

In the period from 1 February 2012 to 22 April, the electricity consumption was reduced by15.02% (See Figure 24).

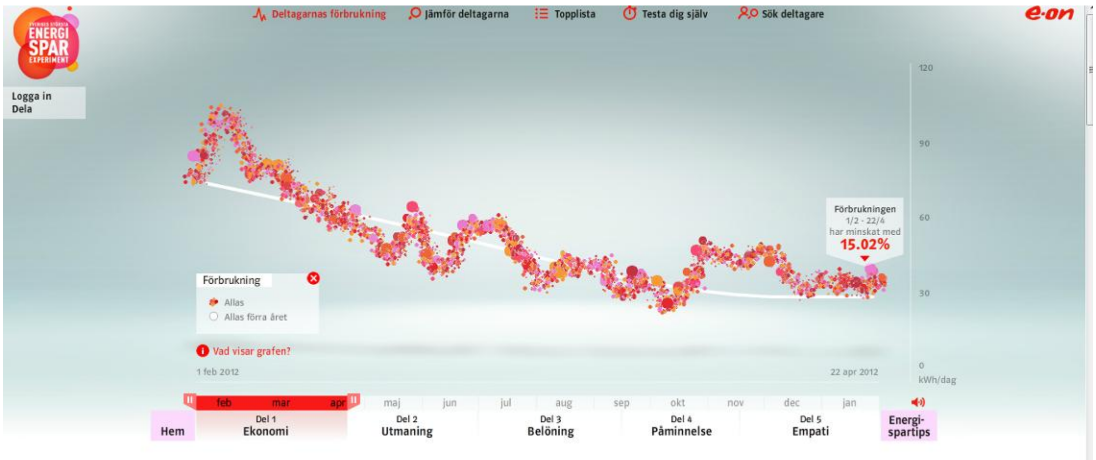


Figure 24 Energy saving achieved (As of 22 April 2012) (Source: www.experiment.se)

Lessons learnt: n/a

4.1.22 Green IT Homes | Sweden

Start time: 2011

Target Group(s): residential customers

Main aim of the project: the Green It Homes solution combines home automation and energy consumption display into one user-friendly system that can be accessed anywhere. The main aim is to lower household energy consumption by up to 20% by letting the user understand energy consumption and take control, all via mobile device[57].

Description of the services (functionalities): in a project funded by Vinnova, the Swedish Innovation Agency, a "plug and play" integration platform that works together with several monitoring and controlling products seen on the market has been designed. The information gathered is presented in a mobile device with an Internet connection.

The Green It homes system is at the moment being installed at two different demonstration houses, one in Gothenburg, Sweden and one Borgå, Finland. The purpose of the demonstrations is to evaluate long-term use, try different communication protocols and electricity metering devices.

Costumer response: n/a

Technology used: mobile device

Data requirements: n/a

Expected results: reduced energy consumption due to more environmentally aware behaviour.

Customer acceptance (if empirical findings are already available): n/a

Empirical evidence for changing behaviour (if available); How has it been measured? n/a

Energy savings achieved (incl. date of evaluation): n/a

Lessons learnt: n/a

4.1.23 Toon® – Home Heating and Energy Management | The Netherlands

Target group: Households

Description: In the beginning of 2012, energy retailer Eneco introduced an innovative programmable thermostat that also helps consumers to monitor and manage their energy consumption. Toon® is a revolutionary programmable display thermostat that, by means of Live Updates, gives consumers also an instant insight into energy consumption and actual

[57] http://www.imcg.se/

costs. The basis of the system is a high quality thermostat design in combination with a corresponding set of energy consumption and tariff information functions for electricity as well as for gas.

Toon® aims to expand the thermostat spot in the living room into a fixed reference spot in-home energy management, an energy display on the wall. The smart thermostat reports in graphics and diagrams about the current energy consumption in energy units and costs in comparison with previous hour, days, months and year. Consequently, people become more aware –and in control- of their household energy use. The thermostat also warns for the risk of additional charges. Finally the display thermostat communicates wifi with internet for comparison actual with estimated use and additional (non-energy related) services such as traffic and weather information.

Toon® will be available for Eneco clients only. The purchasing price for Toon® is €120,-. Toon® is free in combination with a 3 year contract for fixed price gas and electricity. There is an additional 3.50 euro monthly fee for Live Updates (historical consumption information, tariff information, warning signals and internet services). Introduction of an App for iOS, Android or Windows Phone will follow soon.

Data requirements: Toon® will be available for smart meters as well as for traditional meter. In case of traditional meters 2 optical readers need to be installed on the meters in order to measure actual energy usage from the gas and electricity meters

Figure25: Toon® Smart heating thermostat and energy management display

4.1.24 InovGrid

Start Time: 2007

Target Group: residential, commercial and industrial customers

Main aim of the project: The project transforms the traditional electrical distribution grid by adding information and intelligent equipment, which are able to automate energy management.

Description of the services: customers get access to detailed consumption information, empowering them to choose the best options for their energy consumption patterns. New services and prices will be provided to them and remote management will be available, e.g. detecting faults automatically. Services such as tariff and capacity changes can be activated remotely.

Customer response: the response and the participation in the innovative service was very positive, involving initially 1,300 customers from residential, industrial and service segments which consumptions patterns and energy efficiency could be evaluated.

Data requirements: the communications technology that was selected for installation in Évora at the time was PLC DCSK. This is a technology that has served to guarantee the majority of functionalities but it has limitations to support future features, particularly in relation to demand side management, mass use of electric vehicles and micro generation.

In a small percentage of customers in Évora energy boxes with GPRS were installed. Additionally EDP Distribuição has implemented small-scale pilots to test other communications technologies, including PRIME PLC and RF mesh.

Customer acceptance: so far, customer acceptance has been high. The project is supported and financed by EDP, so no direct costs are transferred to the householder.

Empirical evidence for changing behaviour (if available); How has it been measured? n/a

Energy savings achieved (incl. date of evaluation): between 12 – 20% in public tertiary buildings**.**

Lessons learned: the availability of technology, the standardisation work and extensive European partner's participation contributed to the fast dissemination of the project's findings and conclusions.

The methodology of the test project is focused on testing new products and services with a good level of acceptance by customers. The test of concept included a socio-economic study of customers for their segmentation based on Contracted Power and Consumption level and the subsequent definition of client samples with static processes to receive direct and indirect feedback. The graphic shows the tests levels and the tariffs/services offered according to the different groups in which the customers were divided.

4.1.25 Integrated service for residential sector

Start Time: 2010

Target Group: residential sector

Main aim of the project: Energy@home is a collaborative and spontaneous project between Enel, Electrolux, Indesit and Telecom Italia aimed at developing a communication infrastructure that enables provision of Value Added Services based upon information exchange related to energy usage, energy consumption and energy tariffs in the Home Area Network (HAN).

Description of the Services: the Enel Smart Info project aims to develop an innovative device able to provide and support energy services to incentive customer consciousness regarding energy consumptions.

The availability of the Smart Info creates a new energy services marketplace:

- Automatic load management,
- Networking with smart appliances,
- Energy efficiency,
- Active demand services.

The Smart Info will make data collected from the Enel smart meter available to different customer interfaces available in the indoor environment (e.g. PC, TV, custom display, appliances)

The user could improve her/his awareness on energy consumption and cost using information coming from the grid and the home itself. Data and information refer to:

- User and contract references,
- Current power use,
- Historical data,
- Current tariff and tariff time frames,
- Overload alarms.

The Self-Management Mode is the condition where any Smart Appliance receives Price and Volume Signals from a device (Smart Info or Smart Meter or basic Home Gateway) and proposes the proper starting time to the customer to take advantage of the most advantageous tariff. The customer could override the proposal if needed. This is made independently and without any coordination with the other devices.

The Coordinated Management Mode is the condition where any Smart Appliance coordinates its operations with the Home Gateway. The Home Gateway, through a dialogue with the Smart Appliances, plans their operations taking into account Price and Volume Signals, selected Household Appliances programmes and Customer needs and constraints.

The infrastructure for “Smart Grid” and Energy Management advanced functions also enables the extension to a new set of services dedicated to the appliance users as:

- remote access for monitoring and control;
- remote preventive maintenance;
- dedicated marketing services;

Customer response: In development stage, still no feedback from a significant number of customers.

Data requirements: specifications of the HAN communication protocol that enables the set of use cases defined by the Energy@Home partners (protocol available at www.energy-home.it)

Wireless protocol, the data model, the set of application messages, and the sequence activity diagrams

Can be mapped to a standard ZigBee Public Profile that includes connected appliances of CECED and that extends “Home Automation” and “Smart Energy”

Customer acceptance: no information yet.

Empirical evidence for changing behaviour (if available); How has it been measured? n/a

Energy savings achieved (incl. date of evaluation): still under development.

Lessons learnt: the project will make data collected from the Enel smart meter available to different customer interfaces available in the indoor environment (e.g. PC, TV, custom display, appliances), and will improve awareness on energy consumption and cost using information coming from the grid and the home itself.

4.1.26 Plugwise | The Netherlands

Target group: households and SMEs

Description: Since 2009, Plugwise has been developing products for Dutch customers and SMEs, and has developed a range of products and services for energy management to help users understand and control their electricity consumption at appliance level and reduce their energy bill.

In combination with packages ‘Home Start’ and Home Basic’ the customer is able to monitor and control a maximum of 9 individual (or groups of) appliances (expandable to 25 appliances).

The Plugwise system was originally designed to do three things:

1) Provide details of energy consumption per appliance: each plug contains a small power meter that accurately registers energy consumption of connected appliances.
2) Save energy by creating switching schemes: with the Source management software the user can create switching schemes for appliances connected to the plugs.
3) Create virtual power groups and switch them wirelessly: with the software a customer can combine plugs in power groups and switch them wirelessly.

Smile P1

In 2012, Plugwise introduced the Smile P1 (see figure below) for connection to the smart meter to also allow whole house monitoring of electricity and gas consumption. Important Smile P1-functionalities are: real time en historic insight in total consumption of electricity and gas and providing prognosis of annual bills for checking in combination with energy saving tips.

Figure 26: Plugwise Smile P1, the Netherlands

Data requirements: The original Plugwise system consists of a set of plugs that can be connected between a socket and the appliance plug. The plugs store power consumption data and transmit them to the Plugwise Source software installed on a customer personal computer/ laptop using wireless ZigBee. The software shows the data in clear overviews and well-organised charts. For complete overview of domestic energy consumption, Plugwise introduced the Smile P1 in 2012. The figure below shows a high level overview of the technical details of the Smile P1 system and how it integrates into the house.

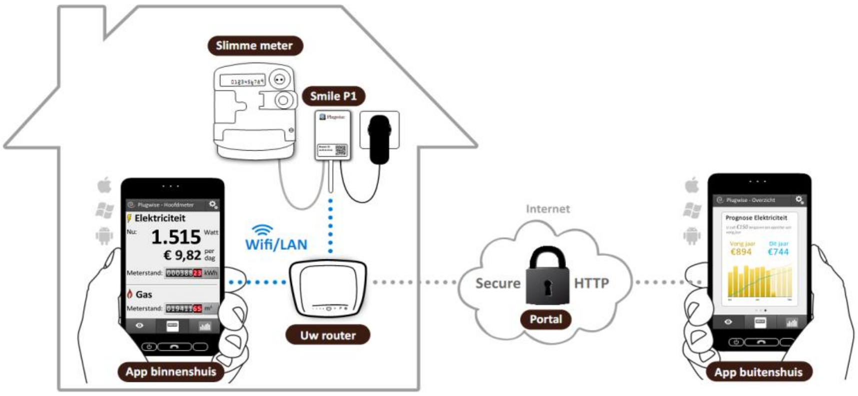


Figure 27: Overview Plugwise Smile P1 system, the Netherlands

Results and assessment: The service has the potential to conveniently reduce standby consumption, increase the awareness of electricity consuming devices and be a starting point for a smart home.

4.2 Demand response programmes (Dynamic pricing, Variable time-of-use tariffs, etc.)

Demand Response is the term used to identify utility actions to reduce or shift peak demand load through customer incentives and direct load curtailment. Here we present pricing models which set peak/off-peak pricing tiers to provide customers with an economic **incentive** to shift their energy consumption to off-peak hours. That is, unlike with direct load control as will be discussed in Chapter 4.3, here it is the customer's choice based on existing incentive to shift the use of appliances to off-peak hours. However, the choices by the customer might be made automatically using embedded control devices that manage consumption locally, according to variable tariff signals.

4.2.1 "Fixed price with return options" energy contract (Market-Based Demand Response project)| Norway

Start Time: 2005

Target group: Residential customers

Main aim of the project: Energy savings and load reduction. This energy contract combines spot and fixed price products, and gives the customers incentives for reducing their electricity consumption in periods with high prices (at least prices higher than the fixed price in the contract between the energy supplier and the customer).

Description of the services: The lack of incentive for load reduction in the ordinary Fixed Price (FP) contract was the reason why the Norwegian Parliamentary White Paper (18-03/04) asked for the development of new products from suppliers that combines spot and fixed price products (Grande et al., 2008). In 2005 the Norwegian retailer Trondheim Energy chose to replace the ordinary FP contract with the "Fixed price With Return" option (FWR) contract, which meets these requirements. In the FWR product Trondheim Energy offers residential customers "crude" electricity price (spot price) combined with a price hedge of a predefined yearly fixed volume. Similar products have been common for commercial customers as part of the portfolio management.

The FWR contract is defined by the local spot price,[58] the contract price and the contract volume. The contract volume is divided over the year according to a profile.

[58] The price paid by the customer is the spot price for the area where the power is delivered plus a mark-up for the supplier. The spot contracts to smaller customers are normally priced according to the average area price over the settlement period, while large customers are settled on the basis of hourly prices.

The fact that most domestic customers have limited knowledge of the power markets is a significant challenge related to marketing this type of power products. Trondheim Energy has therefore chosen to market the product as a fixed price and volume product where consumption below the contracted volume is sold back to the market and excess consumption is bought, both at running area spot price level. By illustrating this with a bottle containing a spare volume that is returnable (Figure 28), the retailer seems to have succeeded in presenting the product in a way that people understand.

Figure 28: Bottle to be recycled (Grande et al., 2008)

However, strictly speaking nothing is sold back to the market. The customer pays the area price for the real consumption and achieves a profit or loss in the financial market dependent on the real system price[59].

However, the settlement of a fictitious buy (or sell) back will be similar to the actual settlement, provided that the area and the system prices are equal. Considering the educational challenges related to explaining the product, this choice of marketing is a reasonable trade-off. It is, however, important that the customers are informed about and are aware of the risk aspects related to the potential differences between the area and system prices.

Customer response: two questionnaires were answered by a selection of FWR customers. The main impression from this study is that customers are focused on their own cost savings and follow the power situation through the media. The customers' response to the marketing and the product as such is on the whole positive. There have, however, been some negative comments to the deviations from the fixed price occurring in periods with a significant difference between area and system prices.

Data requirements: self-reading of the meter is performed quarterly (or monthly is also possible). With hourly metering of the consumption the customer would have incentives to change their consumption based on the hourly spot prices

Results: one of the main aspects in this pilot was to study the price responsiveness compared to the alternative products. Figure 29 shows the load curve for residential customers having Spot Price (Spot), Standard Variable Price[60] (SVP) and FWR contracts respectively for quarterly periods, each category has 800 customers.

The three categories follow each other with the exception of the first quarter of 2006. The customers with the FWR product reduced their electricity consumption by24.5% in the first

[59] The Nord Pool Elspot "system price" is the price initially calculated with no network constraints taken into consideration.

[60] SVP is the default contract for a majority of the retailers. The price may be changed with two-week's notice, and will normally follow the area price with some delay. Settlement is based on yearly or quarterly "self-meter reading" and profiling.

quarter of 2006[61], while customers with spot price power products and standard power products increased their consumption by10.4% and 7.7% respectively, in the same period.

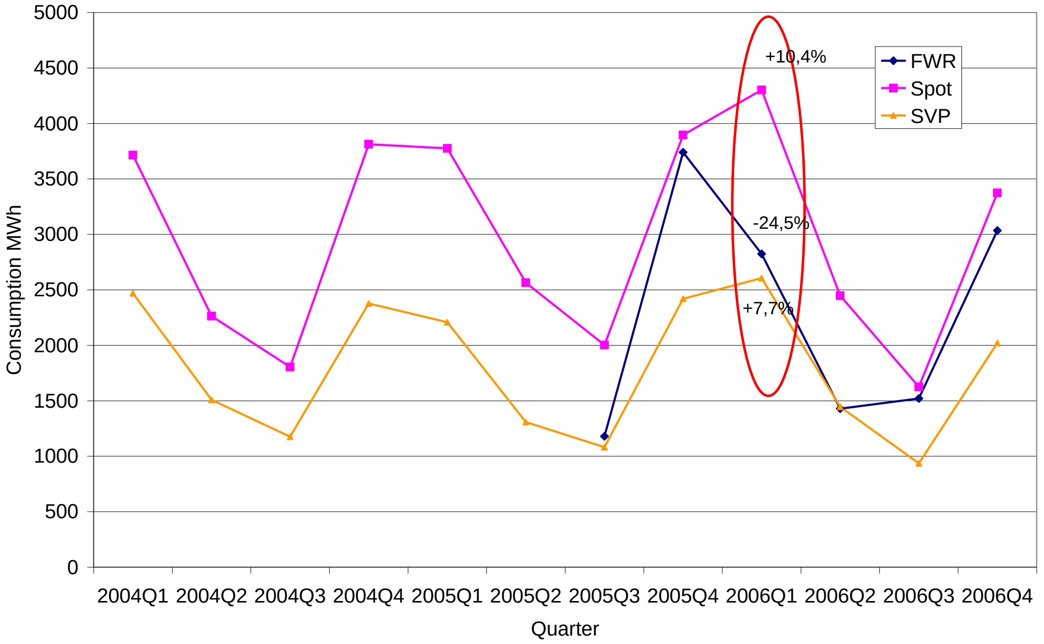


Figure 29: Electricity consumption for groups of customers with different power products (Grande et al., 2008)

The power balance in the Nordic power market was very tight in this period and the spot prices rose significantly. This development of the prices gave the FWR customers a strong incentive to reduce consumption, and the registered response shows very clearly the potential of this type of contract. The customer surveys carried out during and after the test period indicate that a major part of the reduced electricity consumption was substituted by fire wood. Spot price customers did not have the same reaction, although they should have a similar incentive. It is assumed that the reason is the increased awareness of the FWR customers through the marketing campaign that focused on their opportunity to actually make money on the high prices.

The same response was missing in the 3rd quarter of 2006 when the spot prices were even higher than in the 1st quarter. A possible explanation is related to the fact that this period was warmer than normal, which led to low consumption and thereby a substantial benefit from the financial contract without additional actions.

The project recommends that the contract should be further developed. The supplier should consider taking over the area price risk from the customers, since the supplier has the possibility of reducing their own risk trough proper hedging. Alternatively should the contract be marketed as a combination of a spot price contract and a financial contract with the Nord pool area price and system price as the reference respectively.

[61]Compared to the consumption in the 4th quarter of 2005.

Customer acceptance: the main impression from this study is that customers are focused on their own cost savings and follow the power situation through the media.

Empirical evidence for changing behaviour (if available); How has it been measured? n/a

Energy savings achieved (incl. date of evaluation): the three categories follow each other with exception of the 1stquarter of 2006. The customers with the FWR product reduced their electricity consumption by24.5% in the first quarter of 2006, while customers with spot price power products and standard power products increased their consumption by10.4% and 7.7% respectively, in the same period (See Figure 29).

Lessons learnt: this service gives the customers a reduced risk due to the fixed price in the energy contract as long as the customers do not use more than the agreed volume, but at the same time the service gives incentives to reduce their consumption in periods when the spot price is higher than the fixed price they have in their contract with the power retailer. This service was offered to customers who only had quarterly readings of their meter. The settlement was performed with use of a yearly profile. With hourly metering of the electricity consumption the customers would have benefited from hourly changes in demand.

4.2.2 Remotely controlled load shifting (Market Based Demand Response project) | Norway

Start time: 2006

Target group: residential customers with waterborne space heating system with an electrical boiler or a standard electrical water heater.

Main aim of the project: load shifting, peak demand reduction, information and feedback

Description of the services: 40 domestic customers with hourly metering of their consumption participated in the pilot. The pilot was performed by Malvik Everk – a small DSO located in Mid-Norway (Grande et al., 2008). Malvik Everk is one of few DSOs in Norway with full rollout of AMR to the customers. The customers were offered a Time-of-Day (ToD) network tariff and they were advised to buy an hourly spot price energy contract.

The household customers got hourly metering of their electricity consumption, and technology for remote load control of low-prioritised loads[62] were installed.

The ToD network tariff stimulated load shifting, and Remote Load Control (RLC) via the AMR system was offered as an aid to reducing load and costs in peak hours.

The chosen time for the energy peak payment were based on the hours during the morning and afternoon when the peak load for the local DSO occurred. These hours coincide with the periods when high spot prices are expected and when the peak load occurs on a national level.

[62]Low-prioritised loads are electrical appliances that can be disconnected for a limited period.

The ToD network tariff was based on the traditional energy network tariff and was divided into three parts: Firm, Loss and Energy Peak. The Firm part of the tariff was unchanged € 187.5 /year, the loss part was € 0.875 /kWh. The Energy Peak payment was € 7.88 /kWh[63] and only active from8 am to 10 am in the morning and from 5 pm to 7 pm in the afternoon on weekdays. The new tariff was calculated in a way that ensured that the costs for an "average user", acting as before, was unchanged on a yearly basis. This means that a responsive customer, reducing her/his load in the predefined hours, would benefit from the tariff and by avoiding the high spot prices that normally appear in the same hours in case of energy shortage.

10% of the customers had a waterborne space heating system with a 12-15 kW electrical boiler. The rest of the customers had a standard e2-3 kW electrical water heater.

Customer response: during the pilot study two questionnaires were answered by the customers (spring 2006 and 2007). The main impression from these is that the customers care about their own electricity consumption, but personal economy has the higher priority. The customers accept remote load control, as long as this does not affect the comfort negatively. Several of the customers have adapted consumption to the new network tariff by manual efforts, by investing in energy control system and/or by buying fire wood for the winter.

Technology used: Automatic Meter Reading (AMR) and Remote Load Control (RLC)

Data requirements: hourly metering of the total electricity consumption. Technology for remote load control of low-prioritised appliances.

Results: the RLC was carried out in the defined high priced peak hours (Figure 30), and the customers in the pilot were also equipped with a small watch-like magnetic token, the "El-button" (Illustrated in the upper right corner in the figure). This should be placed on dish-washer, washing machine etc. to remind the households to avoid usage =these energy consuming appliances at peak times.

[63] VAT excluded

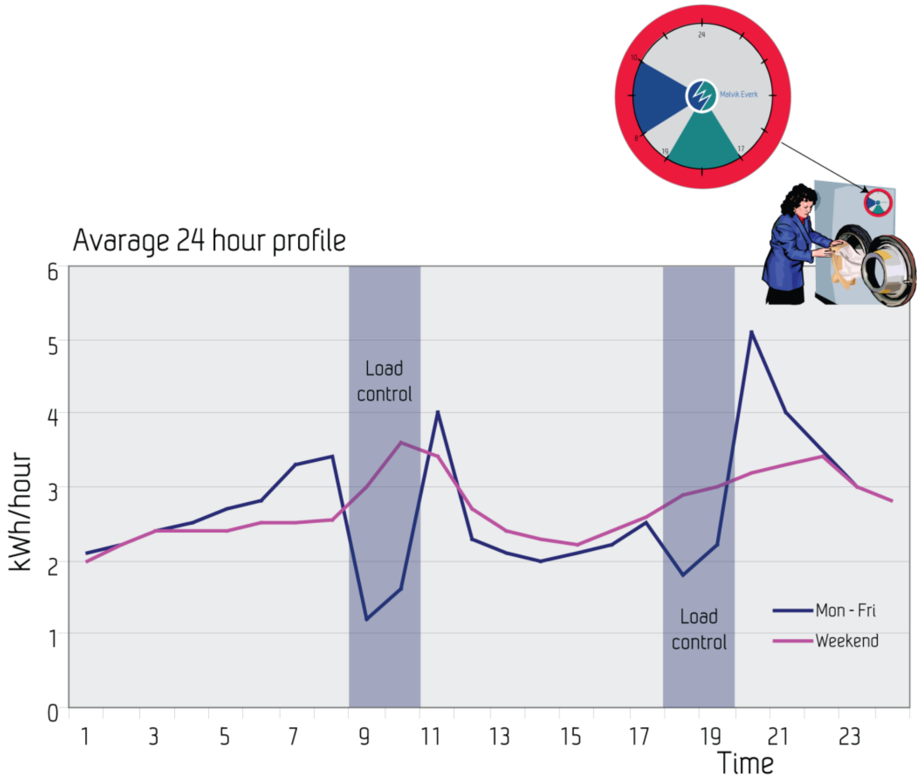


Figure 30: Household load curve with RLC - on weekdays (Grande et al., 2008)

Registered average demand response in peak load during the morning was approx. 1 kWh/h for customers with electrical water heater and approx. 2.5 kWh/h for customers with water-borne space heating system with an electrical boiler. The demand response in this pilot was larger than in previous tests, (0.6 kWh/h) (Grande and Graabak, 2004), which indicates that more than just the automatic load reduction via RLC was activated in the peak hours.

Table 4: Average demand response

Customer categories	**8 am – 10 am**	**5 pm - 7**
Customers with electrical waterborne space heating system	~2.5-3 kWh/h	~1.3 kWh/h
Customers with electrical water heater	~1 kWh/h	~0.5 kWh/h

Figure 31 shows the strong relation between the Elspot prices in Mid-Norway and the hours for RLC within the pilot. If this RLC scheme had been implemented on a large scale and had been included in the Elspot bidding, the price peaks could have been lowered.

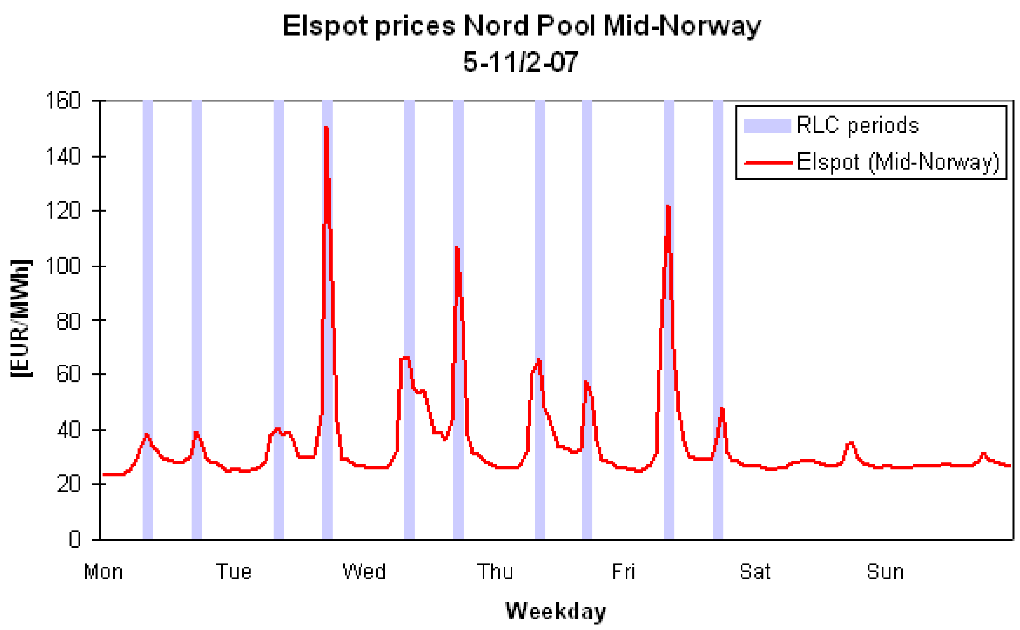


Figure 31: Elspot prices Mid-Norway and periods for RLC in the pilot (Grande et al., 2008)

The remote load control was performed using a Power Line Carrier (PLC) and relays connected to the communication terminal for the AMR system. Each terminal has three relays, one of 16 A and two of 6 A. The electrical circuit for low-prioritised loads were coupled via the relays of the terminal. Separate contactors were used for loads > 16 A.

The remote load control was carried out as a periodical job performed at predefined hours – directly from substations. The weakness of the PLC is a communication failure when changes in the configuration of the power system are performed and/or when terminals are moved within different substations. Therefore an override switch was installed in each household to reduce the risk of the loads not reconnecting.

Customer acceptance (if empirical findings are already available): two surveys were conducted during the pilot study (spring 2006 and 2007). The main impression from these is that the customers cared about their own electricity consumption, but personal economy had a higher priority. The customers accepted remote load control, as long as it does not negatively affect comfort. Several of the customers had adapted consumption to the new network tariff by manual efforts, by investing in energy control system and/or by buying fire wood for the winter.

Empirical evidence for changing behaviour (if available); How has it been measured? Registered average demand response in peak load during the morning was approx. 1 kWh/h for customers with an electrical water heater and approx. 2.5 kWh/h for customers with a waterborne space heating system with an electrical boiler (See Figure 30).

Energy savings achieved (incl. date of evaluation):n/a

Lessons learnt: this pilot shows that demand response/load shifting can be performed through simple means – hourly metering, hourly price incentives, token with predefined peak periods and remote load control to help the customer to secure a demand response. Combined with an energy contract with the hourly spot price included, the price signal to the customers is both dynamic and predictable.

4.2.3 Demand charge electricity grid tariff in the residential sector (Istad Nett) | Norway

Start time: 2006

Target group: Residential customers

Main aim of the project: the objective for this demand charge electricity grid tariff was to give incentives to reduce peak consumption.

Description of the service: the Norwegian DSO "Istad Nett AS" offers a Demand Charge (DC) grid tariff for residential customers. The tariff charges the maximum hourly peak consumption in each of the winter months Dec, Jan, and Feb, thus giving incentives to reduce peak consumption.

In total approximately 700 households have this grid tariff. This amounts for 5% of the DSO's customers. The description in this chapter is based on Stokke et al. (2010) where electricity consumption data from 443 households are analysed. These customers have a spot price power tariff in addition to the grid tariff. Hourly meter data from 1 Jan 2006 to 31 Dec 2006 is used in the analysis.

This DSO has the following grid tariff options for its residential customers:

- An *energy tariff* with a fixed annual charge of EUR 300 and a variable energy rate EUR 0.042 /kWh
- A *demand charge tariff* with an annual charge of EUR 12, a variable energy rate of EUR 0.022 / kWh, and a demand charge of EUR 82/kW/year

The demand charge is settled and billed on a monthly basis in the winter months Dec, Jan, and Feb for the highest registered hourly kilowatt consumption on weekdays between 7 am and 4 pm (hours 8 to 16). For the other months in the year, the average of the highest demand in each of the three winter months is billed.

The DC tariff was introduced on a voluntary basis in 2000. The tariff was designed in such a way that if all customers chose this tariff without changing their demand patterns, revenues for the grid company would be unchanged. The intention, however, is that customers do change their demand patterns by lowering their peak demand, decreasing their costs and at the same time decreasing the costs of the grid company by making it possible to postpone investments. The DC tariff is therefore attractive for customers that are able to lower their peak demand to obtain a lower electricity bill. Note that in addition to the grid tariff, customers also pay their power supplier for the energy they use. The rate structure and actual price depend on the actual supplier and rate each customer chooses.

Customer response: n/a

Technology used: automatic meter reading

Data requirements: customers have hourly metering of their electricity consumption.

Results: the demand reduction in the different hours in the different months is presented in the figure below. Figure 32 shows that the average reduction per household varies between 0 and 0.37 kWh/h dependent on the hour. The largest load reductions occur in hour 8 in the morning for all months. For instance, the highest reduction in hour 8 in December implies a reduction of approximately 12% of the average customer's demand in that hour. The average reduction of demand due to the DC tariff for all the 9 hours in the 3 months in the active window is 5%.

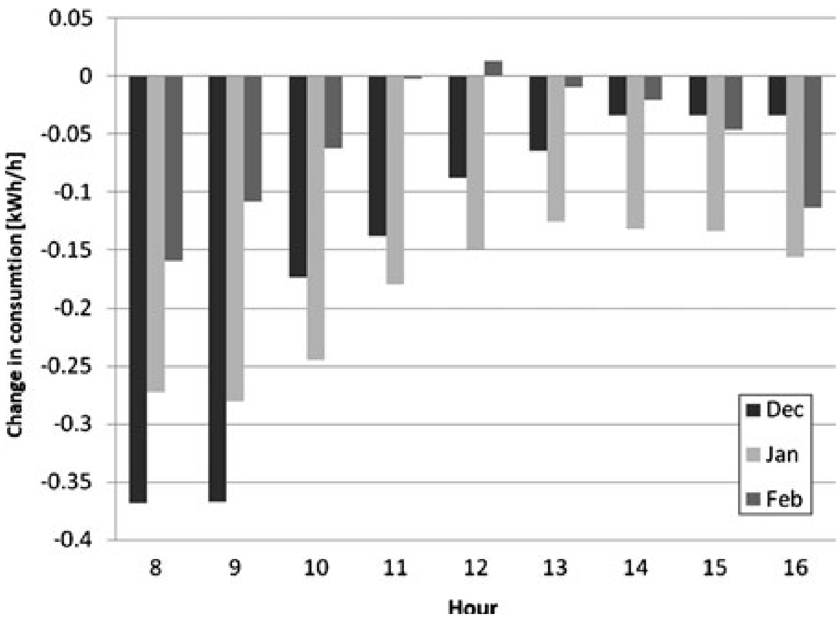


Figure 32: The average change in consumption per customer for each hour in Dec, Jan and Feb within the active window (Stokke et al., 2010)

The estimates indicate average demand reductions up to 0.37 kWh/h per household in response to the tariff. This is on average a 5% reduction, with a maximum reduction of 12% in hour 8 in Dec.

The customers did not receive any information on their continuous consumption or any reminders when the tariff was in effect. It is likely that the consumption reductions would have been even higher with more information to the customers.

Customer acceptance (if empirical findings are already available):n/a

Empirical evidence for changing behaviour (if available); How has it been measured? The estimates indicate average demand reductions up to 0.37 kWh/h per household in response to the tariff. This is on average a 5% reduction, with a maximum reduction of 12% in hour 8 in Dec.

Energy savings achieved (incl. date of evaluation):n/a

Lessons learnt: hourly metering of the electricity consumption combined with a demand charge electricity tariff has given the customers incentives to reduce their peak demand. Even if power has been thought of as difficult to understand and no reminder of the price signal was given to the customers, the household customers participating in this pilot have reduced their consumption according to the price signals.

4.2.4 Price as a control method, family homes with electrical heating (MarketDesign) | Sweden

Start time: 2003

Target group: residential customers (family homes with electrical heating)

Main aim of the project: a demonstration trial performed within the MarketDesign project had the objective of examining the price sensitivity of customers with various heating alternatives (Lindskoug, 2006).

Description of the services: previous tests have indicated a small sensitivity to prices among households, but these trials were carried out with considerably smaller price variations than can be expected in a future capacity shortage situation.

The target group of the trials was household customers at Skånska Energi and Vallentuna Energi. The trial was performed during two winters, where the test of the first winter (2003/2004) included 45 customers at Skånska Energi, and the test during the second winter (2004/2005) included 53 customers of Skånska Energi and 40 customers of Vallentuna Energi.

A special price list was prepared for the trials. This price list allows the electricity supplier to apply a higher charge for a maximum of 40 hours. For the rest of the year the deduction is made from the customer's regular fee. The higher electricity price is EUR 0.3-1 per kWh interval. The customer has been notified the day before of the time and level of peak price via text message or e-mail.

The price list was designed to give cost neutrality relative to the regular price list as long as the customer does not affect any changes. If the customer affects changes the customer's electricity bill is reduced. An example from Skånska Energi's customer offer promised a yearly savings of EUR 150 when cutting usage by 75% during high price instances. Vallentuna Energi trials promised savings during the winter season 2004/2005 of EUR 110 per annum, to evaluate the customer response toward a lower figure.

Customer response: along with the customer agreement, tips were offered on how to temporarily reduce electricity usage and the significant actions one can take depending on heating alternatives and systems. The technical results, questionnaires and in-depth interviews show an unequivocal and consistent picture of the customer's generally large will, ability and persistence to reduce electricity usage during times of high prices. The load was cut back to an average of at least 50% during high price instances.

The results of the interviews 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 could be saved by reducing power usage.
- It was not viewed as troublesome or time-consuming to affect changes.

- No major drawbacks were experienced in connection with lowering electricity usage.
- The response to the level of reimbursement varied between the households. Customers at Skånska Energi had the following opinions; at least EUR 0.5 lower price per kWh. That would save a thousand Kronor. The amount of profit wasn't that important. It felt good to be able to help. In the case of the Vallentuna Energi customers; at least EUR 0.5 lower price per kWh, a thousand Kronor would be saved, the level of profit wasn't important, rather it was about doing something beneficial for the environment. EUR 55 was welcome, all these types of deductions are important.
- Despite many not having a grasp of how 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 considered to present any major problems.

Technology used: automatic meter reading

Data requirements: these trials have been performed without installing new smart metering technology, but it is an interesting trial focusing on how price information can motivate the household customers to reduce their consumption in periods with low outdoor temperatures.

Results: another important conclusion of the project is that the results have been achieved without the need for new technology to be installed at the customer end. In addition, the results show large similarities between the years and the respective power suppliers' customers.

The results from the first and second phase of the trial are presented in the figures below. In the first phase the customers get a high electricity price between 8-10 am, and in the second phase the customers get a high electricity price between 7-10 am.

The results from the first phase of the trial (Figure 33) show that the customers of Vallentuna Energi do not have the same results as the customers from Skånska Energi, while the results for Skånska Energi have improved since last year.

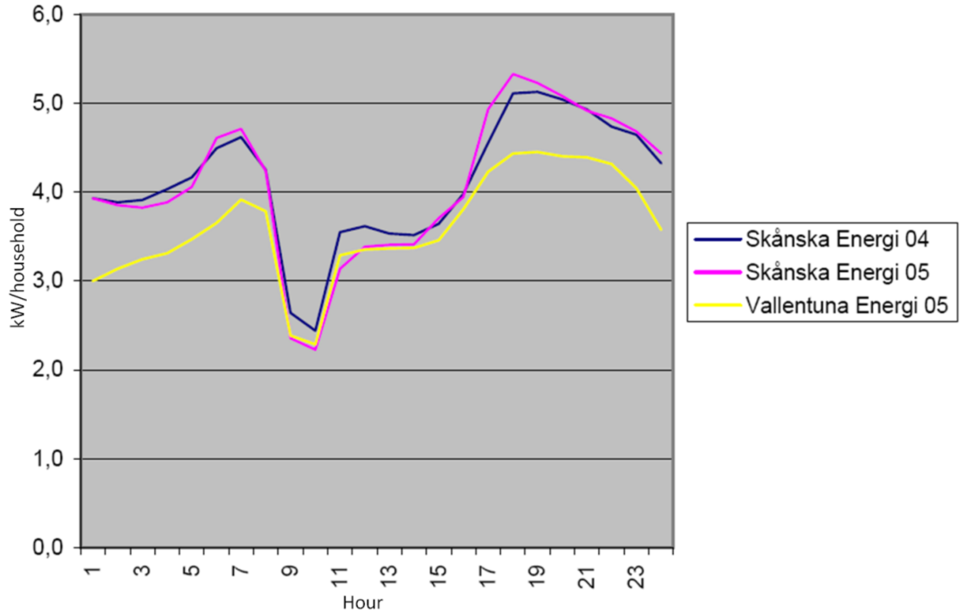


Figure 33: Phase 1 - High electricity price between 8-10 am (Lindskoug, 2006)

The results from the second phase of the trial (Figure 34) are further improvements in relation to Phase 1. Phase 2 also shows almost identical results between Skånska and Vallentuna if taking into consideration that the outside temperature during the period was on average one degree lower in Skåne.

Figure 34: Phase 2 - High electricity price between 7-10 am (Lindskoug, 2006)

Customer acceptance (if empirical findings are already available): n/a

Empirical evidence for changing behaviour (if available); How has it been measured? n/a

Energy savings achieved (incl. date of evaluation): n/a

Lessons learnt: household customers reduced their consumption in peak price periods, when they got a reminder the day before. The changes in demand are performed manually. This was performed during a trial for two winters. To secure a more stable demand response, technology for automatic demand response should be implemented. The customers did not have automatic meter reading installed. Hourly metering of the consumption, combined with hourly settlement, would give the customers stronger incentives for demand response.

4.2.5 Electricity tariff with differentiated grid fees (Sollentuna Energi) | Sweden

Start time: 2001

Target group: residential customers

Main aim of the project: the objective of this electricity tariff with a differentiated grid of fees was to reduce the peak demand. The main objective of the load component in this tariff was to make end-users more conscious of load capacity problems and change their load demand pattern. The long-term aim for the energy utility was to reduce the load demand in the whole service area in order to decrease the level and the price of load contracted from the electricity supplier and secondly, to avoid expensive investments necessary to strengthen the grid.

Description of service: 1 January 2001, Sollentuna Energi, one Swedish energy utility operating in the Stockholm area, introduced a new electricity tariff with a differentiated grid of fees based on a mean value of the peak load every month. This load charge depends on an average load value of three daily 1-hour load peaks during one month.

This tariff was introduced for all household customers in the service area. Analyses of this electricity tariff are presented in Pyrko et al. (2003).

Sollentuna Energi is a Swedish energy utility which operates in the Stockholm area, supplying electricity to about 24,000 customers: 12,000 flats, 8,000 houses and 4,000 terraced houses. Sollentuna Energi was one of the first Swedish energy utilities that installed remote metering/billing systems to all of their customers (1997) (Graabak and Sæle, 2008). The metering technology is used for hourly metering of the electricity consumption.

Customer response: 78 % of customers preferred the traditional tariff (where customers only paid for their electricity consumption) to the new one. Some argued that it was bothersome to have one more thing to think about concerning the electricity bills, and other argued that the new tariff created higher and unfair electricity costs (Pyrko, 2006).

Technology used: automatic meter reading

Data requirements: monthly meter reading

Results: Pyrko et al. (2003) investigate the extent to which a Load Demand Component, included in electricity pricing, can influence energy use and load demand in residential buildings and how tariffs can change the habits of electricity consumption in different groups of residential customers. The changes due to the tariff are calculated based on the differences in data from 2000 and 2001.

The extreme load demand values in 2000 and 2001 expressed in kWh/h are presented in the graph below.

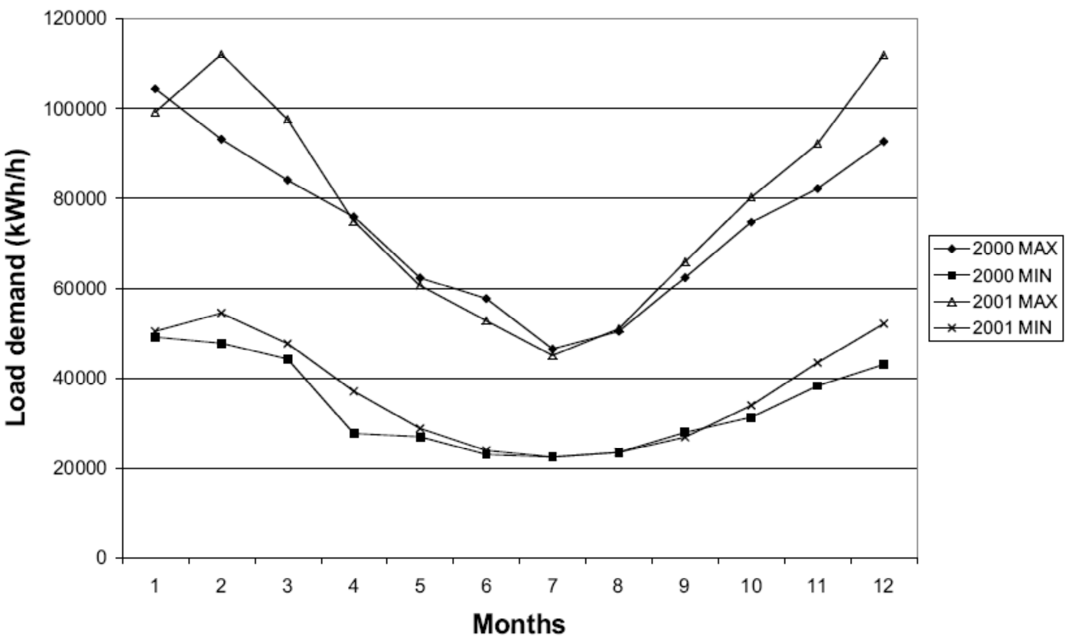


Figure 35: Maximum and minimum 1-hour total load during 2000 and 2001 (Pyrko et al., 2003)

Despite the values being quite similar in 2000 and 2001 there are differences and some interesting aspects to emphasise. Firstly, in February, March and December, the maximum values of load demand were significantly higher in 2001 than in 2000. Secondly, during the warmest period of the year, between April and September, the maximum values of load demand were very close for both years. During the winter period from November to March, every month apart from January was colder. These facts highlight the relationship between climatic conditions and electricity consumption in Sweden, especially for electrically-heated homes.

Pyrko et al.(2003) conclude that a load charge added to the tariff is expected to change customers' consumption patterns. Thus, this charge has to be constructed so that the price of electricity is a bit higher if there are no changes in the consumption behaviour and more expensive if the highest peak of consumption grows more than the energy consumption. Of course, customers' electrical expenses have to be considerably reduced if they are to significantly improve their consumption patterns. It is very important to emphasise two aspects of the new tariff. The electricity price should not vary during the summer, since the utility has no problems then. Neither the saving nor the highest expenses should focus on the summer period.

Customer acceptance (if empirical findings are already available):n/a

Empirical evidence for changing behaviour (if available); How has it been measured? According to the evaluation made by the utility itself, it was possible to lower demand by about 5% due to the new tariff (Pyrko, 2006).

Energy savings achieved (incl. date of evaluation):n/a

Lessons learnt: this electricity tariff with differentiated grid fees gives the customers an incentive to reduce their peak demand. The load charge depends on the average of three daily 1-house load peaks during one month. By using an average value of three load peaks, the customers have incentives to reduce their consumption even after one peak load has occurred.

4.2.6 Price sensitive electricity demand in households | Denmark

Start time: 2007

Target group: residential customers

Main aim of the project: to realise price flexible demand for household customers.

Description of the service: a trial with the objective of achieving price flexible demand at household customers was performed at Syd Energi and SEAS-NVE in Denmark (Togeby and Hay, 2009). The trial was performed from April 2007 to March 2009.

The project was performed by DI Energi branchen, Danfoss A/S, Siemens A/S, SEAS-NVE, Syd Energi and Ea Energi analyse and it was funded by Energinet.dk and the participating companies.

More than 500 household customers with electricity used for heating participated in the trial, and all customers had a yearly electricity consumption larger than 15,000 kWh. Average electricity consumption was 18,255 kWh/year.

238 customers participated in the test group and 355 customers participated in the control group. The customers in the test group were divided into the following three sub-groups:

- 46 customers with installed technology for automatic load control based on the price information (load control performed according to pre-defined price levels).
- 172 customers received a daily email or SMS with price information. Manual load control was performed by the customers.
- 20 customers got a display were the price information was presented. Manual load control was performed by the customers.

The customers in the test group had an energy contract with the spot price included, and they were guaranteed that their costs would not be higher than an ordinary energy contract.

To make it easier to present the different prices, the spot price was presented as low, normal or high – with different colour codes. The customers with installed technology for automatic load control could specify the price levels when the electricity heating system should be controlled.

The different levels (low, normal and high) were chosen based on how the price differed in relation to the average price during the day. If the price differed by more than 5% from the average price, it was classified as low or high. When choosing the 5% limit, most of the days got both low and high prices. Examples of the price information are presented in the figure below.

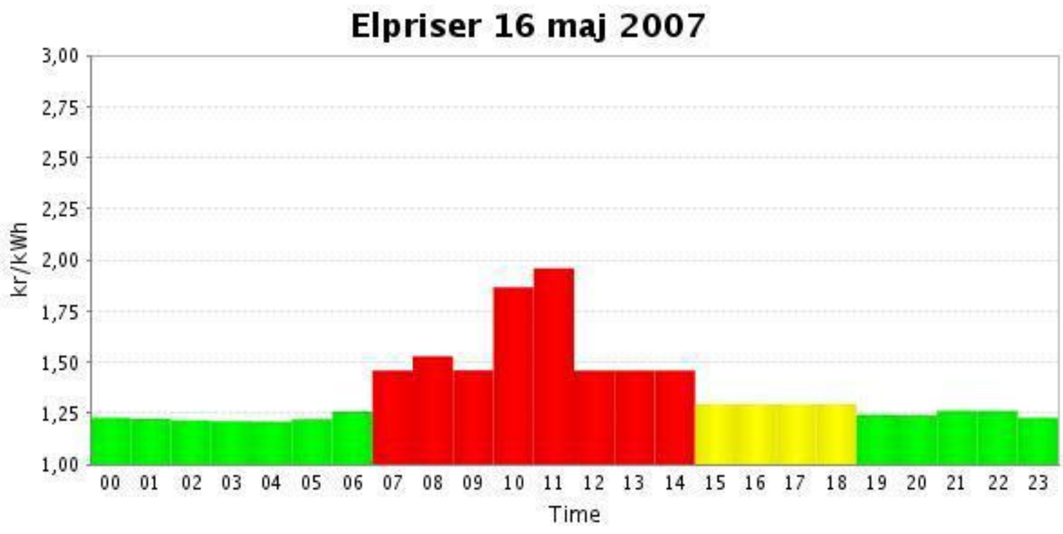


Figure 36: Example of price information (Togeby and Hay, 2009)

There is a certain structure when the low and high prices occur. The low prices usually occur during the night and the high prices usually occur between 9 am – 12 pm in the morning or between 5 pm -7 pm in the afternoon, but there are large variations.

Technology used: automatic meter reading, SMS, mail, automatic load control

Data requirements: hourly metering of the electricity consumption, hourly spot prices

Results: the customers participating in the trial typically saved EUR 200 – 400 per year. Average savings for the customers with installed technology for load control is presented in the figure below.

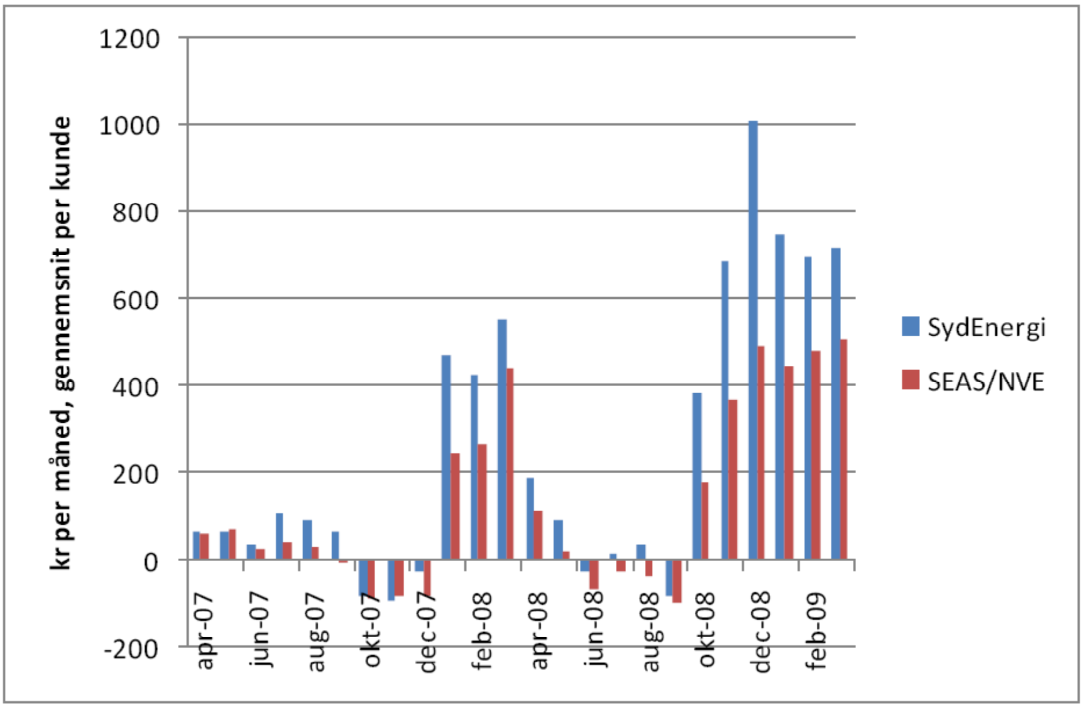


Figure 37: Average savings per month for household customers with installed technology for load control (Togeby and Hay, 2009)

The main savings are not based on load shifting, but rather from the new energy contract with the spot price included. Most customers in Denmark have not changed their power supplier, and they buy the electricity from the local power supplier that is obliged to deliver in the particular area. The prices in these contracts are fixed on a quarterly basis and they are strictly regulated by the Danish Energy Regulatory Authority[64]. During the test period the spot price was lower than the regulated energy price.

The results from the trial have shown that the main results are achieved when price information is given in relation to installed technology for load control. No significant results were achieved from customers that only received price information.

Calculated with great uncertainty, the economic benefit from adapting the demand to the prices is estimated to be EUR13-26/year, but it was difficult to separate the changes in consumption from the normal changes in electricity demand.

Customer acceptance (if empirical findings are already available): n/a

Empirical evidence for changing behaviour (if available); How has it been measured? n/a

Energy savings achieved (incl. date of evaluation): n/a

[64]http://energitilsynet.dk/tool-menu/english/

Lessons learnt: an easy and understandable illustration of the spot prices. The demand response is largest for customers with installed technology for load control. This illustrates the importance of using technology for remote load control – in combination with price incentives.

4.2.7 Energy Forecast (Energiudsigten) | Denmark

Start time: 2008

Target group: residential customers

Main aim of the project: the purpose of the project was to investigate the potential for flexible electricity consumption - whether the customers can be motivated to manual shifting of electricity demand from hours when the electricity has greatest environmental impact to hours with less environmental impact.

Description of the service: the Energy Forecast project is a research project implemented for Energinet.dk in cooperation with the electricity supply company SydEnergi, the local television production company Syd Produktion and the Electricity Saving Trust (Energymap, 2010).

The customers located in SydEnergi's supply area can follow the spot prices daily for the coming day (Energistyrelsen, 2009).

Different means are investigated during the project:

- Media campaigns;
- Energy contracts with spot price;
- A box displaying the level of the spot price the hour in operation and the following hours.

The project is implemented in the area geographically covered by SydEnergi, where the online reading of electricity meters on an hourly basis was implemented. A randomly selected monitoring group of 500 customers was selected and interviewed. Data including the hourly electricity consumption of this group was collected daily as the basis for the analysis of the impact of the demand response measures.

An important instrument in the project is the daily Energy forecast, which is available at the website Energiudsigten.dk

The Energy forecast is published every afternoon displaying the electricity spot prices during the next 24 hours. An example of the price information is presented in the following figure.

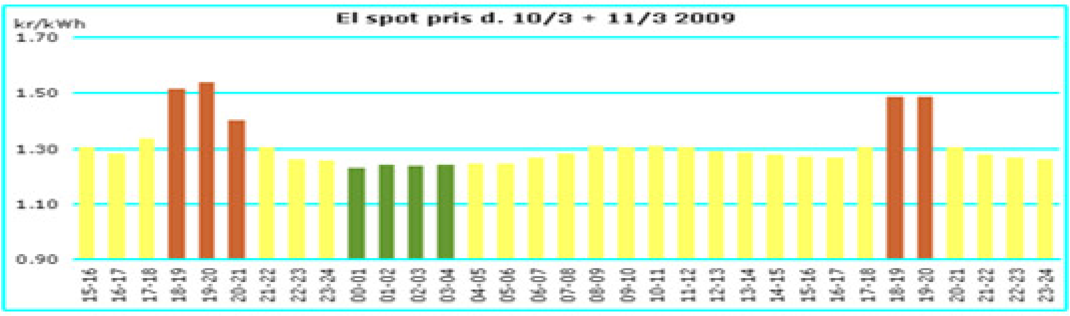


Figure 38: Information about the spot price (Energymap, 2010)

Customer response: n/a

Technology used: Automatic Meter Reading and a box displaying the level of the spot price for the hour in operation and the following hours

Data requirements: hourly meter reading of electricity meters

Expected results: it is expected that the project will result in more flexible electricity consumption, where customers shift loads from hours when the electricity has greatest environmental impact to hours with less environmental impact.

Customer acceptance (if empirical findings are already available): A survey among residential customers has shown that approx. 70% think that load shifting is important for the environment.

Empirical evidence for changing behaviour (if available); How has it been measured? n/a

Energy savings achieved (incl. date of evaluation): n/a

Lessons learnt: the environmental impact of demand response is important, but there is a challenge to keep customers interested and to make them act according to available information (Energistyrelsen, 2009).

4.2.8 EcoGrid EU – Large-scale smart grids demonstration of real-time market-based integration of distributed energy resources (DER) and demand response (DR) | Denmark

Start time: 2011

Target group: the target group for this project is small and medium sized customers, Electrical Vehicles (EV), Photovoltaic (PV) and wind production.

Main aim of the project: the objective of this project is to develop and demonstrate on a large scale a generally applicable real-time market concept for smart electricity distribution networks with a high penetration of renewable energy sources and active user participation. The concept is based on small and medium-sized distributed energy resources (DER) and flexible demand response (DR) to real-time price signals. Market-based, cost efficient and standardised solutions will be aimed for.

Description of the service: the EcoGrid EU project will contribute to the European 20-20-20 goals by showing that it is possible to operate a distribution power system (on the Danish island of Bornholm) with more than 50% renewable energy sources (RES) making active use of new communication technology and innovative market solutions. The EcoGrid EU concept will contribute to the operation of the transmission system by offering the TSOs additional balancing and ancillary services.

EcoGrid is an EU-project (FP7, Energy 2010.7.1.1) that has recently been accepted by the European Commission. The duration of this project is from March 2011 to March 2015.

The project will demonstrate a market concept that is designed for small-scale users by actively involving them in the entire process. The market concept is designed to incorporate small-scale distributed energy resources and flexible demand into the existing power system markets, balancing tools, and operation procedures. The concept allows scheduling of assets that require advance planning, and the customers will respond to the real-time price. In the course of the day the price signal is updated in real-time, i.e. every five minutes, to reflect the need for up- or down regulation due to an imbalance in the power system.

Several interlinking topics will be covered:

- Development: design and implementation of the EcoGrid EU concept covering all aspects from ICT, control systems and market concept to contract design and business cases.
- Preparation: prepare for the demonstration by getting acceptance from all involved parties, recruiting and training participants and installing and testing equipment.
- Demonstration: demonstrate the concept on a large scale with several thousands of participants over the course of two years.
- Exploitation and Replication: establish an exploitation plan and strategy for replicating the results from the specific demonstration site to other regions.
- Dissemination: ensure a broad and consistent dissemination of major project results to stakeholders and decision makers, both in the regions involved and on a Pan-European level.
- Standardisation: accelerate the standardisation process of architectures and interfaces for DER integration by drawing on results from the implementation and demonstration.

The consortium consists of 14 partners representing universities, ICT industry and consultants from Denmark, Norway, Belgium, Estonia, The Netherlands, Germany, Austria, Spain and Switzerland

The initiator of the project is Energinet.dk (The Danish TSO), and the Coordinator of the project is SINTEF Energy Research, Norway.

Specifications and technology:

- Unique market concept close to operation – 5 min. pricing
- Metering: 5 min. consumption values are collected - no control or information via meter

- Smart Controllers: appliances are controlled automatically (three industrial partners involved)
- Manual control based on available information
- Test groups (total ~2000 customers):

  Residential: reference group (~200), manual control (~500), smart controllers (~1200), Commercial / smaller industry: ~100
- Test period: March 2012-March 2014

No results are available.

4.2.9 Tempo tariff by EDF | France

Target group and objective: EDF's *Tempo* tariff is designed for private households and small business customers with a minimum capacity of 9kW. The purpose of the tariff is to encourage customers to reduce consumption during peak load periods, especially in the winter months, by defining higher prices in these periods. It was launched in 1995, and is no longer available for new EDF customers.

Description: *Tempo* combines two pricing structures in a single tariff – Time-of-Use and event pricing, resulting in a total of six price categories.

The Time-of-Use pricing structure divides each day into two price categories – a peak load period between 6 am and 10 pm (HP – Heures Pleines), and two off-peak periods between midnight and 6 am and 10 pm and midnight (HC – Heures Creuses).

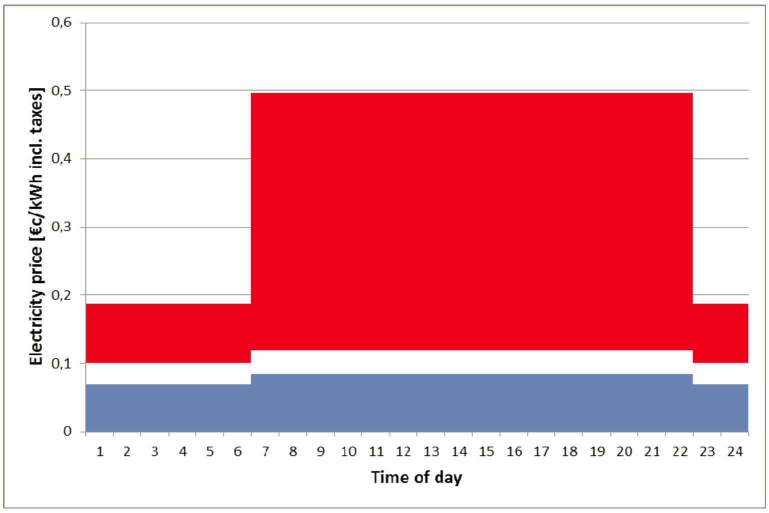


Figure 39: Tempo tariff structure (Altmann et al, 2012, 29)

The actual price/kWh for these periods depends on the event pricing structure, which assigns a "colour" for each day. For each day, one of three "colours" can apply:

- "Red" days are the most expensive and least common. Over the course of a year, 22 days will be red, all from November to March. Only weekdays can be defined as "red" - Saturdays, Sundays and public holidays are never "red".
- "White" days are less expensive and more common. There are 43 white days in the course of a year, mainly between October and May.
- There are 300 "blue" days each year. All Sundays are blue days.

The colour for each day is announced on the previous evening at around 5:30 pm. Customers can find out the colour using several methods: checking the EDF website, receiving an email or a text message, or using a special display that can be plugged into any electricity socket.

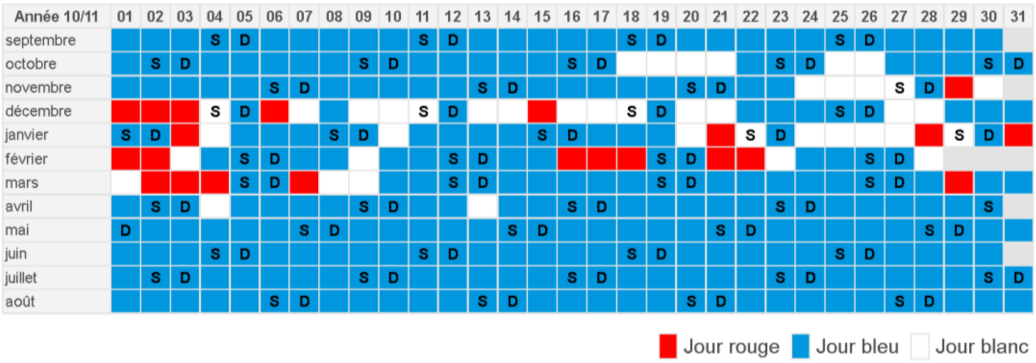


Figure 40: Distribution of red, white and blue days for the September 2010 – August 2011 (EDF, 2012)

Data requirements: in its simplest form, the Tempo tariff requires an interval meter or a smart meter for billing purposes.

Customer response: the customers can respond to the tariff by turning off appliances and avoiding consumption during peak hours, postponing the use of high-use appliances (e.g. washing machines) until off-peak times or days.

Results: compared to the lowest price level, customers have been measured reducing consumption by 15% on the second highest price level and by even 45% on the highest price level. Tempo customers have been able to reduce their electricity costs by 10% on average (Crossley, 2008, 381).

In 2008, 350,000 residential and 100,000 small business customers were subscribed to the Tempo tariff.

Assessment of service: the division of the price in three price levels seems to be well accepted by customers. As electric heating is relatively widespread in France, the potential for shifting loads is relatively high. Therefore the high reduction in load on event days is not surprising. It is remarkable that the customers keep up their reduction of load over the whole event price period. A high satisfaction level with the tariff demonstrates that the reductions in comfort are not overly dominant to the customer.

4.2.10 EnerBest Strom Smart by Stadtwerke Bielefeld | Germany

Target group and objective: the target group is the private customer group and small businesses. The purpose of the product is to encourage customers to shift loads away from peak periods. *EnerBest Strom Smart* has been on offer since July 2008.

Description: *EnerBest Strom Smart* is a variable tariff combined with a smart meter. The whole smart metering product includes an Internet portal, a time-of-use tariff and an annual bill.

The tariff uses four different price categories which apply at different times during the day and on different days of the week. Weekdays are divided into six different periods, while weekends have just two periods.

The prices for the various categories are also variable according to the total annual consumption – customers with an annual peak-time consumption of more than 7,000 kWh pay a higher annual basic fee, but benefit from lower prices per kWh in the peak time periods.

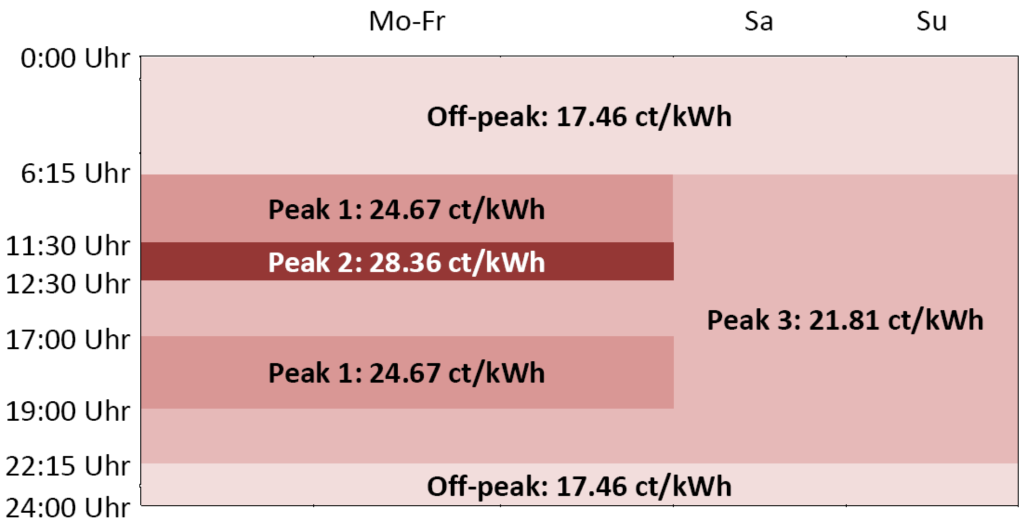


Figure 41: “EnerBest Strom Smart“ tariff by the Stadtwerke Bielefeld

Data requirements: a smart meter is required to bill this tariff. Further requirements concerning the data are not mentioned within the information. Due to the price levels and their times of validity it can be assumed that measuring at 15-minute intervals is necessary.

Customer response: the tariff is planned to motivate customers to shift loads away from more precise peak times than tariffs with just two price categories per day. The customer benefits from shifting consumption within the peak time, rather than only from one long peak period to the nightly off-peak period.

Results: the Stadtwerke Bielefeld has not published results on the use of the *EnerBest Strom Smart* tariff.

Assessment of service: the tariff shows a large price range between the lowest (17.46 ct/kWh) and the highest (28.36 ct/kWh) price, meaning that the customer has a strong incentive to shift loads from the times of high price levels into times of low price levels. As most variable tariffs in Germany use just two price categories, the four different price levels are very innovative. The tariff makes good use of the possibilities offered by smart metering, using shorter periods. The different price categories during the day mean that customers are more able (and therefore more likely) to shift consumption from a higher to a lower price category.

4.2.11 Demand Response | Finland

In Finland, there is decades of experience of the large-scale deployment of time-of-use tariffs for electrically heated houses. All the DSOs are obliged to provide two-time metering and settlement for those customers that want it. The tariffs comprise two time zones. About 1.2 GW of TOU-heating loads are switched on in the cold winter evenings as two steps. Most retailers and DSOs offer two-time-tariffs. (Morch et al., 2008).

Apart from this, plans to introduce further dynamic tariffs in Finland are not yet clear. These are seen as very interesting new products, especially for electricity suppliers and service developer companies, but utilities are still uncertain how these will work and what will they mean to their business, and how the regulation allows them to be implemented. Basically the regulation encourages new tariffs to be offered when the hourly based meters are in place, and utilities are now watching closely who will open the game.

Generally it is seen that, in order to have high customer engagement in demand response, dynamic tariffs have to be coupled with real-time information and feedback as well as automation of building systems and appliances.

Besides utility pilots, two Finnish smart home system developers are offering products and services enabling household demand response, along with information and feedback: There Corporation and Asema Electronics. These are described in more detail in their own articles in this report.

These can be very effective and deliver the largest savings and peak load reductions. Yet the technology is still quite expensive, at least for most households, compared to the standard utility smart metering and information and feedback services to be widely introduced as the national rollout progresses.

- **Target group:** residential buildings (small houses and apartment buildings)
- **Objective of the services:** energy savings and peak demand reduction through home automation
- **Description of the services offered:** a company named There Corporation develops and offers ThereGate (formerly known as the Nokia Home Control Center or HCC) that controls home automation systems. Along with exact consumption information, the system minimises energy consumption and benefits more from the ToU tariffs by automatically using less electricity at peak times.
- **Data requirements:** at least AMR, real-time connection and control to home automation.
- **Customer response, expected energy savings:** as regards the home automation systems, According to a “Response 2010” report published on 2/6/2010 by the Finland-based VaasaETT Global Energy Think-Tank, by combining smart meters with smart home automation in existing homes, householders can realistically expect to reduce their electricity consumption by tens of per cent, depending on the nature of the technology used and the customer’s own consumption behaviour. Also the report finds that such savings are possible with relatively affordable existing technology. Gas savings are also predicted to be large. More specifically, the greatest savings, up to 33% are possible at peak consumption times, through the use of substantially

higher 'critical-peak' pricing in combination with the use of home automation such as the use of home heating/cooling systems.[65]

- **Assessment of the service**: these can be very effective and deliver the largest savings and peak load reductions, but the technology is still quite expensive and usually households will not invest thousands of euros in home automation systems. Therefore, generalising these kinds of systems is harder than the less expensive "one-meter per household" systems, where the utility pays for the investment.

4.2.12 First Utility and British Gas rollouts | UK

Target group: residential and commercial buildings

Objective of the services: initially the objective is energy savings and information and feedback, (better customer care), and once the rollout has been fully done and meters operational, peak demand reduction and more suitable peak pricing through tariffs.

Services: First Utility offers two tariff prices: two rate (day and night) and three rate (morning, afternoon, night). This option is only available to customers whose smart meter has been fully operational in the home for three to twelve months, so that customers can choose the rate that suits their energy usage habits best. The utility's customer service agents are look at the usage patterns and advise on the best rate. First Utility plans to make its smart meter tariff available to the whole of the UK by the end of 2010 in partnership with Google PowerMeter.

British Gas promises new innovative tariffs and services being offered to customers. But right now, the emphasis is on information, feedback and billing.

4.2.13 Demand-based electricity distribution tariff (Sala Heby Energi Elnät AB) | Sweden

Starting time: 2006

Target Group(s): residential customers

Main aim of the project: to investigate the possibility of reducing system peak loads by means of a demand charge in the residential sector (Bartusch, 2011).

Description of the services (functionalities): as part of a pilot project the DSO Sala Heby Energi Elnät AB offered 500 residential customers a demand-based time-of-use tariff (Bartusch, 2011). The tariff was made up of a fixed access charge (€) depending on the fuse size (A) and a variable distribution charge (€/kW) calculated on the average of the five highest meter readings (kW) in peak hours. In off-peak hours the electricity distribution was free of charge. The hours between 7 am and 7 pm were defined as peak hours, while the remaining hours were referred to as off-peak hours. The rate of the tariff also varied between the summer and the winter seasons, which ranged from April to October and November to March. Additionally, there was a value added tax rate of 25% on the aggregated amount, irrespective of the distribution tariff.

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[65] http://www.vaasaett.com/2010/06/respond2010launch/

The DSO also provided a Web-based statistics services, where all households could get feedback on their electricity use the following day – providing that they had access to the Internet.

Costumer response: semi-structural, in-depth interviews were performed among 10 of the households. Among these 8 of the 10 families knew that they were charged according to the load based tariff. The informants that were aware of the pilot, had a positive attitude towards the demand-based tariff and they were familiar with its fundamental principles (Bartusch, 2011). They understood that the objective of the tariff was to use less electricity in hours of high demand in the industrial sector.

Technology used: Automatic Meter Reading

Data requirements: hourly meter data

Expected results: the shift in total electricity consumption from peak to off-peak periods reduced the demand between 8 and 9 pm in summer seasons and between 7 and 8 pm in winter seasons (Bartusch, 2011).

The households benefited economically from being charged according to the demand-based tariff as opposed to the conventional tariff (Bartusch, 2011). On average, costs of the households were 39.3% and 40.6% lower in the summer seasons and 14.8% and 19.1% lower in the winter seasons of 2006-2007 and 2007-2008 than they would have been under the conventional tariff.

Customer acceptance (if empirical findings are already available): n/a

Empirical evidence for changing behaviour (if available); How has it been measured? Semi-structural, in-depth interviews were performed among 10 of the households

Energy savings achieved (incl. date of evaluation): in the two 12-months periods after the implementation of the demand-based tariff, the electricity consumption decreased by 112 and 142 MWh, which corresponds to 11.1% and 14.2% of the total electricity consumption in 2005-2006.

Lessons learnt: the study demonstrated that households are generally sympathetic to being charged according to a demand-based tariff. Most households adjust their behaviour to the tariff's means and the most common measures are to run various domestic appliances in off-peak periods (Bartusch, 2011).

4.2.14 SmartCities | Norway

Start time: 2009

Target Group(s): residential and commercial/industrial customers in cities

Main aim of the project: the SmartCity concept is developed by Siemens, Bellona and several Norwegian municipalities. The concept consists of several measures for energy efficiency, both for commercial/industrial buildings owned by the municipality and for residential customers. Trondheim and Bergen are among the cities involved in the "SmartCities" concept.

Description of the services (functionalities): the SmartCities concept consists of several services such as advice for energy saving, campaign in schools to increase energy consciousness, reward for energy saving (for the best project), etc.

The main objective is to reduce energy consumption with use of existing technology for load control, economy bulbs, etc.

In addition all residential customers can make their own energy plan, consisting of tips for saving energy in their home.

Costumer response: in April 2012, 8170 households had made their energy plan[66].

Technology used: energy control system,

Data requirements: n/a

Expected results: energy efficiency and increased consciousness regarding energy consumption.

Customer acceptance (if empirical findings are already available): n/a

Empirical evidence for changing behaviour (if available); How has it been measured? n/a

Energy savings achieved (incl. date of evaluation): n/a

Lessons learnt: n/a

4.2.15 Energy Demand Research Project (EDRP) trials - Lessons learnt

Target group: households, utility clients selected for the trials.

Objective and description of the services: two trials (EDF and SSE) tested time-of-use (ToU) tariffs for electricity (i.e. tariffs that vary with the time of day and sometimes the season) in combination with smart meters and other interventions (advice, historic and real-time feedback, and incentives to reduce overall consumption). The trials concentrated on electricity only. (Ofgem 2011.)

Customer response and delivered results: the trials showed effects on shifting load from the peak period, with bigger shifts at weekends than on weekdays. Estimates of the magnitude of shifting effect vary with trial but were up to 10%.

The EDF trial showed that the effect is stronger with smaller households (1 or 2 people), thus providing a clear focus for where such interventions should be targeted. The effect was

[66]http://www.smartcities.no/smart-cities/

weaker in the SSE trial and this may be because awareness of the intervention was limited and it was seen as overly complex.

Neither of the ToU tariff trials involved any automation of energy-consuming appliances to facilitate load shifting. No data were gathered during the trials to provide evidence on what appliances or behaviours were responsible for the observed shifting.

The literature shows that time-of-use tariffs can also bring about reductions in total energy consumption. However, the evidence is almost exclusively from studies in hot regions (where the dominant energy demand is for air conditioning) and cold regions with electric heating. The limited evidence from the UK suggests small reductions (3% or less) in overall electricity demand and no such effect was detected in EDRP. (Ofgem 2011.)

Data requirements: half-hourly electricity usage data was used to match the consumption with prices and analyse the consumption changes. Also real-time data was offered through RTD.

Assessment of the service: although the peak shifting results were modest, these trials provide valuable information on load shifting potential and how and where it should be implemented. Load shifting seems to be at its best in heating and cooling applications with larger consumption loads, and when there is thermal storage capacity to extend the possibilities to shift loads. Also, involving smart automation to control load shifting would probably have brought better results. As mentioned in this trial, measures designed for load shifting are usually less efficient in reducing the overall consumption. To enable efficient load shifting, it should be made very simple with good customer engagement and real-time data, or alternatively, it should be automated and inconspicuous to the customer.

4.3 Direct load and consumption control services

Direct load control allows utilities to turn specific appliances on and off during peak demand periods, typically in industrial and commercial enterprises but also increasingly with residential customers using pre-defined price signals. Remote appliance controllers can manage appliances such as water heaters, pool pumps, and air conditioners. In a more sophisticated form the appliances might also be used as auxiliary services which feed electricity back into the grid depending on certain power parameters (e.g. vehicle to grid solutions, etc.).

4.3.1 "Smart house" control in housing cooperative (Market-Based Demand Response project) | Norway

Start time: 2007

Target group: a cooperative with 24 flats in Bergen, equipped with a programmable home automation system was monitored and analysed (Grande et al., 2008).

The aim of the project: the main aspects of this test were to monitor initiatives taken by the residents with regard to the utilisation of the available technology options, and by that achieve a cost reduction.

Description of the service: the local DSO (BKK) offered the customers a Time-of-Use tariff based on the same principles as in the pilot presented in Chapter 4.2.2 (in this case with an

Energy Peak payment of EUR 11/kWh)[67] valid from 7 -10 am and 5 – 8 pm on weekdays). All customers had hourly metering of their electricity consumption and were advised to have an hourly spot price contract with the supplier.

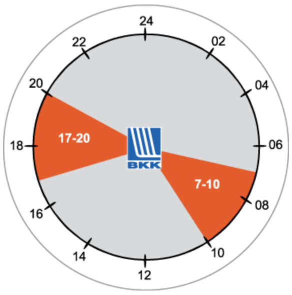

Figure 42: "El-button" Sparresgate (Grande et al., 2008)

To remind the customers of the peak load period, each customer received three magnetic tokens “El-buttons”[68].

Customer response: the feedback given in meetings and in a questionnaire was in general positive. The most used functionality was an “absence-button” which turns all electric appliances into a saving-mode when people leave the flat.

Technology used: automatic meter reading and programmable home automation system.

Data requirements: hourly metering of electricity consumption

Results: the electricity consumption of the 24 customers was metered on an hourly basis and analysed. An average demand profile for weekdays was calculated for November 2006 (before the tariff was introduced) and February 2007 (after the tariff was introduced) (see Figure 43). The peak load periods are presented in the figure. The calculations are not corrected based on differences in outdoor temperature.

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[67] VAT excluded

[68] Note that the layout of this button is different from the one used in the Malvik pilot. In this case a 24-hour clock is used. There were, however, no indications with regard to which layout was the best.

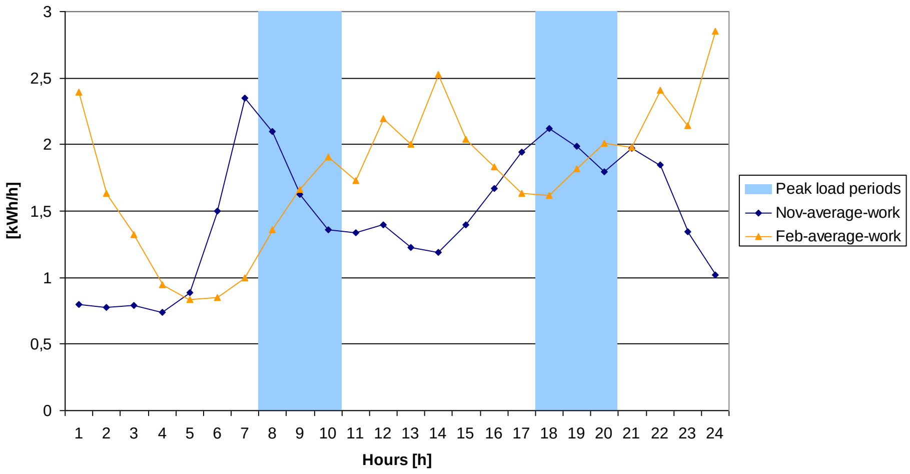

Figure 43: Average consumption for all customers (weekdays) (Week 47-06, Week 7-07) (Grande et al., 2008)

The registered changes in consumption pattern in February, compared to November, indicate a demand response based on the new tariff. The customers have shifted loads from the peak load period in the morning to later in the day. In November the peak load was in hour 7, but in February a large part of the consumption is shifted to the hours 12-15. In the afternoon consumption is shifted from peak load periods until later in the evening.

Different solutions for home automation have been presented in recent years, and this pilot shows that this technology can be used to reduce consumption in peak load periods and also to increase each customers' knowledge of their own electricity consumption pattern.

Customer acceptance: the pilot received positive feedback from the customers.

Empirical evidence for changing behaviour; How has it been measured? Figure 43 show that the customers have shifted loads from the peak load period in the morning to later in the day.

Energy savings achieved (incl. date of evaluation):energy savings were not analysed. The focus in the pilot was on peak load shifting.

Lessons learnt: this pilot shows that demand response/load shifting can be performed through simple means – hourly metering, hourly price incentives, token with predefined peak periods and remote load control to help the customer to secure a demand response. Combined with an energy contract with the hourly spot price included, the price signal to the customers is both dynamic and predictable.

4.3.2 Low prioritised loads controlled by building energy management in an institution (Market-Based Demand Response project) | Norway

Start time: 2007

Target group: commercial building institution (owned by Statsbygg[69]) with Building Energy Management System (BEMS) installed.

Main aim of the project: to test the demand response from introducing a Time of Day (ToD) network tariff.

Description of the service: the possibility for demand response has been tested in an institution (owned by Statsbygg[70]) with Building Energy Management System (BEMS) installed (Grande et al., 2008). In this building only electricity is used for space and water heating. The customer was offered a new ToD network tariff from the local DSO.

This ToD tariff has a part for power peak payment, which implies that only the registered power in defined peak periods (hours 8 – 11 am and 5 – 8 pm on weekdays 1 October – 31 March) are included in the settlement basis.

The Building Energy Management System is used for load control and for reducing the total consumption by rotating the turning on/off of the different loads. The load control is programmed to minimise the costs, based on the total price signal.

Reducible loads were mapped for the building, and installed power and possible duration of disconnection periods are indicated for each consumption category (Table 5).

Table 5: Reducible loads (Grande et al., 2008)

Load	Duration for period of shortage			
	Hour	Day/ Night	24 hours	Month
Roof heating (16.0 kW)	X	X	X	X
Under floor heating (14.4 kW)	X	X	X	X
Engine heater (20.0 kW)	X	X	X	X
Electrical water heater (for showers) (4 x 15 kW)	X	X		
Electrical water heater (15 kW)	X			
Kitchen (20.0 kW)	X			
Electrical heater cables in the floor in the shower/cloakroom	X	X	X	(X)
Ventilation	X			
Electrical panel heaters (18 zones)	X	(X)		
Indoor swimming pool (60 kW water heater + 60 kW ventilation)	X		X	X

The swimming pool is the largest load in the table, and the loads related to the swimming pool are marked with grey.

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[69]http://www.statsbygg.no/System/Topp-menyvalg/English/
[70]http://www.statsbygg.no/System/Topp-menyvalg/English/

Customer response: n/a

Technology used: automatic meter reading and Building Energy Management System (BEMS)

Data requirements: hourly metering of the total electricity consumption

Results: the demand response achieved after introducing the new tariff is illustrated in Figure 44 and Figure 45.

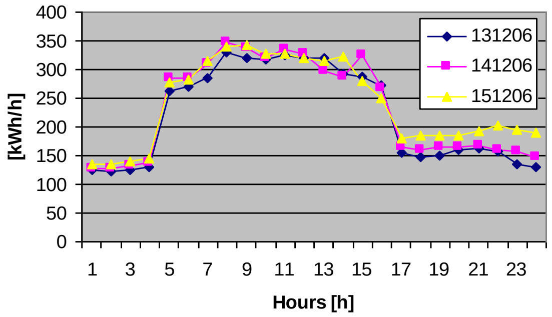

Figure 44: Consumption BEFORE introduction of power tariff (13-15 Dec. 06)

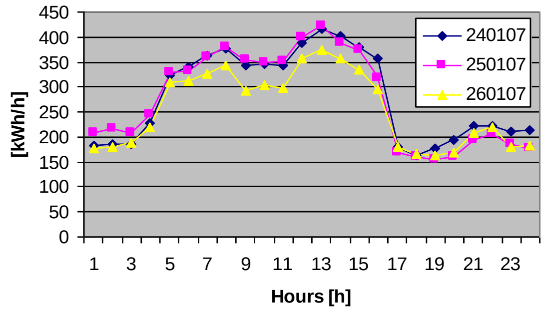

Figure 45: Consumption AFTER intro-duction of power tariff (24-26 Jan. 07)

A considerable change in the consumption pattern is visible, especially for those hours where the power peak payment was effective. The difference in the level of consumption in the two figures is due to differences in outdoor temperature. The demand response performed using BEMS resulted in a reduced consumption in peak load hours of about 50 kWh/h.

Customer acceptance: n/a

Empirical evidence for changing behaviour (if available); How has it been measured?: The demand response performed with use of BEMS resulted in a reduced consumption in peak load hours of about 50 kWh/h.

Energy savings achieved (incl. date of evaluation):n/a

Lessons learnt: this pilot shows that demand response/load shifting can be performed through simple means – hourly metering, hourly price incentives (Time of Day power tariff) and existing Building Energy Management System.

4.3.3 Low prioritised loads controlled by building energy management in a shop (Market-Based Demand Response project) | Norway

Start time: 2008

Target group: commercial building (shop)

Main aim of the project: to test demand response for a large customer – with use of an energy contract with the spot price on an hourly basis.

Description of the service: the customer utilised the Building Energy Management System (BEMS) to adapt his consumption to the expected spot price variations over the day.

For a customer with hourly metering and settlement of the electricity consumption it will always be profitable to reduce the consumption in peak hours (Grande et al., 2008).

A histogram showing which hours the maximum and minimum spot price which occurred in the period from 20 Nov. 2006 to 16 Nov. 2008 is presented in the figure below. The maximum price occurred in hour 9 in 140 days, and the minimum price occurred in hour 4 in 264 days. The largest price difference between night and day for the NO2 price area in Norway was EUR 12.29/kWh[71].

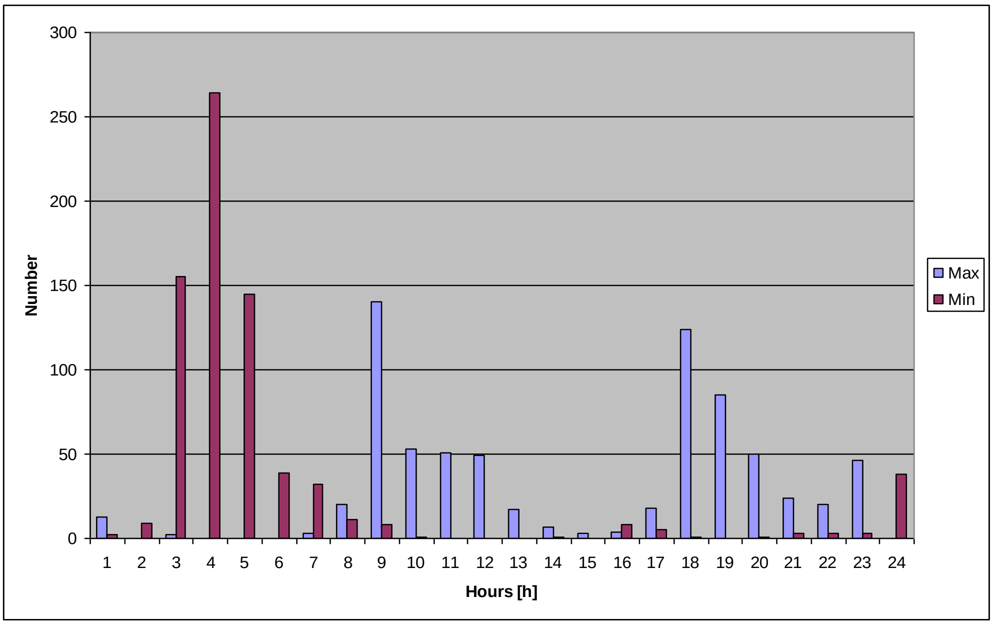

Figure 46: Histogram for the maximum and minimum of the spot price during the day (NO2) (Source: NordPool) (Grande et al., 2008)

Customer response: n/a

Technology used: automatic meter reading and Building Energy Management System (BEMS)

Data requirements: hourly metering and hourly settlement of the electricity consumption.

Results: an example of demand response at the shop is presented in Figure 47. The darkest curve represents the demand the week before the actions were activated (week 20). No actions were performed during the first 3 days of the week 21 (2008), and for these days a peak occur when the shop is starting up in the morning.

[71] In this calculation hours 7-20 are defined as “day” and the rest of the hours during the day are defined as “night”. The calculation is valid both for weekdays and weekends.

Actions for demand response were performed during the last 4 days of week 21 (2008). For these days the “traditional” peak is removed from the start-up in the morning. This was a consequence of switching the appliances for heating on earlier than before, and then switching them off when other appliances were started. The heating was on from 5.30 am – 7.30 am and 9.45 am – 8.00 pm. (The first day of week 20 was Whit Monday and the shop was closed.)

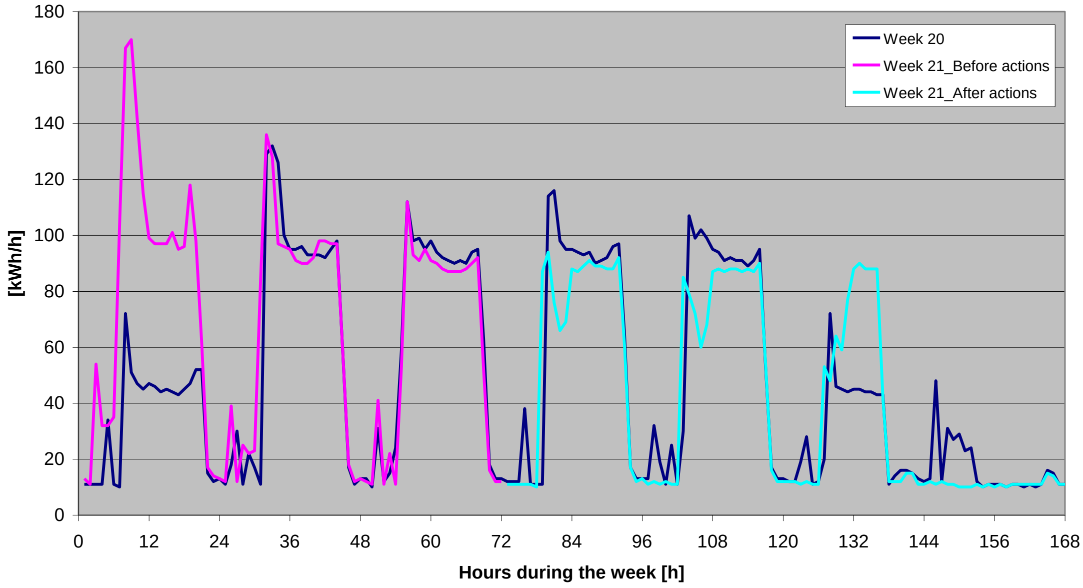

Figure 47: Electrical consumption before and after actions for demand response (Week 20 and 21 – 2008) (Grande et al., 2008)

Customer acceptance: n/a

Empirical evidence for changing behaviour (if available); How has it been measured?
The reduction of peak load in the morning for week 21 is presented in Figure 47.

Energy savings achieved (incl. date of evaluation): n/a

Lessons learnt: this pilot shows that demand response/load shifting can be performed through simple means – hourly metering, hourly price incentives (spot price) and existing Building Energy Management System.

4.3.4 Control of direct electrical heating and water heaters in family homes (MarketDesign) | Sweden

Start time: 2004

Target group: residential customers with direct electrical heating connected to Jönköping Energi (the local DSO).

Main aim of the project: to verify the controllable load of the direct electrical heating at various outdoor temperatures, the controllable load of water heaters and also to evaluate how customers are affected by load control during cold weather.

Description of the service: Sweden has around 300,000 family homes with direct electrical heating. Previous research for load control has shown a potential for load reduction of 4-5 kW per family house, with outdoor temperatures of -10 – 15 °C. This does not include the water heater. This represents a technical potential for load control of direct electrical heating of 1,500 MW.

Agreements were signed between Jönköping Energi and 50 customers to participate in the project. The deals were accepted and set to a low level of compensation – EUR 33 per annum. The customers were grouped under the same network station and the installed measuring equipment carried out readings at 6-minute intervals.

By utilising remote control, electrical heating was reduced by 67% between 8-10 am in five instances. These were set to days when the outside temperatures were expected to be at their lowest. On one such instance, 22 January 2004, the outside temperature at the time of reduction was –15°C.

Customer response: one result from the trials has shown that the installations carried out in the early 1990s still work and the load control during the winter of 2003/2004 showed an average controllable load of 4-5 kW per small family size house at -10 to - 15°C. No customers complained about the heating following the controlled incidents.

Technology used: automatic meter reading in substation, in 6-minute intervals

Data requirements: to implement this service only technology for remote load control is necessary, but measurement on a customer level will make it possible to provide information about the response for each customer.

Results: the measurements performed in a substation with 200 households connected are presented in the figure below. 50 of these 200 customers took part in the trial. (The load increase at 10 pm is due to tariff control for several of the water heaters.)

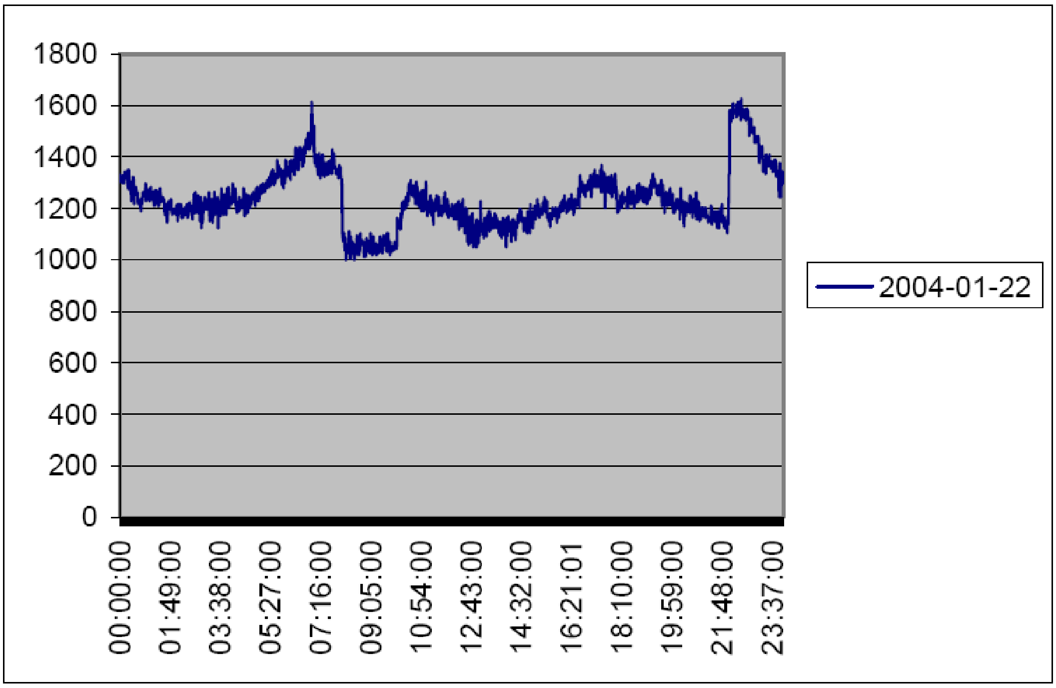

Figure 48: Control on 22 January 2004. Outside temperature -14.6 °C. Controlled load approx. 280 kW. Remote control performed between 8-10 am (Lindskoug, 2006)

In this trial the total demand was only measured in the substation – for 200 household customers in total, from which 50 participated in the trial. No measurements were performed at customer level. With measurement on the customer level, it had been easier to analyse the response per customer, and not on average per customer.

Customer acceptance (if empirical findings are already available): n/a

Empirical evidence for changing behaviour (if available); How has it been measured? By utilising remote control, electrical heating was reduced by 67% between 8-10 am in five instances.

Energy savings achieved (incl. date of evaluation): n/a

Lessons learnt: the pilot shows that households with electric heating and water heaters have a large potential for demand response through remote load control. With hourly metering of the consumption the customers could have increased incentives for demand response.

4.3.5 Ripple-control system by various DSOs | Czech Republic

Target group and objective: the Czech ripple control system was developed by CEZ, E.OM and PRE over several decades. Its purpose was to optimise grid load control and shape the residential demand profile to match the suppliers predictions (McKenna et al, 2011, 3). The target group were customers with night heating or water boilers.

Description: in the Czech Republic double-tariff products on the market have been made possible by using two traditional meters. For a limited amount of customers with accumulated night heating or water boilers, remote ripple-control systems or long-wave radio are used to control the load. These systems were installed in the 1970s, but since the deregulation of the Czech energy market, the ripple-control system has been operated by local electricity distributors. As they are not participants on the electricity market, the system is not being used to its full potential. The possibility of replacing this demand side management with smart metering-based technologies is being evaluated (ESMA, 2010, 48).

Data requirements: no data required.

Customer response: there is an automatic response by night heating devices and water boilers.

Results: the load connected to the ripple-control system accounts for up to 2,500 MW. This represents about 10-15% of the maximum grid load on winter days. In 2009 there were around 1,150,000 ripple control receivers installed in the Czech Republic.

Assessment of service: the ripple-control system does not depend on smart metering data. Nevertheless, the service is quite widely spread and accepted in the Czech Republic. This fact could be beneficial to any attempt to build-up a load control system based on smart metering.

4.3.6 Direct load and consumption control services| Finland

Up until the early 1990's, utilities implemented direct load control with business clients. However, as the distribution and sale are unbundled this has become harder. Currently it is seen as undesirable and even illegal for the DSO to control the load if e.g. the electricity supplier requests this, even if it is based on a contract with the customer. Currently only heavy industry is doing load control to minimise their energy prices.

Yet load control issues are studied, and saving power capacity, money and emissions through peak load reduction is seen as a very interesting option, and also a possible business area (e.g. load savings bundled and sold forward to utilities thus avoids investments in new capacity). E.g. in a pilot for electric heating (which covers altogether 600,000 apartments in Finland), the common controllable power for 6,133 houses was found to be 20 MW on cold winter days.

4.3.7 Market-based electric heating load control with smart meters (ENETE-project) | Finland

Target group: mostly residential buildings, with water-circulated, full storage electric heating system, with a possibility of supplementing it with other heating methods

Objective of the services: shifting electric heating load to use the lowest priced times in the night and, therefore, to reduce peak electricity demand and the average price of electricity paid. In addition, when introduced at national level, the service also has the potential to lower the electricity system price and emissions from coal and peat using peak load production.

Description of the services: the developed model consists of a centralised load shifting service utilising remotely read meters. Data is used for controlling and shifting the next 24 hours electric heating load in order to use the lowest priced times in the night, on the basis of day-ahead market price. The heat demand is determined as a linear function on the basis of the average temperature of the previous 24 hours.

The system was piloted in the Helsinki area Helen Electricity Network, whose current metering systems, equipment and controlled night-time product were used as a test platform.

The objective was to have no need for separate equipment or system acquisitions by the DSO or the customer. The sites have a water-circulated, full storage electric heating system, with the possibility of supplementing it with other heating methods.

The input powers of the systems vary between 20 and 50 kW. The ripple-like control based on heat demand was replaced with the new system.

The entire load of the system is transferred behind a single control:

- The load control model enables automatic and inconspicuous control of electricity use for the customer.
- Moreover, the system can be also be complemented with features through which the electricity user may participate in the load control (e.g. by reducing or widening the pre-defined time frame for the load control).

The system was introduced during 2010 in eight metering pilot sites of Helen Electricity Network, and system testing continued in the heating season of 2010 - 2011. (ENETE-project 2010.) The aim is to expand the load control system to cover the whole Helsinki are in 2012 (Seppälä, 2011).

In principle, the service can be also applied to control electric cooling peak loads in regions with large cooling needs.

Data requirements: hourly remote metering with two-way data transfer connection, a load control functionality, and connected controllable electricity heating load, i.e. full storage heating systems such as water circulating heating systems, and heating systems with supplementing heating methods.

The current smart meters introduced in Finland have all the features needed for this service. Also, two-rate time-of-use tariff sites (electrically-heated houses) often have some connected controllable load. Thus the current systems can be harnessed and there is no need for separate equipment or system acquisitions by the DSO company or the customer.

Customer response: no response known yet, but the system is essentially automatic and inconspicuous to the customer.

Expected and delivered results: the load control service model has been tested and found feasible. A well-functioning information exchange model has been developed and has shown that current processes and new smart meters can be used to implement a load control systems based on the electricity market price.

In the Helsinki region alone, there is around 120 MW of controllable load.

The benefits gained from load control are substantial compared with its investments, and can be further improved by optimising the time frame of heating with respect to each metering site. The development cost of the load control system was € 2.000. The annual costs of data transfer are in the region of € 0 - 1 per metering point, depending on the DSO’s service and data transfer medium.

According to earlier studies, transferring the storage heating of controlled night-time sites in the Helsinki region to the cheapest hours of the 24-hour period would bring a benefit of EUR 100,000 per year compared with the current control when only the price of electricity according to the spot price is examined. The relative benefit in the costs of energy use, achieved on the basis of simulations, would be 3–15% depending on the heating system of the site. Over a period of ten years, the theoretical discounted yield on a system investment of EUR 2.000 is EUR 750,000 with a 5% imputed interest. The beneficiary depends on the pricing structure of the electricity transmission and sales product. Pilot results found that the average electricity price paid went down from €35/MWh to €31/MWh when using the load shifting service.

Macroeconomic benefits: not estimated yet. If the system can be introduced on a nationwide scale, it may also have an impact on electricity market prices, production mix and emissions at the system level. E.g. in Finland there are over 660.000 households with electric heating, of which many could be utilising this kind of service when supplied with the new smart meters.

Assessment of the service: the service has considerable potential in cutting peak load consumption. Moreover, the service is a quite simple centralised load control, which can be introduced by any DSO using modern remote reading and metering data management systems. Thus the service can be easily transferred to different DSOs and markets with controllable loads.

Further flexibility arises from the fact that the model only takes a stand on the message format in the interfaces, not on the medium that the message is transmitted with. The service provides a fully automated and effortless way for the end-user to reduce peak hour usage and save money, and also benefits the whole system. Integrating the service with other available end-user energy reporting services (information and feedback services) would be a good addition. Also, finding incentives and right pricing structures for different market actors (suppliers, DSOs, customers) is important in order to reach a broader deployment of this system.

4.3.8 Energy Demand Research Project (EDRP) trials | UK

Target group: around 58.000 households. The EDRP trials involve a range of different domestic customer types, e.g. those likely to be in fuel poverty; and a range of different billing types, e.g. those using pre-payment meters.

Some trials were specifically targeted at particular groups, aiming to determine whether certain interventions are particularly effective for those groups. However, also the trials that were not targeted at particular groups, information about income levels, payment methods, etc. was being gathered, allowing for studies of the effects of different interventions on different customer groups. (Ofgem. 2011)

Objective of the services: The EDRP is a suite of large scale trials across Great Britain between 2007 and 2010. It seemed to better understand how customers react to improved information about their energy consumption over the long-term, covering electricity and gas.

The trials are different combinations of *interventions* and explore the responses of the households. Four energy suppliers were running trials: EDF Energy, E.ON, Scottish Power and Scottish and Southern Energy. Ofgem oversees the trials on behalf of the Government.

Nearly all the trialled services (or interventions) can be described as information and feedback type.

Description of the services:

The trials included a variety of interventions, assessed either individually or in combination with each other:

- Energy efficiency advice.
- Historic energy consumption information (such as comparison of energy consumption with earlier periods).
- Benchmarking of the customer's consumption against the consumption of comparable households.
- Customer engagement using targets (commitment to reduce consumption).
- Smart electricity and gas meters.
- Real-time display (RTD) devices that show energy use (including audible usage reduction alarms).
- Control of heating and hot water integrated with RTD.
- Financial incentives (including variable tariffs) to either reduce consumption or shift energy demand from periods of peak demand.
- Other digital media for delivering information (Web, TV). These interventions are sometimes used in combinations, so it can be useful to consider themes, rather than trying to draw conclusions about individual interventions.

Customer response and results:

The following conclusions and are summarised from the EDRP Final Analysis report (Ofgem 2011).

When comparing the changes in energy consumption between different interventions, smart metering was demonstrated generally as a necessary enabling platform for behaviour change measures. While the savings were sometimes small in percentage terms, the absolute savings scaled up to national level would be substantial.

- The positive savings from smart meters depended on providing customers with appropriate additional interventions
- The provision of a real-time display (RTD) was particularly important in achieving savings in electricity consumption.
- Gas savings could be achieved through by installing a smart meter without further intervention, although evidence of persistence was not as strong as for electricity savings with RTDs.
- Advice and historic feedback on consumption can promote energy savings, but they cannot be relied upon on their own and should be combined with smart meters.

- Savings were found in combination with benchmarking against the consumption of a peer group, without smart meters.
- Financial incentives and commitment to reduce consumption, in contrast had either no effect or a very short-term effect.
- Delivery of information through the Web or customers' TVs was also not successful in reducing consumption.
- Savings were generally persistent where the trial was long enough to test this, especially electricity savings from the combination of RTDs and smart meters. In contrast, any savings from financial incentives rapidly dissipated when the incentive was withdrawn.
- Real-time feedback is more relevant to electricity consumption than to gas. Applications of gas tend to be subject to occasional adjustments having long-term effects, which are less amenable to influence by real-time feedback. (This can be also considered with other heat sources such as oil or district heat).

All in all, these results point towards the fact that just providing smart meters does not save energy and the effect of RTDs (or in-home displays) can and should be supported with other services. To gain behaviour change, one must pay attention to advice and communication - the interaction with customers and how the meters, displays and other services are explained to customers. Also, the savings seem to be persistent when the feedback (or intervention) is persistent, yielding long-lasting behaviour changes.

Savings are not guaranteed simply by implementing a particular type of intervention or service, and the EDRP results list the following points that need to be considered when designing smart metering schemes.

- *To maximise the impact of smart meter and RTD*, further information, advice and prompts are likely to be required.
- *RTDs should be installed ready for the customer*, and also guidance should be provided on how to access and use the information they provide
- *Customers need to know what to do*: what means should be deployed to save energy.
- *Quality matters*: information needs to be clear, easily seen amongst other material sent, presented in an attractive way, relevant and timely and kept up-to-date as the options for action change
- *Quantity matters:* provide sufficient information and avoid information overload. For example, regular small nuggets of information appear to be more effective.
- *Tailored information can be the most effective*: the literature suggests that the more closely an intervention can be tailored to particular households or individuals, the more effective it is likely to be. E.g. Web portals have potential for this.
- *Quality, quantity and tailoring of interventions are relevant to all points in the customer journey:* from engaging the customer to the intervention (e.g. reading advice

or installing an RTD), to the initial impact of the intervention and sustaining actions over a longer period.

In addition to the above lessons, the EDRP progress report (March 2010) presented an interesting concept of *a cycle of learning and action* to reduce customer energy consumption, which should be taken account when designing smart metering schemes:

- feedback to customers about energy consumption,
- advice to customers about how make savings,
- and motivation for customers to implement savings.

Data requirements: differing, as depending on the trialled intervention. In the case of smart meters, the meter readings were sent in daily to monthly intervals. The RTD received its real-time data from the smart meter or via clip-on connection to electricity supply.

Your assessment of the service: the EDRP provided a large-scale, versatile and long term set of trials, and its results can be used across Europe. It provided knowledge on implementing large-scale rollouts, and more importantly, gave significant information on how domestic customers react to different kind of information and feedback on their energy consumption over the long term.

4.3.9 Energy saving by load curve monitoring

Start Time: 2010

Target Group: Tertiary sector, building, Santander Festivals Palace

Main aim of the project: The company CLECE, energy services provider, offers its customers the real-time demand monitoring with the aim of detecting the consumption peaks and other load curve particularities, discovering great consuming equipment and modifying their behaviour to save energy.

Description of the Services: the service consists of the replacement of the company meter (normally rented) by a smart meter with higher performance owned by the customer. This situation, in which the meter becomes owned by the user is very uncommon in Spain.

Once the electricity meter is replaced by a **meter with communication output for the user**, it is possible to get real-time data collection, for energy consumption on a quarterly or hourly basis, demanded power, intensity, etc.

With this service, energy savings as a result of certain equipment operation improvement are detected, a “daily virtual bill” about the energy consumption is generated and the user can look up a ”monthly virtual bill” before the electricity supplier sends the real bill, avoiding invoicing mistakes. Likewise, with this system the energy consumption is improved and the contracted power is reduced.

The service also includes a software installation which allows email notifications generation in order to have a permanent checking of consumptions and other main data.

Customer response: correct operation of the equipment and detection of consumption failures is easy through alarms generated in the monitoring system. Electricity contracting is adjusted to real needs.

Data requirements: 3-phase meter and registration device CIRCUTOR CIWATT (electricity measurement and registration)

CIRCUTOR Power Studio Scada monitoring system

Customer acceptance: the customer reacts positively, because the offered energy service is adapted to various parameters such as the consumed energy cost and the demanded power.

Empirical evidence for changing behaviour (if available); How has it been measured? The ESCO company confirms the change of behaviour due to energy and economic savings are needed in this kind of project.

Energy savings achieved (incl. date of evaluation):the new system with an increase in the maintenance dedication and quality control is leading to 15-20% energy savings, and it is expected that this can increase.

Lessons learned: smart metering combined with efficient services provided by an ESCO, which also assumes the maintenance role and maybe investments in efficient equipment, lead to important energy savings which are sustainable over the years.

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6 List of figures

7 List of tables

8 Abbreviations

AEA	Austrian Energy Agency
AMR	Automatic Meter Reading
AMM	Automatic Meter Management
BEMS	Building Energy Management System
BM	Balancing Market
CFEA	Benet Oy / Keski-Suomen Energiatomimisto
DA	Day Ahead (Market)
DC	Demand Charge
DER	Distributed Energy Resources
DP	Fixed Price
DSO	Distribution System Operator
EnCT	Research Group Energy & Communication Technology GmbH
ESCAN	ESCAN S.A.
EV	Electrical Vehicles
FWR	Fixed price With Return option
ID	Intra Day (Market)
ISPE	Institutul de Studoo so Proiectari Energetice
JI	Jyväskylä Innovation Ltd
KAPE	Krajowa Agencja Poszanowania Energii S.A.
MBDR	Market Based Demand Response
NLA	Agentschap NL
PLC	Power Line Carrier
PV	Photovoltaic
RES	Renewable Energy Sources
RLC	Remote Load Control
SINTEF	Sintef Energi AS
SVP	Standard Variable Price
ToD	Time of Day
TSO	Transmission System Operator
UPB	Universitatea Politehnica Din Bucaresti

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