SmartRegions

European Smart Metering Landscape Report

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INTELLIGENT ENERGY EUROPE
FOR A SUSTAINABLE FUTURE

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Overview

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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 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 the installation of meters but to do so with the goal of achieving energy savings and/or peak load shifting.

(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.

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. Denmark, Finland, France, Ireland, Italy, Malta, The Netherlands, Norway, Spain, Sweden and the UK are part of this group.

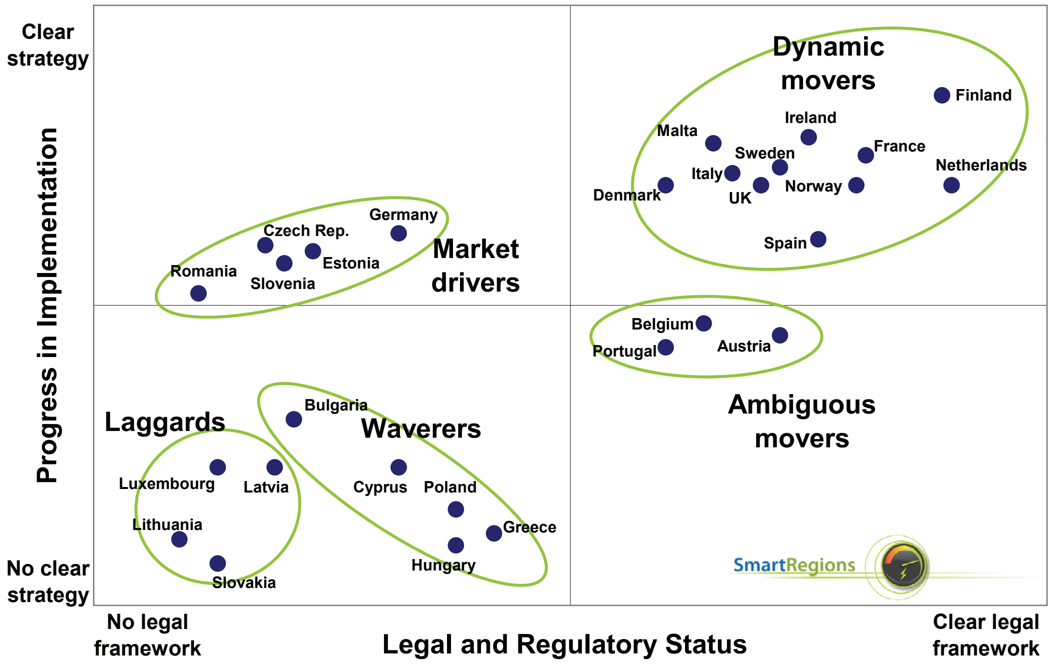
2. The "***market drivers***" are countries where there are no legal requirements for a rollout. Some DSOs or legally responsible metering companies nevertheless go ahead with the installation of electronic meters either because of internal synergetic effects or because of customer demands. We classified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

3. Austria, Belgium and Portugal ("***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 Bulgaria, Cyprus, Greece, Hungary and Poland in this group.

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

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



As to **smart metering services** in Europe there is a wide range of feedback tools available to energy utilities and consumers 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 final customers are key to achieving actual energy savings from the alleged saving potential.

Even though it is contested by the literature as to the 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 final 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 the real 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 to the consumers.

Only metering services will provide added value to the consumers.

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. 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 programs show promising results with very little intervention. This report summarizes trials that are completed 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	According to the new Electricity Act (ElWOG 2010), the Minister of Economy may introduce smart metering per decree, following a cost-benefit-analysis. The regulator may define functionalities and data requirements of a smart metering system. A first draft of meter functionalities is available.	Some network operators install electronic meters although there is no legal framework yet. EnergieAG has installed 10,000 meters and has plans to install another 100,000 in the near future. LinzStrom has decided to rollout for its 240,000 customers. Some other operators have pilot projects with some hundreds of installed meters, but there are no official plans for a full rollout from these network operators.
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.	The focus in Belgium is on technical tests of the meters and the communication technology. A number of pilot projects are in progress or in preparation (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 plans of a complete rollout of 2.5 Mill. electricity and 1.5 Mill. 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 evolution of smart metering markets. With transposition of Directive 2009/72/EC there is an amendment expected to the energy law by the end of March 2011.	The DSO of Cyprus started a pilot project in July 2010 with 3000 smart meters. The goal is to publish a cost and benefit analysis report by July 2012. 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.
Czech Republic	There are no legal obligations concerning smart metering. However, a national rollout plan is under discussion. A cost-benefit-	Some pilot projects are in progress: E.ON Ceska with 400 metering points, ČEZ Mereni with around 2,000 meters. ČEZ

Member state	Legal and regulatory status	Implementation status
	analysis in 2006 led to a negative result (ERGEG, 2009, 25).	announced a multi-energy pilot including 40,000 meters, feedback to customers and data acquisition for a cost-benefit-analysis. ČEZ plans a rollout with 1 Mill. meters by 2015.
Denmark	There is no legal framework for the provision of smart meters for household 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 performed and a number of DSOs install electronic meters even without legal requirements. Of a total of 3 Mill. metering points in Denmark, by 2011 approximately 50% will have remote reading (ESMA, 2010). Demand response is one of the main drivers.
Estonia	There are no legal obligations for a rollout for smart metering yet. However, a large-scale rollout is under discussion. Establishing requirements for smart meters is part of the Estonian NEEAP (2006/32/EC).	About 2% of all customers already have an electronic meter and minimum requirements for meters are defined (ERGEG, 2009). Distribution networks have plans to invest into smart metering infrastructure. The dominant DSO OÜ Jaotusvork is planning a major roll-out (680 000 meters) to be implemented in 2011 – 2017.
Finland	Electricity Market Act (66/2009) demands 80% smart meter penetration by 2014. The regulator defined minimum functional requirements for the metering system.	Well over 1 Mill. electricity meters are installed (around 2 Mill. are left to be installed). All network operators have started their rollout. 50% of district heating meters can be remotely read.
France	Legislation is in preparation for a mandatory rollout. The goal is from January 2012 to only install electronic meters and have a 95% coverage by the end of 2016. This goal was enforced by a government decree in August 2010. The regulator defined some guidelines and minimum functional requirements for electricity meters. A cost-benefit-analysis with a positive result was presented in 2007. The rollout of gas smart metering is under discussion.	In mid 2008 ERDF and Atos Origin announced a pilot test with 300,000 smart meters and 7,000 concentrators. The pilot will be conducted in the regions of Tours and Lyon. By the 20th of September 2010, over 47.000 AMM meters have been commissioned.
Germany	A mandatory rollout is not planned. Germany follows a policy driven by customer demand. The metering service is liberalised. The national legislature (EnWG 2009) only demands to install smart meters in new buildings and buildings that are undergoing major refurbishing from the beginning of 2010. By 2011 electricity suppliers have to offer load-variable or time-of-use tariffs. Minimum functional requirements are not available. A cost-benefit-analysis has not been carried out yet.	Some pilot projects are in progress. However, due to the unclear legal situation, the majority of the energy suppliers wait and see. The incentives for DSOs or metering service companies to invest are small. In early 2010 only 15 of about 800 utilities offered smart metering products. Smart meters trigger additional costs for customers, thus only customers with medium or high consumption may benefit from smart meters. Neither the market nor regulation is a major driver.
Greece	Greece is proceeding to a rollout of electricity smart meters and has adopted a legal framework (Article 15 of law 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	The dominating Public Power Corporation (PPC) has plans to install 60,000 smart meters in large end customers of low 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 the water and the natural gas consumption are

Member state	Legal and regulatory status	Implementation status
	been announced yet.	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. Yet 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	A National Smart Metering Plan is in place, the regulator (CER) started consultation process on a rollout strategy and functional requirements for electricity and gas (ongoing). A cost-benefit analysis will be available in March 2011 and will inform about the decision on a possible rollout.	The regulator (CER) initiated a major pilot project with network operators to acquire technical experience and test around 6,000 customers (households, SMEs) on how they react to additional feedback (four test groups with frequent billing, displays, time of use tariffs, etc.). Technology trials were completed in September 2010. The results of the trials will feed the cost-benefit-analysis.
Italy	The installation of remotely readable electronic meters is mandatory. Minimum functional requirements are available. Focus of metering system is on reduction of non-technical losses, not on energy savings.	Rollout started in 2008 and by the end of 2011 95% of 36 million customers will have received electronic meters. No additional feedback to customers is currently available, the system was design for DSO requirements.
Latvia	No legal framework is in place, the installation of smart meters depends on the activity of DSO. No cost-benefit-analysis. The current monopoly situation is not encouraging.	Latvenergo (dominant DSO) prepares a concept for rollout. Conventional meters are step by step replaced by electronic meters (not necessarily AMM). 10,000 meters are already connected to AMR system (7,000 of them are industrial clients). However, monthly self reading is still predominant.
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 pilot phase. In 2010 Enemalta launched a rollout plan to replace all electricity and water meters of 245,000 customers by the end of 2012. However, significant billing problems caused public protests and the government in November 2010 to start an investigation on the work of the revenue management service company.
Netherlands	Dutch Parliament adopted legal framework for voluntary installation of smart metering in November 2010. Customers may choose between four alternatives (from	A two-year pilot phase will be carried out in 2011–2012. Following an evaluation of the results a 6-year rollout phase could start in 2013. A multitude of pilot projects has been

Member state	Legal and regulatory status	Implementation status
	keeping conventional meters to full AMM). Privacy concerns dominated public discussions. Smart meters need option for "administrative off" and port for decentralised metering services (real-time feedback with data remaining in the house, etc.). An updated cost-benefit-analysis and functional requirements are available.	performed (Alliander, Oxxio, etc.).
Norway	Currently, hourly metering is required for large customers only. A proposal for a full rollout and functional requirements was postponed in late 2009 in order to wait for European standards. In January 2011, the Ministry of Petroleum and Energy asked the Norwegian regulator to submit a proposal for earlier installation of smart metering technology in Central Norway by 2013 and a full rollout by 2016. A discussion document is published in February 2011.	Some DSOs have installed AMR technology to all customers for weekly meter readings. Pilot projects have been completed or are in progress. DSOs are awaiting final requirements from regulator to start with investments. 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 substitution plan started with a pilot phase in 2010. A consortium led by EDP Distribuição started the project InovGrid. Around 50,000 smart meters will be installed in several points of the country (no geographical concentration). EDP also presented in 2010 the project InovCity for the city of Évora with 30,000 meters. Customers receive near real-time consumption information.
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.	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.
Slovakia	There is currently no official strategy, legal framework or cost-benefit-analysis available. A possible rollout is in discussion.	DSOs gradually install smart meters on 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 about 80,000 customers in 2011. Other companies have not decided about a rollout yet, but some of them are also running pilot projects. Since 2008 all industrial customers are quipped with AMR-systems.
Spain	The energy act of December 2007 includes a meter substitution plan for household electricity meters for the period until the end of 2018. A set of functional require-	Endesa has installed 22,000 meters in Andalusia (within the framework of the "smart city" project) with a target to install 13 million meters by the end of 2015.

Member state	Legal and regulatory status	Implementation status
	ments is available. A cost-benefit-analysis has not been performed yet.	Iberdrola has started with the installation of approximately 200 units in the city of Castellón with the goal of installing 100,000 meters.
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. 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.	By 2009 nearly all final customers had remotely readable electricity meters. However, only about 750,000 meters (mainly for larger customers) can perform hourly metering and data handling. Further 3.9 million meters require some investments to increase reading frequencies for demand response and load shifting projects.
UK	Mandatory rollout for larger customers until 2014 (electricity & gas), mandate in place for domestic electricity & gas rollout until 2020. The main energy suppliers, rather than distribution networks, are responsible for the rollout. In December 2009, DECC published an impact assessment for the domestic sector and estimated costs of about £340 per household in the preferred central communications market model. Total costs for £8,6 bn are relative to £14,6 bn of savings in the operational costs of energy companies and lower bills for customers. In July 2010, the government published the smart metering prospectus outlining the rollout strategy. Minimum requirements for meters and displays are proposed but not yet finally decided.	The regulator (Ofgem) initiated the Energy Demand Research Project (EDRP) with around 58,000 households. Four suppliers (EDF, Scottish and Southern Energy, Scottish Power and E.ON) installed smart meters, in-home displays, financial incentives and other feedback mechanisms. A final report is expected in 2011. Some suppliers (British Gas, First Utility, nPower) have already begun installing smart meters including customer response trials.

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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 ongoing 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 co-ordination 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 liberalization process with the transposition of the Directives 96/92/EC and 98/30/EC in the late 1990s, most European energy markets could be characterized as local monopolies. Energy consumers were dependent on the local (city or regional) electricity or gas distribution company to purchase their electricity or gas. These companies were characterized 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 consumers via agreements that are realized 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 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 ongoing 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 final 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 is to ultimately 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 same user category;
- contact to consumers' 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 in which frequency. 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 as 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 the use of electricity by, for example, introducing intelligent metering systems or smart grids.

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[1] OJ L 211, 14.8.2009

Annex I(1)(i) states that consumers 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 measures on consumer protection as listed in Annex I, Member States shall ensure the implementation of intelligent metering systems. The implementation of those metering systems “may be subject to an economic assessment of all the long-term costs and benefits to the market and the individual consumer or 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 rollout of smart meters is assessed positively, the Directive on internal market demands that at least 80% of consumers 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 consumer protection measures and provided direction 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 final 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 consumer 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 allow a consumer to regulate her or his consumption.

As to 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 consumers 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 those groups of the total number of final customers that have an overall net benefit from the introduction of intelligent metering systems. Only from this group 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 consumers 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.

2.3 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 means to modernise electricity grids and improve the information that is available for grid operators. The modernisation of the electricity grids is 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 consumers 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 await the results of these various working groups and task forces, some actively move towards smart metering and start with a rollout independent of existing barriers to the deployment of smart grids.

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

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

[3] OJ L 153, 18.6.2010.

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 the installation of meters but to do so with the goal of achieving energy savings and/or peak load shifting.

(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.

According to these two dimensions we arranged all countries 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. Denmark, Finland, France, Ireland, Italy, Malta, The Netherlands, Norway, Spain, Sweden and the UK are part of 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 the installation of electronic meters either because of internal synergetic effects or because of customer demands. We classified Estonia, Germany, Czech Republic, Slovenia, and Romania in this group.

3. Austria, Belgium and Portugal (“***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 Bulgaria, Cyprus, Greece, Hungary and Poland in this group.

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

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

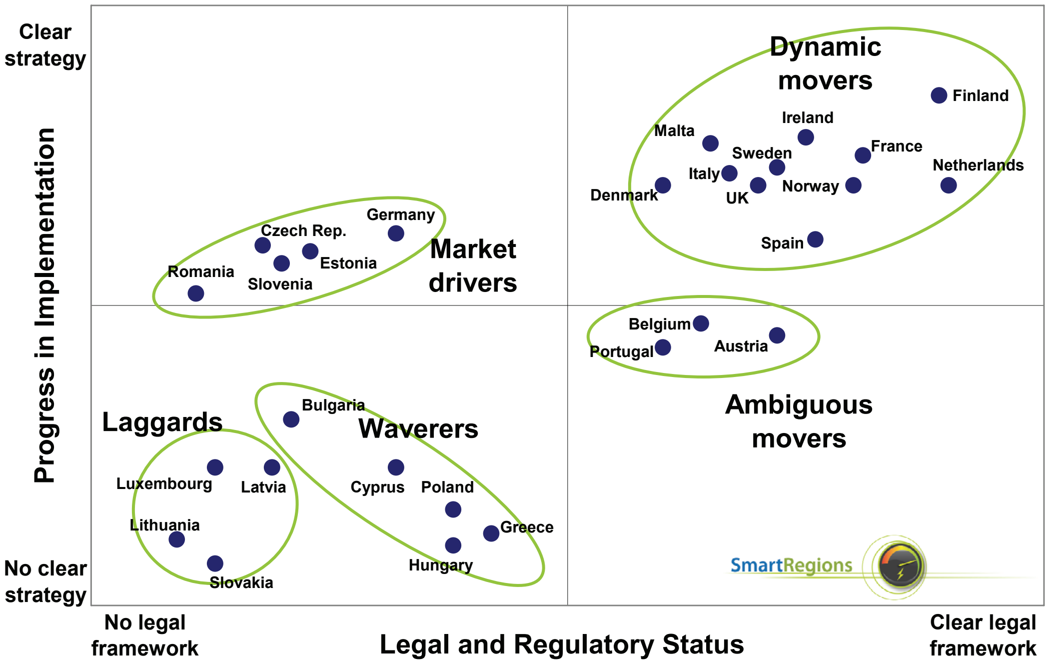

Figure 1: Regulation and implementation of smart metering in Europe

3 Legal and Regulatory Framework for Metering Services

3.1 Austria

3.1.1 Policy objectives for the introduction of smart metering

From the Austrian Energy Regulatory Authority's point of view, the main drivers for smart metering are correct billing based on currently metered data, better customer information that could increase energy efficiency and more efficient work processes for network operators and other market participants.

The topic has been under discussion for some years, with the network operators holding a position quite different from the regulator's. There are serious concerns regarding the costs of smart metering and the feasibility of smart metering systems in general. There are negotiations between the regulator and the network operators regarding the consideration of smart metering implementation costs in the network charges.

Suppliers do not play an active role in the public discussion regarding smart metering. So far, no supplier has official plans to offer new tariff models (e.g. time of use tariffs).

On 30 November 2010, Austrian parliament passed a new national Electricity Act[4] which authorizes the responsible minister (Ministry of Economy) to introduce smart metering in Austria, following a cost-benefit analysis.

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 effect strong national economic benefit. However, the study is controversial and was contested by network operators and independent institutions. It is unlikely that this study is sufficient to fulfil the requirements of Directive 2009/72/EC.

3.1.2 Legal foundation of smart metering services

The new electricity law provides a legal basis for the introduction of smart metering in Austria. Until then, only large consumers with an annual consumption of more than 100,000 kWh were equipped with at least electronic meters which allow automated meter reading.

The new national Electricity Act (ElWOG) contains general regulations for the national transposition of the 3rd energy package of the EU (Directive 2009/72/EC). The Electricity Act as passed by parliament on 30 November 2010 contains the following key points regarding smart meters:

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

- The Minister of Economic Affairs has to conduct a cost-benefit-analysis for the implementation of smart metering. Then she/he has to consult the Energy Regulatory Authority (E-Control), as well as organizations for consumer protection and the Austrian Data Protection Commission.5 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.
- 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 protections laws and consumer protection laws.
- Electricity distributors are obliged to send customers a monthly information about their actual consumption and related costs 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 new Electricity Law will come into effect in March 2011. Similar provisions are included in the Gas Law that was published as a ministerial draft in January 2011.

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 involved market participants. There are no plans in Austria to liberalize the metering business.

The Energy Regulatory Authority (E-Control, 2010) has published a catalogue with minimum function requirements for smart metering systems in June 2010. This catalogue was published for public consultation and contains the positions of the regulator regarding the requirements for smart metering. It is expected that a future decree of the regulator regarding the functional requirements of smart metering systems will contain the topics of this catalogue.

The functional requirements according to the regulator's draft catalogue suggest that smart meters

- have to comply with the national weights and measures regulation.

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

- have to be equipped with an internal clock. A calendar function must be provided by the smart metering system. There must be a possibility to synchronize the clock at least once a day.
- need a bi-directional communication-connection (Input/Output).
- must be able to measure the consumed or generated energy correctly in compliance with the operational errors limits according to the national weights and measures regulation and to save these data in the meter.
- have to save the actual meter counts, date, and time for 15-minutes-periods.
- have enough metering registers to count at least 4 different tariff-periods a day. This shall ensure that suppliers can offer different time-of-use-tariffs for customers.
- must save all metered data for at least 40 days within the meter.
- have to export all data at least once a day. All data of one day has to be transferred at the latest by 08:00 a. m. of the following day. All communication needs appropriate encryption to avoid unauthorized access to the data.
- have to ensure 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.
- have to enable the remote connection and disconnection of the customers system and to limit the maximum load.
- need communication ports which allow that at least 4 external meters (e.g. gas, water etc.) can use the communication line of the smart meter in both directions, and which support data transfer from these devices.
- need an additional communication port which provides an interface for the communication with external devices of the customer.
- need an information display on the meter which complies with national weights and measures regulation.
- be able to receive and process remote software updates without interruption of the metering process.
- must record time, duration and number of all supply interruptions and other voltage quality parameters.
- need a customer-friendly manual in German language which has to be provided to all customers.

3.1.3 Smart Metering Landscape in Austria

The adoption of the new Electricity Act (ElWOG) in Austria will probably not be an immediate push for a rollout of smart metering in Austria. The law does not determine the design of a smart metering system but only delegates decision-making powers from the legislator to the responsible ministry and the regulator. However, before the ministry is able to issue a decree for a rollout, a cost-benefit-analysis has to be performed together with a process of consultation regarding consumer and privacy protection. In parallel, the regulator (E-Control) will continue with its proposal for functional requirements and data necessities.

There are some network operators in Austria who have decided to implement smart metering systems although there is no mandatory legal framework.

Energie AG Oberösterreich, which is a regional distribution network operator in Upper Austria has installed already more than 10,000 smart meters and has plans to install another 100,000 in the near future. The overall plan is to install more than 400,000 smart meters in the next years. Energie AG Oberösterreich is negotiating with the Energy Regulatory Authority regarding the coverage of costs for the implementation of the smart metering system and will continue with the implementation when these negotiations are completed.

LinzStrom, another regional distribution network operator in Upper Austria, has already decided the rollout of smart meters for all of its 240,000 customers. LinzStrom deploys 20,000 smart meters a year. At the time being, there are more than 40,000 meters installed and the plan is to finalize the rollout by about 2020. New national regulations for smart metering could accelerate the rollout.

Some other network operators have pilot projects with some hundreds of installed meters, but there are no official plans for the rollout of smart meters from these network operators.

Most of the network operators are still temporizing until there are official regulations for smart metering. In the public discussion they often raise concerns regarding data privacy and ask for comprehensive regulation of this topic (Renner, 2010).[6]

3.2 Belgium

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

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, and *Ores* in Wallonia. Alongside these, a number of (smaller) distribution system operators also operate independently in both Flanders and Wallonia. *Sibelga* operates as the only operator in Brussels. Electricity and gas suppliers are separate entities to distribution system operators, the most important of which are *Electrabel*, *SPE* (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*.

[6] http://www.futurezone.at/stories/1664713/

3.2.1 Policy objectives for the introduction of smart metering

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. The three regional regulators have held a number of consultations, organized study days and started work groups.

The most important trigger for these developments in Flanders is the fact that there are many complaints about late or erroneous invoices. This translated into (excessively) high costs for the energy suppliers and ultimately also for the energy consumers. 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 has been performed by order of Flemish regulator VREG (Schrijner et al., 2008). The objective of this analysis was to obtain insight into the costs and benefits of a large-scale introduction of a smart metering infrastructure for the gas and electricity usage of consumers 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 minus 389 million euro. 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 2009 comparable analyses were performed for Wallonia and Brussels by order of a private party, with comparable results (CWAPE, 2009; Hujoel, 2009).

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.

The Flemish regulator VREG has formulated an overview of possible functions in smart meters (both for electricity and gas) (VREG and Deloitte, 2009). The functionality is divided into *basic functions*, which the smart meter must have as standard, and *optional functions*, which are not (yet) envisaged in the basic meter but which are deemed interesting in the long term. In Flanders, VREG has drawn up an overview of the possible functions of a smart meter (for both electricity and gas). Functionality is sub-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. *Basic functions* include:

1. Measurement of electricity acquisition and electricity provision to the grid;

2. Measurement of (temperature-adjusted) gas acquisition;
3. Transmission of meter status (measurement registers) on request;
4. Periodic transmission of measurement status (measurement registers);
5. Saving of meter status and/or load curve;
6. Remote adjustment of the electricity supply power;
7. Remote collective restriction or deactivation of meters;
8. Remote disconnection/connection of the gas supply;
9. Registration of consumption in different tariff periods;
10. Remote adjustment of tariffs/tariff periods;
11. Remote firmware upgrades;
12. Registration of power quality (voltage level, interruptions and grid status);
13. Communication with other meters (for example gas meters) possible via the electricity meter;
14. Prepaid function, the meter may be used as a budget meter;
15. Display on the meter;
16. Local port for external display.

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.

At the end of 2008 the Walloon regulator, CWAPE (2009), published a four-stage plan relating to the introduction of smart meters. It is envisaged that the functionality required for an infrastructure with smart meters will be defined in the first phase.

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 by 'functioning of the market' is broadly defined so that both 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.

As mentioned above, the Walloon regulator, CWAPE (2009), published at the end of 2008 a four-stage plan relating to the introduction of smart meters. It is envisaged that the functionality required for an infrastructure with smart meters will be defined in the first phase. The second and third phases will deal with the preparation and realization of a pilot project. In the fourth phase the pilot project will be analyzed and a decision must be made about the large-scale introduction of smart meters in Wallonia. However, a timeline is not provided.

Regarding metering services, no information on existing smart metering services that already entered implementation and commercialization could be obtained. Instead, the focus in Belgium is on technical tests of the meters and the communication technology. A number of different pilot projects are in progress or under preparation. Network Operator Sibelga in Brussels recently completed a pilot project. In a collaboration with three meter suppliers (namely Landis, Actaris and Siemens) around 200 electricity meters (no gas meters) have been installed since the autumn of 2008. The communication technology was based on GPRS and PLC. A total of between 1,000 and 2,000 meters will be installed. The objectives of this pilot are, among other things, evaluating the interoperability, testing the communication technologies and accumulating general know-how (Hujoel, 2009).

The Flemish network operator Eandis will be installing smart meters in three phases.[7] An evaluation will follow each phase to decide whether the project will be continued. In the second quarter of 2010 around 4,000 meters will be installed in the cities of Leest and Hombeek, near Mechelen. In 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 under its own management. For the communication between the meter and the centralized data server Eandis uses a proprietary invention for the real-time exchange of information.

In addition to these technical aspects, economical 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 135 million euro 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 1.5 billion euro. It is expected that the entire coverage area will have been provided with smart meters by around 2019.

3.3 Bulgaria

There are no official plans for a nationwide rollout of intelligent metering systems and no legislative or regulatory initiatives driving smart metering. A cost-benefit-analysis as requested by Directive 2009/72/EC has not been carried out yet. At present, consumers in Bulgaria do not have access to their metering data in electronic format because Bulgaria uses analogue metering equipment (single-phase electricity meters in the residential area).

In line with Directive 2003/54/EC and the Energy Act, the electricity market in Bulgaria has been fully liberalized since July 2007. The total installed capacity in the country is 11,280

7 Nieuwe elektriciteits- en aardgasmeters in Leest en Hombeek (New electricity and natural gas meters Leest and Hombeek), Eandis press release, 16 June 2009 (http://www.eandis.be/eandis/persberichten.htm).

MW. In 2009, the maximum net output capacity was 9,035 MW, and the peak load in January 2009 amounted to 7,270 MW. The yearly net output in the country for the reporting period was 37.4 TWh. Out of free market sales of 13.0 TWh (domestic market and net export), the share of open electricity market for 2009 was 35%. Net commercial exports for 2009 amounted to 5,1 TWh.

The production is ensured by seven companies that are being privatized - the Nuclear Power Plant (NPP) Kozloduy and the Thermal Power Plant (TPP) coal/lignite of Maritza East 2 remaining public. Independent producers, concentrated into 9 municipal district heating companies and 17 industrial TPPs make up for 11% of generation in the country. Several hydropower plants are being sold. There was no market monopolist of the 26 active traders on the domestic market in 2009. The largest share or purchased/sold electricity by a trader is below 17.5% of the total traded volume on the market.[8] Households annually consume around 10.4 TWh, that is around 36.3% of total electricity consumption in the country.

The energy market is regulated by the State Energy and Water Regulatory Commission (SEWRC). The former vertically integrated national electric utility NEK (Natsionalna Elektricheska Kompania) is now only responsible for transmission (TSO).[9]

Since 2005, 67% of the Electricity distribution business is 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. Dominant player with 88% of total consumption is Bulgargaz EAD. District heating is with 25% of the total energy consumption the dominant form of heating in major cities (Open Meter Consortium, 2009, 30; 60).

3.3.1 Smart Metering Landscape in Bulgaria

As mentioned above, there are no official plans for a nationwide rollout of intelligent metering systems in Bulgaria (Shargal, 2009). In electricity, legislation allows 3 energy tariffs but no demand measurement. Meter reading for electricity, natural gas, district heating and district heating supplied hot water is carried out monthly at present but efforts are ongoing to be reduced to three-monthly reads.

Figure 2: Electronic meter by EVN Bulgaria

However, 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

8 State Energy and Water Regulatory Commission (SEWREC) Bulgaria, 2009 National Report to the European Commission, pages 4,9,15,20,22,23-27.

9 EnerCEE: http://www.enercee.net/bulgaria/energy-supply.html

related to disputing the calculation of interim bills caused by quarterly metering and mistakes in the work out of the bills.

3.4 Cyprus[10]

Cyprus has no physical energy links to other EU Members States, and it 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. Electricity is transmitted through a high voltage Transmission System (132kV and 66kV) to the Transmission Substations where the high voltage is converted to medium voltage 22 kV or 11kV. Competition in the electricity market is weak, although there are some producers that have entered the generation sector by producing electricity for 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 consumers) as of 1st of 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.

3.4.1 Policy objectives for the introduction of smart metering

The DSO of Cyprus, that is part of EAC, the vertically integrated utility of Cyprus, is currently working on a pilot project for installing 3000 smart meters. This project has 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 architecture 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

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

and regulations. The main element of the framework is the Cyprus Law on Regulating the Electricity Market, that 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 allowed access to electricity networks, ensures public service obligations and introduces effective and independent regulation. With transposition of Directive 2009/72/EC there is an amendment expected by the end of March 2011.

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 that will satisfy the expected functionalities that are currently under discussion within the various working groups of 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. At the moment information is being gathered by various pilots to allow for a possible roll out.

3.5.1 Policy objectives for the introduction of smart metering

3.5.1.1 National objectives to introduce smart meters

As there are no legal obligations concerning smart metering at the moment, the national objectives are not officially announced. It can be assumed, that the key drivers are similar to the ones in other European countries as are summarized by Vasconcelos (2008). Those are for example the reduction of greenhouse gas emissions and the reduction of end-user electricity price. Of course the compliance with the EU directive is another strong driver.

3.5.1.2 Cost-benefit analysis

According to a questionnaire conducted by European Regulators' Group for Electricity and Gas (ERGEG) in 2006 a feasibility study had been carried out in the Czech Republic. This cost-benefit analysis led to a negative result (ERGEG, 2009, 25).

There is a pilot planned, where the economic profitability will be analysed. This pilot shall include about 40.000 meters served by the CEZ Company. It is also planned to include feedback systems and other non technical related issues within that pilot (ESMA, 2010, 18).

3.5.2 Legal foundation of smart metering services

3.5.2.1 Energy law

In the Czech Republic to date there is no official implementation plan for smart metering. Also there are no law regulations or obligations related to the implementation of smart metering (ESMA, 2010; Open Meter Consortium, 2009, 31).

3.5.2.2 Market model

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. However the DSO is still responsible for the meter (ERGEG, 2009, 19f).

3.5.2.3 Minimum functional requirements

In the Czech Republic there is no definition for the term Smart Meter. Nevertheless the regulator defines a smart meter as a metering system that can measure data on consumption, collect data and support two-way communication. Also a smart meter should be able to handle supplementary equipment such as a display (ERGEG, 2009, 11).

3.5.3 Smart Metering Landscape in the Czech Republic

In the Czech Republic a national rollout plan is under discussion. At the moment information is being gathered to lay the ground for a possible rollout.

Since 2006 E.ON Ceska carries out a smart metering project. Within this pilot project 400 metering points are equipped with smart metering technology. The company CEZ Mereni started a one and a half year pilot project in the east Bohemia region with just under 2000 metering points. This pilot focused on technical issues and not on products for customers.

CEZ announced to perform a multi-energy pilot including 40,000 meters. After this second pilot CEZ plans to rollout smart metering technology in a specific region with 1 million inhabitants by 2015. It is also being discussed whether feedback options for end customers will be included in this pilot. Partner for this pilot is Hewlett Packard. They are in charge of the metering infrastructure (AMM system), data analysis and demand side management. The completion of the project is due in late 2011 (ESMA, 2010, 46ff).[11]

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. 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.

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[11] http://www.presseecho.de/computer%20&%20it/PB375682.htm vom 28.09.2010.

3.6.1 Policy objectives for the introduction of smart metering

There exists no plans deployment of smart metering technology to final customers with smaller 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 exceed the gains for the households (Open Meter Consortium, 2009). An analysis described in Energinet.dk (2009) concludes that there were no socio-economic reason to reduce the limit for hourly metering of 100.000 kWh/year, because the value of a price flexible demand was lover than required the 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. According to ESMA (2010), approximately 50% of the customers will have remote reading in 2011. Also according to ESMA (2008, 15) demand response is one of the main drivers for introduction of smart meters in Denmark. However, if only demand response was to pay for new meters this would not be economically attractive.

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 final 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 that approx. 9,000 new customers were equipped with hourly metering (Morch, 2008).

The 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 internet 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 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).

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 among the Nordic countries, with 13% of the households connected. More than 50% of the households have district heating, and Denmark has the largest population of heat meters in Europe (Ryberg, 2009).

The Danish utility industry is characterised by multi utility companies that often supply gas, heat and water as well as electricity. In Denmark it is approximately 115 electricity DSOs that operate on a local or regional level. Many of these companies have ventures into cable TV, Internet and other telecom related services. With exception of the state owned DONG,[12] the DSOs are mainly owned by the customers (Ryberg, 2009).

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

3.6.2.3 Minimum functional requirements

The 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 is presented. In January 2009 the Danish Minister for Energy and Climate established a working group that should present minimum functionalities for electricity meters in order to support the development of flexible electricity demand (Energistyrelsen, 2009).

Example of suggested requirements are (Energistyrelsen, 2009):

- Remote meter reading should be possible
- The meter should register both consumption and production of electricity
- The meter should have a display showing electricity demand
- Consumption data should be registered and stored in the meter location
- It should be able to connected external equipment to the meter
- Open standards should be used for connecting and communication with external equipment
- The electricity demand should be registered with the frequency defined by the authorities (both 15 and 60 minutes registration frequency are presented as possible alternatives in the report.)
- Interruptions should be registered

There are no minimum functional requirements for heat, water and gas.

3.6.2.4 Smart Metering Landscape in Denmark

Since January 2005 Denmark has mandatory hourly metering of the electricity consumption for customers with a yearly consumption larger 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 also water data are collected. There are no apparent initiatives for gas meters.

[12] www.dong.dk

Totally there is 3 mill. Metering points for electricity in Denmark, and about 50% of these have already got installed smart metering technology or the DSOs are planning to do this. A map over the implementation of smart metering technology in Denmark is presented in the figure below. The red areas have planned for or already installed smart metering technology.

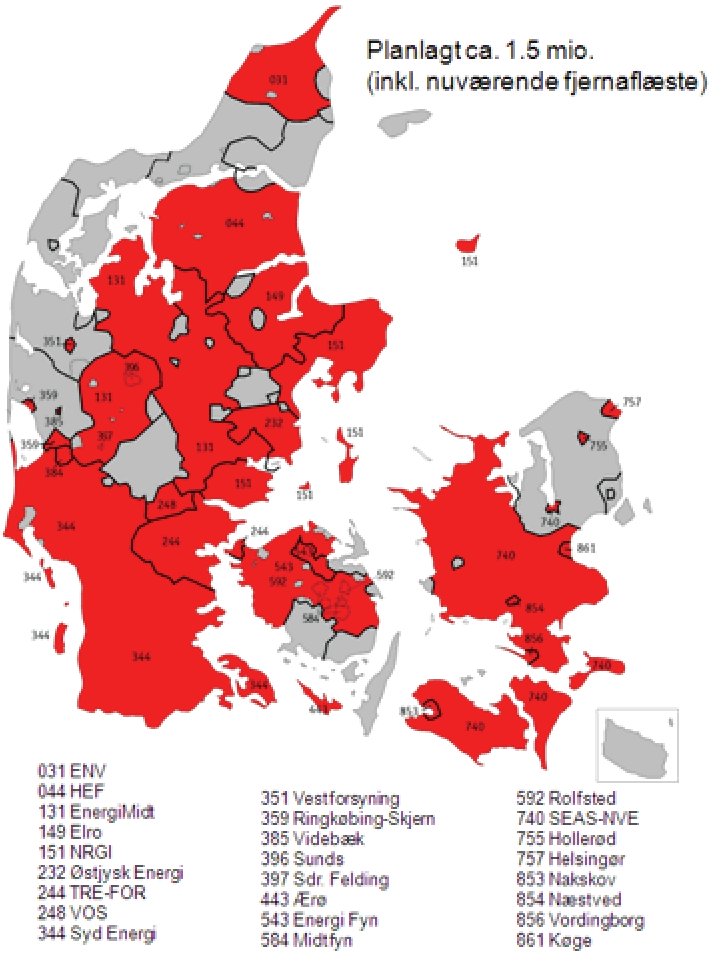

Figure 3: Danish map for smart metering technology (www.danskenergi.dk)

Increased amount of trials for smart metering technology for different types of energy commodities, combined with initiatives for new electricity price systems may increased the focus on implementation of smart metering technology. Since the Danish utility industry is characterised by multi utility companies that often supply gas, heat and water as well as electricity, such 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 perhaps also gas.

3.7 Estonia

3.7.1 Policy objectives for the introduction of smart metering

- Compliance with EU-directives

According to the responsible ministry (The Ministry of Economic Affairs and Communications), there are no current requirements on smart metering, and the **cost-benefit analysis** as required by Directive 2009/72/EC has not been performed yet.

However, according to ERGEG (2009), a large-scale smart meter rollout is under discussion, and minimum requirements are defined. A rollout should begin in 2011 and end in 2013. About 2% of all customers already have a smart meter device. The ESMA annual report (2010) reports similarly.

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

- Support for competition in the energy market,

The privatization of large scale enterprises, 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 characterized 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 ongoing economic reform program. Actual management of energy infrastructure is to decentralize 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 allows customers to choose their electricity supplier (Iklaa, 2010; Shargal, 2009).

3.7.2 Legal foundation of smart metering services

According to the responsible ministry (Ministry of Economic Affairs and Communications), the national regulation does not cover smart metering and there are no clear plans to adopt legislation related to smart metering. However, according to ERGEG (2009), a large-scale smart meter rollout is under discussion, and minimum requirements are defined. A rollout should begin in 2011 and end in 2013. Also the ESMA annual report (2010) states this.

3.7.3 Smart Metering Landscape in Estonia

According to the responsible ministry, there are yet no plans to adopt smart metering regulation. Since there is no clear direction through regulation, the adoption of smart metering technology services is dependent solely on the activity of utilities. Some distribution networks have plans to invest into smart metering infrastructure, and a large-scale smart meter roll-out is under discussion, for which minimum requirements are being defined. A roll-out should begin in 2011 and end in 2017 (ERGEG 2009, ESMA 2010).

Related to the roll-out mentioned above, the dominant DSO OÜ Jaotusvõrk is planning to switch to smart meters to seize the opportunities of smart grids (at the moment they have 55,000 remotely readable meters, installed between 1995-2010) with the following initatives:

- Preparing the documentation (technical requirements, IT, etc.) for procurement of smart metering system (680,000 meters), also currently deploying Meter Data Management system.
- Tender announcement is planned in spring 2011 and completion of the project by 2017.
- When the Estonian energy markets are opened for competition in 2013, the plan in OÜ Jaotusvõrk is to have 220,000 AMR meters and all customers metered within 3 years.

However, the current monopoly-like situation in the energy markets may not be the most encouraging context to uptake innovative smart metering services, especially without any demanding legislation to do so. Yet, as the market opening 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:

  Regarding the implementation of Article 13 ESD, there is a wide variety of legislation and agreements related to this area, the most important being:

  - Electricity Market Act and two Decrees under the law - including the new decrees regarding the electricity smart metering
  - Natural Gas Market Act Decree under the law.
  - New Law on Energy Services - obligations for energy retail sellers to give feedback and energy saving information to end-users
  - Energy Efficiency Agreement for Industries/AP-Energy Services
  - Energy Efficiency Agreement for Disrtibution of LiquidHeating and Transport Fuels

  With these legal acts, Article 13 ESD has been implemented in Finland. Moreover, the implementation is reinforced and even exceeded with the new electricity smart metering regulation demanding almost full rollout by 2014.

  However, in heat the ESD requirement of individual metering is still not completed, as in many residential buildings there is no apartment specific heat meters (when the heat distribution is based on water with radiator or floor piping). In some buildings (however much less frequently) there are no individual water meters.

  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 with possible costs at a general level. The ministry of employment and economy has estimated roughly that the costs of a full rollout are EUR 565–940 million (for 2.2 million customers who do not yet have AMR).

- Support for competition in the energy market

Finland's electricity market was 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 operations and to integrate Finland's electricity market into the Nordic market. These liberalisation and integration actions increased productivity and environmental efficiency, as the Nordic hydropower capacity can now be utilised efficiently and the market allows for trading in "green" energy.

- Consumer protection

  Although intelligent metering systems in Directive 2009/72/EC are mentioned under the headline "consumer protection," those issues are not central on smart metering discussions in Finland, rather there are some notes on the new metering regulation on DSO responsibilities for the smart metering data safety. Furthermore, the regulation does not demand real-time metering data flow from the customer, which for its part may mitigate the objection from consumer organisations. Also the common societal trust between citizens and authorities is generally quite high.

- Energy efficiency and carbon reduction

  There are no official or other country specific energy efficiency or carbon reduction targets specified for the smart metering itself. Rather the smart metering along with related services is seen as an integral part of making energy efficiency and related carbon reductions possible. Also improving the electricity market functioning towards efficient real-time markets and peak load reduction are major motivators for the government to implement smart metering.

- 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 is allocated to smart grids R&D.

- Energy security

  Energy security improvement through energy efficiency is an acknowledged goal, but generally the discussion and policy measures on energy security seem to be more emphasized in the production side issues, i.e. nuclear power and renewables.

3.8.2 Legal foundation of smart metering services

Smart metering regulation in Finland only covers electricity so far. There is no official country-wide plan for district heat meters or for water meters.

A new electricity market act (66/2009 act on electricity supply reporting and metering) came into effect 1 March 2009 and requires the following:

- 2011 all over 3x63A connection points must have remotely readable hourly metering.

- By 2014, full smart metering penetration with no more than 20% exception, when the user has max. 3x25 main fuses, or over 3x25 main fuse but the use is no more than 5000 kWh/a (and the electricity is bought from seller obliged to supply).

Regulated and partly monopolized market model: metering belongs to the regulated activities of the DSO, however electricity sellers, which operate in a liberalized market are expected to offer new and innovative services. Also service providers are expected to enter the market providing new services. In short, the metering technology is quite regulated and under DSO monopoly but the services should be in a liberalized market.

There are some minimum functional requirements for the metering system defined by the regulator in Finland:

- Remotely readable hourly interval measurement data available next day to market actors including the customer;
- If requested by the customer, the DSO must deliver metering equipment that has standardised connection for real-time hourly based monitoring;
- Consumer must receive the data at the latest when the electricity seller receives it;
- Meters are able to receive and execute load control commands, or forward the commands to devices that are able to limit the loads (i.e. two way communication), which mean in practise
  - The customer makes a contract with seller for a load control at peak times when the electricity stock market price is high - the seller gives control command either directly to the meter (using mobile phone network) or through DSO;
  - The customers orders from DSO a meter which forwards the load limiting commands to house automation control system (e.g. HVAC) which controls the system as it's programmed;
- DSO data security in data transfer and storage properly managed;
- support for variable time-of-use (TOU) tariffs;
- Registering over 3 min outages;
- Starting 1 January 2012 settlement by hourly metered data is required for all customers that have meters capable to hourly metering.

Remotely readable meters that have already been installed are allowed some exceptions regarding the minimum functional requirements.

3.8.3 Smart Metering Landscape in Finland

There is a regulatory push for smart metering in Finland, and its impact is about to peak at 2014 when almost all end-users should have smart meters installed. Also utilities have started implementing their Smart Meter rollouts swiftly, with well over 1 million meters at place (with around 2 million left to be installed). While the technology side seems to be taking off well (as one of the most advanced in the world) because of the regulation, the service side is still ambiguous from the technical, market model and regulation point of view. *The most important question at this point is: is the huge amount of metering data coming from end-users (now stored by DSOs) available to all relevant actors who can make end-*

user services (and energy savings) with it, and at what cost and restrictions? Who will pay the better service and who will pay for the new building systems integrated to the meter and related controls - and when will these services and technologies reach the end-user masses?

Although the electricity smart metering rollout is well on its way, many utilities are still uncertain how to use the technology and data in order to reap the benefits of the investment demanded by the regulation. In recent years, there have been a few AMR solutions providers, mostly to industry, commercial and service sectors, and now some ready service applications have emerged also to the consumer sector. Usually these are provided by the utility, as a part of their customer service**.** These have been mostly DSOs, but also energy seller companies are quickly getting to the game in order to differentiate their product and improve their competitiveness in a liberalized energy market. Rather than in-home displays, the Finnish AMR and smart metering end-user services are more leaning towards web-based applications.

As for other energy forms than electricity, about 50% of district heat meters are in remote reading and many meters can be connected to remote reading. Except for some pilots, the utilities have not yet applied large scale smart metering of water consumption.

3.9 France

In France the electricity and gas markets are dominated by EDF and ERDF. Therefore the activities concerning smart metering are concentrated within those companies. In subject to a pilot run by EDF in the electricity sector, the regulatory authority (CRE) aims at a 95% connectivity of smart meters to AMM (automated meter management) systems by 2016.

3.9.1 Policy objectives for the introduction of smart metering

In 2007 the national regulator stated, that the installation of smart meters will contribute to better structures and better operation of the whole energy market, to a more efficient supply of energy as well as to a diversification of services offered .

Already in 2006 EDF identified four areas for which smart metering will provide improvements within the energy market. The areas in question are the billing and customer service, grid operation and monitoring, remote connecting and disconnecting and also the accounting. ERDF plans to adapt their processes to the arising potential of smart metering and to install completely new information and data management systems. In addition ERDF plans to offer new services for energy suppliers via their supplier portal. Because of its dominance, ERDF is expected to be the future provider of smart metering solutions for the smaller DSOs in France (Nabe et al., 2009, 94ff).

In France a cost-benefit analysis has been carried out. The CRE commissioned an international benchmark which included a cost-benefit analysis. According to Vasconcelos (2008, 51ff) Capgemini Consulting presented the final report early in the year 2007. It stated that AMM reading could be positive for the distribution network operator. But also the positive impact on electricity supply and generation costs could be significant. Consumers could for example profit from more competition on the retail market and lower prices due to simpler supplier switching.

3.9.2 Legal foundation of smart metering services

At the moment there are no legal obligations concerning smart metering. Never the less the regulator set a few guidelines.

In France for both gas and electricity the DSO is in charge of the metering. In general the distributor is in charge of the installation of the meter, the maintenance, the reading and the data management. In some cases the customer can be in charge of the installation and the data management (Vasconcelos, 2008, 21ff). The meters have to be read at least once a year (ERGEG, 2009).

The regulator defined goals that have to be reached by implementing smart meters. These lead to a set of minimal criteria. There should be at least a two-way communication system and the management of remote operations should be supported (ERGEG, 2009). It is expected that there is no need for standardisation due to the dominant role of ERDF in France (Ryberg, 2009, 111).

The Open meter consortium (2009, 56) states the following functional requirements of smart meters in France:

- 4 registers for the distributor and 10 registers for suppliers
- A load profile should be configurable in an interval of 30 or 60 minutes steps. A 30 minutes data interval load profile should be stored at least two months.
- The power quality should be definable by the date and duration of power cuts, the date and duration of power sags and swells and the meter has to store this data for two years.
- There should be the possibility for remote disconnection and distant reconnection authorisation.
- Variable tariffs should be possible and remote configuration of tariffs and scheduling should be possible.
- For peak shaving there should be at least one relay based on the tariffing and commanded by the distributor or retailer.
- There should be one interface for a display which has to provide the 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

The goal is to implement mandatory legislation, so that all electricity customers will be metered by a smart meter. There is legislation on the way, which covers three milestones:

- 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.

The strategy for a rollout will most likely be due to technical specifications by the regulatory body. Responsible to fulfil these specifications is the DSO. Starting point will be in 2012, when in case of new installations of meters only smart ones will be allowed. The aim is to have a 95% coverage of smart metering by the 31st of December 2016. A rollout of smart metering for gas is currently under discussion (Ryberg, 2009, 111).

In mid 2008 ERDF and Atos Origin announced a pilot test with 300,000 smart meters and 7,000 concentrators. The pilot will be conducted in the regions of Tours and Lyon. Atos Origin is in charge of installing the information system and is the leader of the consortium. Power line carrier is being used for data communication. By the 20th of September 2010 over 47.000 AMM meters have been commissioned. Most of the meters (57%) are Landis&Gyr products followed by devices from Itron and Iskramenko (Mercadier, 2010; Ryberg, 2009, 145).[13]

On the 31 of August 2010 a decree was adopted stating that 95% of smart meters must be deployed by the end of 2016. The meters have to allow users to access data on their energy production and consumption. This data has to be made available at least daily.[14]

3.10 Germany

Germany follows a policy of competition within the metering market. The metering operator is obligated by law to install smart meters in new buildings and buildings that are undergoing major refurbishing from the beginning of 2010. Also by the same date smart meters have to be offered to all customers. It is assumed that the legislature will adopt the policy in the near future to suit the European requirements drawn in the 3rd Energy Package.

3.10.1 Policy objectives for the introduction of smart metering

The national legislature (EnWG 2009) states two goals concerning smart metering. One is to ensure a save, low-priced, consumer friendly, efficient and environmentally friendly supply of electric energy and gas. The compliance with the EU-directives is another goal. Those goals can be assumed to be the objectives to introduce smart meters.

An official cost-benefit analysis according to the directive 2009/72/EC has not been carried out in Germany so far. Nevertheless, the Federal Ministry of Economics and Technology commissioned a report regarding the potential energy savings due to smart metering. This report was written by KEMA, a German branch of a Dutch consulting company. It concludes that smart metering can contribute to energy savings but to maximise this effect, energy savings should be more heavily demanded by legal obligations (KEMA, 2009, 16).

3.10.2 Legal foundation of smart metering services

There is no rollout planned with smart meters in the near future. Instead a policy of competition is being followed. The national legislature (EnWG 2009) states that by 2010 the meter-

[13] http://www.edna-initiative.de/de/data/news/114/ vom 26.09.2010.

[14] http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022765140 from 05.10.2010

ing operator has to deploy meters that show the real consumption of energy and the time of use, in case this is reasonable on technological and economic bases[15]. The policy also states that by 2008 the customer has the right to receive a monthly, quarterly, biannual or annual bill. Also by 2011 the electricity suppliers have to offer load-variable or time of use tariffs[16]. Those two paragraphs are the only ones concerning smart-metering in Germany, whereby the second one does not apply to the supply of gas.

In Germany the energy market has been fully liberalized in 1998. With the amending energy law in 2008 (EnWG 2008) a new market role has been introduced – the metering operator. Therefore the role of the metering operator is separated from that of the metering service provider. Thus customers can choose a metering device according to their needs. The DSO (distribution system operator) is the default metering operator as long as no other one is chosen by the customer. Because the DSOs can roll out smart metering technology in case they are the metering operator, the technologies can be quite different from DSO to DSO. Therefore problems in privacy issues and technical standards arise.

In Germany the meters of the standard load profile customers have to be read at least every three years. This has to be done by the metering operator. In between those 3 years the billing is based on customers self reading or estimation (ERGEG, 2009, 19).

In Germany there is no official definition of the minimum functional requirements of a smart meter (Open Meter Consortium, 2009, 58). The legal text speaks of a meter that reflects the final customer’s energy consumption and also provides information on actual time of use. There have been a lot of discussions about the requirements based on this legal text. This applies for electricity as well as for gas.

Within a study for the German regulator (Bundesnetzagentur) the interpretation of the legal text resulted in quite low minimal functional requirements. The analysis concludes that it is sufficient to offer a meter display, that shows different time intervals of consumption. A load profile is not necessary to supply. According to the study, the requested tariffs could even be metered by standard meters with two registers (Nabe et al., 2009; Nabe et al., 2010).

Also because of the very unstable legal foundation concerning the minimum functional requirements there are two main initiatives working on standard requirements. Those are the Open Metering initiative, which is a community of manufacturers, and the MUC (multi utility communication) initiative, which is mostly utility driven (Open Meter Consortium, 2009, 58).

3.10.3 Smart Metering Landscape in Germany

Due to the current legislation with a lot of questions unanswered, the majority of the energy suppliers have not taken any action in implementing smart metering. There has been a great demand for a statement of the national regulator concerning those uncertainties. The national regulator therefore published a paper, which helped to interpret the legal text but did not dissolve these uncertainties mentioned above (Bundesnetzagentur, 2010).

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[15] EnWG (2009) §21b Abs.3a & 3b

[16] EnWG (2009) §40 Abs.3

Because of the current legislation – which sets goals which can almost be met by the metering standards today – the drivers for the introduction of smart metering are the European directives. But as there are no minimum functional requirements for smart meters, the utilities hold back on their investments. Also as long as the purchase of energy has to be carried out according to the standard load profiles by law, there is no possibility for the supplier to make profit through better knowledge of the customer's consumption. Therefore neither a market driven nor a regulatory driven incentive exists for the suppliers or the DSO to roll out smart metering technology.

A market survey carried out by EnCT shows, that in early 2010 only 15 of about 800 utilities in Germany offer smart metering products with a time of use tariff and feedback system. Except for one utility offering its products nationwide, the area of delivery is limited to the former supply area and in some cases even to some geographical areas respectively to existing clients (Schäffler, 2010).

Because of the regulatory guidelines in Germany to buy and bill energy for private and business customers with a consumption of less than 100,000 kWh/a based on the standard load profile, there is only a small range for the utilities to design the tariffs. Accordingly time of use tariffs with two price levels and a small difference between the highest and the lowest price are dominant. One analysed tariff with four price levels and a price difference of about 11 cent seem to be some kind of "market experiment". Never the less, several utilities offer products including a tariff with a third price level which is valid for the weekend.

The analysis of the costs on the basis of a simulation shows that transparency and cost control through smart metering are worthwhile for customers with a medium or high annual energy consumption. Households with a consumption higher than 3,400 kWh/a might be able to compensate the additional costs by saving energy and shifting loads. Customers with a high annual energy could even reduce their energy cost. This is due to the relatively high basic fees. Whilst the costs for consumption based on the price levels are normally lower compared to the standard tariff, the basic fee of the smart metering products is considerable higher. Customers with low energy consumption cannot compensate the higher basic fee by the lower energy price. Even by saving energy and shifting loads those additional costs cannot be avoided entirely.

It is to mention, that the analysis of the costs exclusively apply to average costs. In individual cases smart metering products can be worthwhile for customers with a low annual energy consumption. Just as well there are smart metering products that account for considerable additional costs in comparison to standard products even for customers with a high annual energy consumption.

Some literature states that for electricity a roll out plan is under discussion (ERGEG, 2009, 38, 22). Even though the energy law (EnWG) will be most likely revised in the beginning of 2011, a mandatory rollout is not expected by the industry at all. Therefore the discussion about a mandatory rollout seems to have died down.

3.11 Greece[17]

The Greek electricity market is divided into two different systems: the grid-connected mainland and the non-interconnected islands, which refer to the islands of 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 sole distributor of electricity. It owns 93% of the installed power capacity. The Regulatory Authority for Energy (RAE) is an independent administrative authority and holds the primary regulatory responsibility remaining 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 exception of the networks located on the non-interconnected islands.

3.11.1 Legal foundation of smart metering services

Greece is proceeding to a rollout of electricity smart meters and has adopted some type of legal framework on the implementation of smart metering (Article 15 of law 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. Fraud detection and self-diagnostic of the functioning of the meter will also be important functions of the smart meter infrastructure in Greece (ERGEG, 2009).

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 from the metering companies. Electricity is actually read every four months (bill is issued bi-monthly), while natural gas is read bimonthly. In order to provide metering services, secondary legislation and regulations stipulate the release of information to third parties and is also subject to data privacy legislation.

Law 3855/10 ("Measures to improve energy efficiency in end-use energy services and other provisions") requires additional information to the final 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 aforementioned 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

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

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.

In specific, PPC has planned to install 60,000 smart meters in large end customers of 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 know the amount of electricity consumed, while PPC will be able to apply flexible pricing rules, depending on the time of the day the electricity is consumed. This scheme will start from the 60,000 large customers that together with 8,000 commercial customers consist 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

Currently, there is no legislation in Hungary regarding the introduction of smart meters. The Hungarian Energy Office (HEO), which is the national regulatory authority, is responsible for the preparation of regulations for smart metering which comply with the respective EU directives.

By order of HEO two consultant firms (A.T. Kearney, Force Motrice) have examined the different options for the introduction of smart metering in Hungary and made recommendations for the method and timeframe of the introduction (AT Kearney and Force Motrice, 2010). In their study the political intent to implement smart meters was identified as one of the key drivers. Where it is technically feasible and economically reasonable, Hungarian utilities will have to provide smart meters from 2010 on and load variable tariffs from 2011 on. But there are no concrete regulations in force so far.

Beyond that, A.T. Kearney and Force Motrice (2010) have recognized that smart meters are the technical basis to provide energy customers with transparent information regarding their actual energy consumption, which is a prerequisite that consumers can react with a change of their consumer 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.

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

- Contribution to energy savings
- Secure energy supply
- Development of services based on prepayment systems
- Development of energy services based on tailored tariffs
- Information on the peak of consumption and contribution to an accurate network management
- Support a self diagnostic of the functioning of the meter

In view of an unclear legal framework and unclear cost issues, there are also strong obstacles to smart metering in Hungary.

In the study by A.T. Kearney and Force Motrice (2010) 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 is 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.

There is debate about whether the existing cost-benefit analysis fulfils the requirements of Directive 2009/72/EC. Some experts expect that there will be another comprehensive cost-benefit analysis necessary when the main legal framework for smart metering is available. The legal transposition of Directive 2009/72/EC will happen during the course of 2011.

3.12.2 Legal foundation of smart metering services

Hungary does not have any legislation regarding the introduction of smart energy meters. However, A.T. Kearney and Force Motrice (2010) recommended the following timeframe to HEO .

- 2010 – 2011: Preparatory regulation
- 2011: Launch of pilot projects
- 2013: Closure and evaluation of pilot projects, invitation for concession tender
- 2014: Launch of the domestic rollout of smart meters

The most 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 found separate 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 SM Operators will have a natural monopoly. Network losses will have to be covered by the DSOs. The Area SM Operator will provide the suppliers and DSO with relevant metered data.

If Hungary decides to implement this model, comprehensive amendments in 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-minutes measuring intervals)
- Possibility for remote programming and update, controlling software can be remotely managed
- Possibility for recording and storage of 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 have to transfer their metered data to the TSO. There is at least one meter reading per year for small customers, more frequent meter readings can be agreed in the network utilization contract).

As for the legal framework for the introduction of intelligent metering services, the necessary development steps are still under discussion in Hungary. Concrete decisions from the parliament are expected for 2011 with the transposition of the Third EU Energy Market Package. Then it will be clear which approach for the implementation of smart metering will be chosen for Hungary. First smart metering pilot projects are expected to start in early 2011.

3.13 Ireland

3.13.1 Policy objectives for the introduction of smart metering

Since 2007, the Irish government has a National Smart Metering Plan in place. The National Smart Metering Programme in Ireland has the following strategic objectives (CER, 2010a, 16):

Energy Efficiency

- Encouraging end-use energy efficiency via enhanced information and pricing signals to combat climate change and reduce pollution;

Peak Load Management

- Reduce demand for peak power, with consequential electricity generation savings and improved security of supply, through pricing signals such as Time of Use tariffs;

Support Renewable and Micro Generation

- Assist in achieving of Irelands stated national targets for renewable generation (40% by 2020) by facilitating demand response solutions that will complement increasing levels of intermittent wind generation on the electricity system.
- Facilitate the wider take up of micro generation (via export measurement function of smart meters).

Enhanced Competition and Improved Consumer Experience

- Promote competition in the electricity retail market by enabling electricity suppliers to create innovative pricing arrangements that can be offered to consumers to support the efficient use of electricity, such as Time of Use electricity tariffs.
- More accurate billing of customers with the elimination of estimated billing.
- Support more timely and efficient switching by customers.
- Support more flexible and diverse service offerings to consumers from suppliers including potential for expanding prepayment offerings.
- Empower consumers to make better decisions regarding their energy use by providing them with accurate, detailed and more frequent information on their energy consumption and costs.
- Improve change of supplier process through auditable timely final meter reading.

Improved Network Services

- Improve services to customers in areas such as power quality, fault monitoring and meter reading.
- Prevent theft and measure losses more accurately.
- Become a key component of a 21st century smart electricity network for Ireland.
- Provide a potential platform to support national targets on Electric Vehicles

- Improved load forecasting and network planning, possibly leading to deferment of infrastructure expansion costs.

In June 2010, the Commission for Energy Regulation (CER, 2010a), as an independent body responsible for regulating the natural gas and electricity markets in Ireland, launched a consultation paper in order to seek the view of the public and the CER's stakeholders with regard to Possible National Rollout Scenarios for the Smart Metering Cost Benefit Analysis. In November 2010, CER (2010b) published a second consultation paper in order to get further feedback on possible functional requirements for a national smart metering rollout to inform the cost benefit analysis for smart metering in Ireland. Following this consultation, CER will develop a Smart Metering cost-benefit analysis to be completed in March 2011.

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. These Regulations also amend the Electricity Regulation Act 1999 to allow the Commission for Energy Regulation to place requirements on energy undertakings in relation to informative billing.

Following the National Smart Metering Plan, 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 specific, this project has the objective of setting up and running Smart Metering Trials and assessing their costs and benefits, which will inform decisions relating to the full rollout of an optimally designed universal National Smart Metering Plan. In four test groups different forms of feedback to the final customer are tested (monthly billing, bi-monthly billing, in-house displays, overall load reduction). The results of all these trials will feed into a cost-benefit analysis by early 2011, which in turn will inform decisions related to any national rollout of smart meters (Mannion, 2010; Wynne, 2010).

In trying to come to a decision on the functionality of smart metering, the Irish government is still looking to build a system which will meet as many of the key strategic objectives of smart metering, while taking into account costs, technology challenges and risks.

The system will probably be based on three levels of functionality: core smart metering system functionality (supporting remote meter reading, multiple supplier tariffs, profile data and remote operation), additional functionality to provide real time in-home communications and additional functionality to support smarter homes and smarter electricity networks.

The **electricity smart meter** could have the following functionality (CER, 2010a, 30):

1. Half-hourly profile data

2. Limited Range of Standard ToU register readings – A time of use register can record consumption of electricity in different time blocks (e.g. daytime 8am – 11pm) associated with different prices

3. Import and export data to facilitate measurement of export data.

4. Watt-less energy measured

5. Events such as power outages recordable on the meter

6. Alerts can be recorded on the meter, for example if there are attempts to remove the meter cover or tamper with the meter

7. Voltage / Power quality monitoring available as required

8. Remotely operable embedded switch for de/re-energisation (single phase meters only)

9. Controllable physical circuit for loads such as night storage heating

10. Load limiting capability

11. Firmware upgradeable

12. Strong Encryption

13. Storage of data on meter for agreed period of time

Further, the standard electricity smart meter should have a life time of typically 20 years. Possible gas meter functionalities are listed in CER (2010a, 30).

As part of the second consultation on possible national rollout scenarios for smart metering in Ireland (CER, 2010c), the respondents highlighted a range of questions related to data ownership and the availability of data that need to be addressed:

- Granularity of data requirement
- Access to data for suppliers
- Access to data for customers
- Data required for billing
- Data required for prepayments
- In-Home data requirements
- Data ownership and security
- Vulnerable customers

It is generally recognised that consumers own their consumption data generated by smart metering and that data protection should be paramount in smart metering. Consumers 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, consumers can give permission to other third parties to access their detailed historical consumption data.

As for data access for suppliers a proposal is made to establish a data portal through which suppliers can access data for their customers, updated daily, on a push and/or pull basis subject to their requirements. At the design stage of a full rollout this would have to be explored further, as well as the fair processing requirements of the Data Protection Acts. Energy market participants expressed their historic and ongoing commitment to data protection legislation (CER, 2010c).

3.13.3 Smart Metering Landscape in Ireland

CER established the Smart Metering Project Phase 1 in late 2007 with the objective of setting up and running smart metering behavioural and technology trials and undertaking a cost benefit analysis (CBA) of smart metering. The findings from these trials and the CBA will inform decisions relating to the full rollout of an optimally designed universal National Smart Metering Plan in Ireland. The project is managed by CER, with the support of the Department of Communications, Energy and Natural Resources, Sustainable Energy Authority of Ireland, ESB Networks, Bord Gáis Networks and the electricity and gas industry in Ireland (CER, 2009).

From 1st January 2010, around 5,500 household electricity customers nationwide began using smart meters. The trial participants will also be receiving new “smart bills” which contain enhanced information on their 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). Some participants will also be receiving web access and in-home displays (IHDs) which display (real-time) information on current electricity usage and costs in the home. The electricity trial also contains 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.[18]

The trials will run throughout 2010 and will inform decisions in relation to an optimal design for a full rollout of smart meters. Latest information is that overall progress has been very positive with all key milestones having been achieved. In effect there are 17 test groups (four stimuli such as detailed bills, in-home displays etc.) across 4 different time of use tariffs and a weekend tariff. In total, 5,375 customers were recruited for the residential trial. The initiation of the electricity Customer Behaviour Trials (CBT) for residential and SME customers are due to complete end-2010.

The technology trials were completed at the end of September 2010. This included testing of the smart metering functionality on different communications layer networks such as power line carrier, wireless mesh (RF 2.4GHz) and GPRS. Following the technology trials three likely scenarios were developed including DLC (urban) combined with RF (rural) and GPRS (rural) or GPRS for all meters. Ultimately the guiding principle will be to ensure that the most cost effective communications solution is put in place through a public procurement process (CER, 2010c).

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

Initiation of the Gas CBT for residential customers is due to complete in June 2011. This encompassed a roll out of circa 2,000 smart meters to trial participants testing a range of smart metering enabled stimuli, including detailed & more frequent billing, IHDs and a variable tariff.

A small prepayment trial is also planned during 2010. The findings from this trial will be presented early in 2011.

These trials will enable information to be obtained on customer consumption patterns and will provide participating customers with the opportunity to monitor their own consumption and make energy consumption changes across the day.

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;
- Consumer protection: transfer to customers as much as possible 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.[19] 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 31st December 2011, 95% of smart meters should be installed.

19 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.

- **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 signals with timeliness any errors to the control centre;
  - Remote transactions: periodic readings for billing purposes; reading of interval metered data; contractual changes: meter activation (including for succession) and deactivation; name change (without interruption of supply); change in contractual power; change in weekly profile; reduction, suspension and reactivation of contractual power; meter reparameterisation; synchronisation of meter clocks; transmission of messages on the meter display; continuous reading of the status word; reading information related to slow voltage variations, according to EN 50160;
  - Freezing of withdrawal data (billing, contractual changes, switching, etc.);
  - Meter display;
  - Upgrade of the programme software;
  - Slow voltage variations (according to EN50160);
  - 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 in almost all houses an electronic metering system that is composed by 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 with the company central systems and a switching device enabling, remotely, the supply connection and disconnection.

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 six months.

By 2011, all 36 million electricity customers will be equipped with a smart meter (ESMA, 2010). However, the focus of the smart metering system is on electricity theft prevention and not energy savings. Therefore, the system is DSO-oriented with only a minor focus on the demand of customers.

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 percent (Lejins and Aljens, 2010).

The current underlying technologies are:

- Residential customers have mainly ordinary electromechanical meters, which are being replaced step by step with electronic meters but which are not necessarily connected to the AMR system.
- Consumers 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 Consumers 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 are 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.

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 given 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 of payment 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, at 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 is dependent on the activity of utilities. Yet the current monopoly situation in the energy markets is not the most encouraging context to uptake new smart metering technology and services making the development of smart metering in Latvia to one of the slowest compared to other EU Member States (Morch, 2008; Morch et al., 2007). However, the dominant DSO Latvenergo is preparing a concept for smart metering in Latvia as the first steps. This document will include applications of smart grid, describes possible technologies and calculates business cases. Now they are working with requirements for MDM system. Currently they have 10,000 meters connected to AMR system (7,000 of them are industrial clients). The current purpose of this system is to get load data, and to make balance and billing. Thus the current implementation activity for smart metering services and enabling technology can be characterized as low.

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).[20]

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 conditions promoting competition in the electricity sector. Since July 2007 the electricity market is 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, currently there are no concrete plans for a smart metering rollout (Shargal, 2009).

3.17 Luxembourg

In Luxembourg there are currently no plans for a rollout of electronic meters (Shargal, 2009). However, trial tests of smart meters with internet portals, in-house displays are being carried out by some DSOs. The regulator is responsible for the cost recovery surveillance. Luxembourg has not done 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 made a definition of 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 of 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 23 Mill. on evaded revenues per year[21] (7% non-technical electricity losses per year).[22] One of the objectives is

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[20] www.enercee.net

[21] http://www.smartmeters.com/the-news/1381-malta-investigates-power-billing.html

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 1 Mill. 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 foresaw the use of smart metering to provide consumers 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 consumers (MRRA, 2009).

3.18.2 Legal foundation of smart metering services

- Provision in the Energy Law: During 2010, a nation plan for substitution of traditional meters by smart meters has started, leaded by Enemalta, the vertically integrated 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 consumers. 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 customer (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 CO2 emissions).

3.18.3 Smart Metering Landscape in Malta

Enemalta Water Services Corporation Transformation currently implement the Integrated Utilities Business Systems (IUBS), a pilot project for electricity and water across Malta. The IUBS programme is a 5 year programme that started with the implementation of 5,000 meters in 2009 and is followed by a 3 year phase of high 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 should replace 245,000 electricity

[22] http://www.cipmalta.com/Uploads/Resources/2_4_Sean%20Barabara.pdf

meters and install AMR modules for 245,000 water meters during the next years. The meter is owned by Enemalta corporation, the national electric company. In 2010 Enemalta launched an on-line portal allowing to access the customer consumption details.

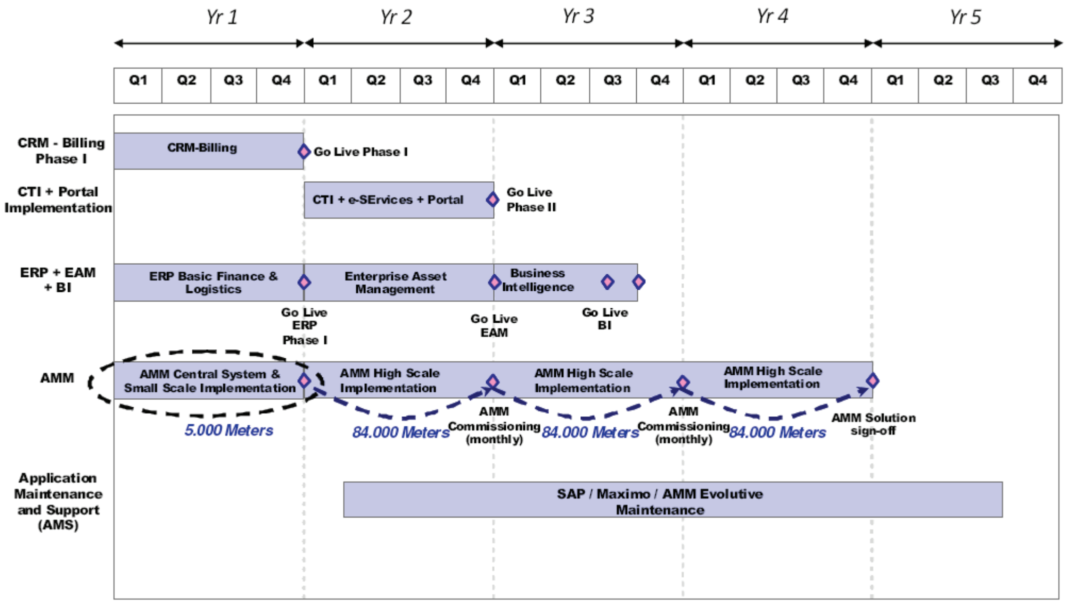

Figure 4: Timetable of Integrated Utilities Business System (IUBS) in Malta (Klatovsky, 2010)

While the installation of electronic meters is moving according to plan, there were some serious problems with electricity bills that were issued by Automated Revenue Management Services, Ltd (ARMS). Instead of receiving electricity bills of their actual consumption, many customers still receive estimated bills or no bills at all. In November 2010, the government of Malta has approved an investigation into alleged mismanaged handling of water and electricity bills by ARMS Ltd. Minister for Transport, Communications and Infrastructure, Austin Gatt, explained in parliament that software, and not employee bungling, was the reason behind the billing problems. Out of 889,117 bills which the company issued, 47,841 were incorrectly billed, which translates into a failure rate of 5.3 percent.[23]

3.19 Netherlands

The Netherlands is one of the front runners in smart metering in Europe. On 9 November 2010 the Dutch House of Parliament passed a revised bill that sets the legal framework for a voluntary rollout of smart meters.

The electricity and gas markets in the Netherlands were deregulated in a number of phases: first the large - mostly industrial - customers, followed by the middle segment and the market for green electricity and finally, from 1 July 2004, the market for *all* low-volume users. An

[23] An overview is provided by following Sources: http://www.smartmeters.com/the-news/1381-malta-investigates-power-billing.html; http://www.maltatoday.com.mt/news/arms/smart-meter-clients-still-receiving-enemalta-estimates; http://f1plus.timesofmalta.com/articles/view/20101110/local/mugliett-slams-government-on-arms-ltd

independent regulatory authority appointed by the government – in the Netherlands the Office of Energy Regulation (part of the *NMa*) – supervises the entire energy market.

3.19.1 Policy objectives for the introduction of smart metering

The restructuring of the Dutch meter market for small energy users and rollout of smart meters is an important part of a broader new market model for households and small business users. Important national drivers for the reform of the Dutch meter market were a strong desire to correct administrative problems with billing that followed the liberalization of the Dutch energy market in 2004. Other goals were to facilitate more energy market competition (easy switch for consumer), improve operational efficiency for market parties and -last but not least- the stimulation of 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 for a meter that allows a fixed switch between two tariffs: day- and night/weekend tariffs. It is expected that the roll out of smart metering will stimulate 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. 1.3 billion euro (SenterNovem, 2005).

Because the 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, a new cost benefit analysis was required to calculate the financial implications on a national level. The Ministry of Economic Affairs has therefore instructed KEMA to perform a revised cost-benefit analysis to gain insight into 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 urged 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 consumer can a detailed reading be taken. In the 2005 analysis detailed reading was still the standard situation.

2. The consumer will have the **option of refusing the smart meter**. This means that the consumer in question will keep his or her traditional meter. In the case of new construction and renovations it *does* become compulsory to install a smart meter, and there is no obligation to replace it with a traditional meter at the request of the consumer. In this case the consumer 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** into the direction desired by the Dutch government.

Referring to a situation of almost 100% acceptance of the smart meter as well as almost 100% standard readings, the updated cost-benefit-analysis concluded there is a positive business case of app. 770 million euro. 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 the management of the metering data;
- The smart meters must comply with the basic functionality and technology mentioned in the smart meter industry standard NTA-8130 and DSMR.

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

The government considered a mandated rollout as prerequisite, because it was expected that in a liberalised market, without further regulation, a smart metering roll out 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 three terms of intense debate and influenced by vigorous campaigning of the national consumer's organisation *Consumentenbond* and privacy watchdog groups, the Dutch senate (First Chamber) declined to approve the mandated roll out of smart meters. To solve the privacy issue in the Netherlands, the smart metering bill was reintroduced in September 2010, based on a voluntary rollout of smart meters and passed by the Dutch House of Parliament on 9 November 2010. The Senate will discuss the revised proposal probably in

January next year. General expectations are now that the Senate will also approve the revised bill and give permission to start a two year pilot-phase in order to gather and evaluate rollout experiences in 2011 and 2012. Based on this evaluation, a decision will be taken on the final rollout up to 2020.

The future legal and regulatory framework for the introduction of the smart meter in the Netherlands will therefore be based on a **voluntary rollout of smart meters** among all households. The actual legal framework does not allow for enforcement measures for the acceptance of the smart meter. The role of the government is to focus on stimulation, information and persuasion of smart meter acceptance. Areas for attention with respect to policy targets are the *acceptance* of the smart meter, the *effective use* of the smart meter and an *efficient rollout* of the smart meter.

In the meantime, a meter standard was defined for the residential meter market by the Netherlands Standardization Institute. This meter definition, with the registration number NTA 8130, defines a **minimal set of basic functions** for connecting the consumer to the energy distribution infrastructure in the Netherlands. The minimum functional requirements required in the smart meter include:

- Remote reading of the energy consumption (both periodic, actual and interval values);
- Remote reading of the electricity supply (both periodic, actual and interval values) – meant for individual (decentralized) generation;
- Monitoring of the quality of the electricity supply (outages, voltage swells and sags);
- Registration of violation and fraud attempts;
- Remote activation and deactivation of the energy supply;
- Temporarily limit the electricity supply by setting a threshold;
- The possibility to connect external services devices;
- Sending short messages to the display of the meter;
- Sending long messages to the meter for on-line interaction – these will be forwarded to the external devices;
- Status information (errors, tariff indicators, breaker and valve positions, thresholds);
- The possibility of firmware updates; and
- The provision of access and security.

3.19.3 Chronological overview of the development of smart meter legislation in the Netherlands.

The Dutch government already started thinking about smart meters since the liberalisation of the domestic energy market in 2004. The electricity and gas markets are now fully liberalised in the Netherlands. Water and heat are in practice not liberalised. The regulator for electricity and gas is DTE.

In February 2006, the Dutch minister of Economic Affairs submitted a ‘policy intention’ to the Lower House, addressing the restructuring of the meter market for small energy users. This as a part of a new (meter) market model for households and small business users (defined as having an electricity connection less than 3 x 80 A and gas usage less than 170,000 m3 per annum). Important drivers for the reform of the Dutch meter market were a strong desire to correct administrative problems with billing that followed the liberalization of the Dutch energy market. Other goals were to facilitate more energy market competition (easy switch for consumer), improve operational efficiency for market parties and –last but not least- the stimulation of energy savings for end-use customers. Also, in a liberalised market, without further regulation, a smart metering roll out would probably reach no more than about 30% penetration. In the case of a partial penetration, several of the smart meter benefits mentioned above would not be realised. Therefore, a 100% rollout was considered to be a prerequisite.

Except for the ‘national’ drivers, the legal rollout proposal was also be designed to meet the requirements of the Energy End-use and Energy Services directive (2006/32/EC). Because Article 13 in the ESD does not make an explicit link to smart meters, there is substantial variation in the interpretation of Article 13. While for some member states the existing meters in combination with an annual bill can fulfil the requirements of the ESD, the Dutch government interpreted the paragraph 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 for smart metering in The Netherlands.

In April 2007 a meter standard was defined for the residential meter market by the Netherlands Standardization Institute. This meter definition, with the registration number NTA 8130, defines a minimal set of basic functions for connecting the consumer to the energy distribution infrastructure in the Netherlands. The minimum functionality required in the smart meter includes:

- Remote reading of the energy consumption (both periodic, actual and interval values);
- Remote reading of the electricity supply (both periodic, actual and interval values) – meant for individual (decentralized) generation;
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- Registration of violation and fraud attempts;
- Remote activation and deactivation of the energy supply;
- Temporarily limit the electricity supply by setting a threshold;
- The possibility to connect external services devices;
- Sending short messages to the display of the meter;
- Sending long messages to the meter for on-line interaction – these will be forwarded to the external devices;
- Status information (errors, tariff indicators, breaker and valve positions, thresholds);
- The possibility of firmware updates; and
- The provision of access and security.

The Netherlands Standardization Institute also ruled that meter technology will not be dictated, but rather there must be a functional basic level on the basis of which grid operators are able to perform their public tasks and for which commercial parties can develop services. In this respect, other important key aspects of the smart meter are interoperability and compatibility between systems.

In 2008, 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, was discussed in the House of Representatives. Following consultations in the 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 supplier/ energy retailer will be given some initial influence on rollout prioritization;
- 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 the management of the metering data;
- The smart meters must comply with the basic functionality and technology mentioned in the smart meter industry standard “NTA-8130 and DSMR.
- The intention to meet the obligation arising from the ESD to provide regular feedback to consumers about energy consumption, has led to a preference for setting a minimum frequency of 6 times per year (every two months).

The rollout of smart meters 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. These costs will now become regulated, while the data collection costs, which will be set by the supplier, will be unregulated.

Although the House questioned the smartness and possible privacy implications of the proposed smart meter, the mandated rollout was reluctantly adopted by the House of Representatives on 3 July 2008. Especially the Netherlands' main consumer organisation Consumentenbond opposed the new law, mainly because of privacy concerns. Moreover, the Consumentenbond questions the energy saving claims of the smart meter.

To obtain approval from the House, the Minister of Economic Affairs agreed to facilitate the following extra functions regarding the smart meter (Samson six, named after Labour member of parliament Diederik Samsom):

1. More possibilities for own energy generating;
2. A user friendly direct display for in home use;
3. An alarm for unexpected peak usage;

4. Real time measuring and use versus own generating of energy;
5. Possibilities for remote programming of appliances such as laundry machine or dryer;
6. Possibilities for communication with other meters.

Other points of agreement between the Minister of Economic Affairs and Parliament are:

1. The introduction of a standard bill for consumers;
2. Higher volume (5000 kWh instead of 3000 kWh) for own generation of electricity;
3. Timely billing by grid operators.

Regarding the **privacy concerns**, the Ministry of Economic Affairs also promised to ensure that privacy-sensitive 15-minute and 60-minute measurement data will only be used for specific purposes and only for which the customer has given its consent. Additional regulation will set out what measurement data these parties need in order to provide the customer with the desired services. Important is the distinction between the minimum level of consumption data required in all cases in order to bill the customer for the quantity of energy supplied (for example the two-monthly meter readings in kWh and m3) and consumption data at a lower aggregate level (for example weekly meter readings in kWh and Wh). When entering into a supply agreement, the customer will be obliged to authorise the supplier to use the minimum requisite level of consumption data. Small consumers have to explicitly give their consent before commercial use can be made of any other measurement data and data beyond the minimum regulated level (for example, actual output). The customer therefore determines in all cases in advance, which measurement data generated by the smart meter is to be used by which party. To be able to access the measurement data to be provided by the grid operator as standard, the grid operator has set up authorisation and authentication procedures. These procedures must ensure that individual measurement data is only used for the specific purposes for which the customer has given its consent.

Last but not least, the Minister of Economic Affairs agreed that the introduction of smart metering will take place in two phases: a two year ‘try-out’ phase en an ‘acceleration’ phase after evaluating the qualities of the present smart meters being used so far. During the try-out-phase, the roll out of smart meters would only be compulsory in new construction, renovations and large-scale redevelopment projects. However, after this period, the introduction of smart electricity and gas meters in virtually all households would become mandatory in the subsequent period (likely to be a period of six years).

On April 7th **2009** and after three terms of intense debate and influenced by vigorous campaigning of the national consumer’s organisation Consumentenbond and privacy watchdog groups, the Dutch senate (First Chamber) declined to approve the mandated roll out of smart meters. Most crucial in the debate was the publication of a report by university of Tilburg researchers, commissioned by the Netherlands' main consumer organisation, to look into the privacy aspects of the smart meters. The report indicated serious privacy issues related to hourly and 15-minutes readings. This information could give away sensitive information about the consumer's habits (i.e. when someone leaves the house or returns). Second, the smart meter could provide insights into a family's living patterns and relationships "which can affect people's freedom to do as they please in the confines of their homes". Third, there is a risk that information about a person's energy use will fall into the hands of third parties such as the police or insurance companies. As a consequence, a mandated roll out of the smart meter is being considered a violation of the right to privacy as guaranteed by Article 8 of the European Convention on Human Rights. Finally the Dutch Senate considered the mandatory nature of the rollout unacceptable: refusing a smart meter would be considered an ‘economic offence’, punishable with a fine up to 17,000 euros or six months in prison.

To solve the privacy issue In the Netherlands, the smart metering bill is reintroduced in 2010, containing a compromise (voluntary) version and offering four legal options for a consumer in accepting a smart meter (see details below). This compromise proposal was accepted by the Dutch Parliament on 9 November 2010. Expectation is that the start of the two year trial/pilot will start in the beginning of 2011. After that there will be an evaluation which (could) start(s) the roll out in 6 years.

3.19.4 Smart Metering Landscape in the Netherlands

Following a controversial public debate on the introduction of smart metering in The Netherlands, on 9 November 2010 the Dutch House of Parliament passed a revised bill that is based on a voluntary rollout of smart meters. Following the acceptance of the Senate, which is expected in January 2011, a two year pilot-phase will be started in order to gather and evaluate rollout experiences in 2011 and 2012. Based on this evaluation, a decision will be taken on the final rollout up to 2020.

Considered to be a responsibility of market parties, the provision of metering services is not part of the Dutch regulatory framework. However, within the settlement of the functionality of a ‘standard smart meter’ under the supervision of the Dutch Standardization Institute (NEN), dedicated functionalities to support metering services have been included in the so-called ‘Dutch Technical Agreement’ in this area (NTA 8130), which later was expanded with the so-called Dutch Smart Meter Requirements (DSMR) under the control of the Dutch Independent Grid Management Company.

These minimum specifications and requirements for all gas and electricity smart meters should allow grid operators to perform their public tasks and commercial parties to develop smart metering services. In this respect, other important key aspects of the smart meter are interoperability and compatibility between systems.

The current state of smart metering services in The Netherlands is also closely related to the **four legal options for a consumer in accepting 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 your 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 remove to a new 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. This is (of course) the preferred option for the government and energy market players.

The consumer's opportunities for saving energy depend on the meter choices mentioned above. It is important that even with a meter that is turned to 'administrative off' additional services via the P-1 port and the installation of a display are still possible. The starting point is that a standard reading also provides standard indirect feedback. With detailed meter readings additional services are possible, such as time-based tariffs (detailed time of use tariffs, ToU), variable price contracts (real-time pricing, RTP) and demand management (demand side management, DSM). The starting point is that direct feedback must always be via the P1-port.

In short, the acceptance level of the smart meter is relevant for achieving a positive Dutch business case in which the effects of energy saving services are considered to be the most important benefits.

3.20 Norway

In the Norwegian deregulated power system, the final customers are free to choose their power retailer. This means that the 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 and the energy contract is based on a contract between the power retailer and the 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 second quarter of 2010 55% of household customers had an energy contract related to the market price (NVE, 2010b).

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 EUR 625 Mill.[24] 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 additional 625 mill. Euros (TU, 2010).

3.20.2 Legal foundation of smart metering services

3.20.2.1 Provision in the Energy Law

The prevailing Norwegian requirements regarding metering and settlement of the electricity consumption are specified in a regulation (FOR-1999-03-11-301).[25] 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 larger 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 meterings should be performed at the turn 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.

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 2005/2006 a survey was performed to find 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 this (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).

In January 2011, Ministry of Petroleum and Energy asked the Norwegian regulator to submit a proposal for earlier installation of smart metering technology in Central Norway by 2013.

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[24] 5 bill. NOK

[25] “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).

Moreover, the final deadline for the rest of the country should be expedited to the end of 2016. This will be included in the discussion document concerning smart metering that is released in February 2011.

3.20.2.2 Market model and responsibilities for metering

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.

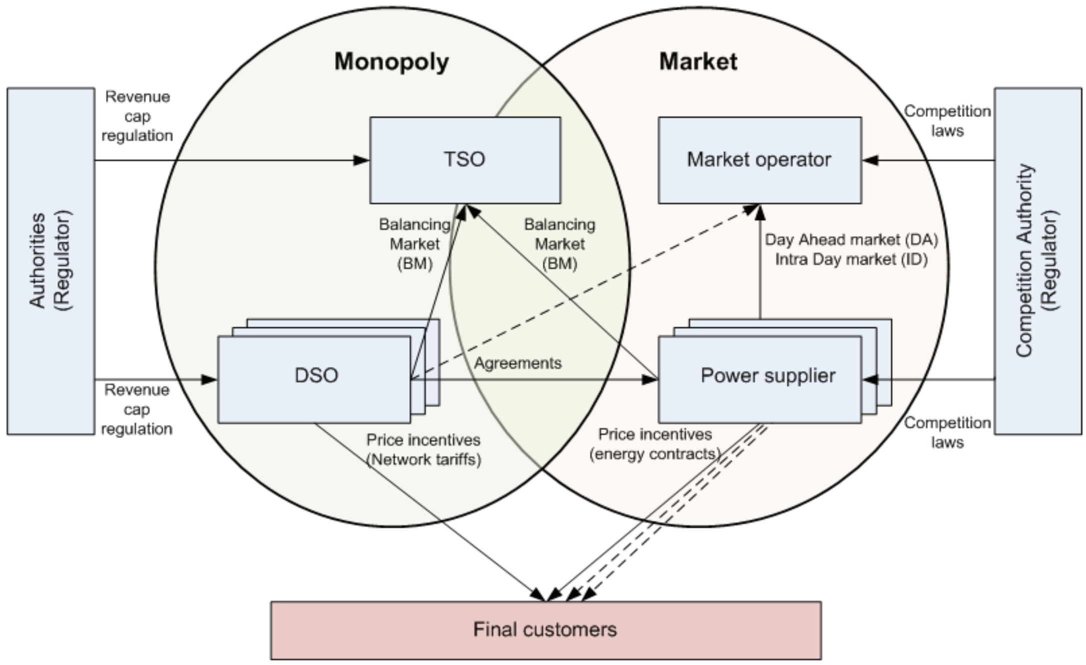

Figure 5: Monopoly actors and market players (Sæle, 2010)

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 organizer of the Balancing Market (BM). The market operator (NordPool) is the organizer of the Day Ahead (DA) and the Intra Day (ID) market.

The figure also indicates the network tariff and the energy contract that the final 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.

3.20.2.3 Minimum functional requirements

A discussion document concerning changes in the regulations for metering and settlement was published in autumn 2008 (NVE, 2008). The changes were planned to come into force 1. January 2014. NVE (2008) mentioned that it should be possible to connect external equipment to the AMR system, but it was not specified what kind of equipment this should be – not the communication capacity nor the communication speed.

Due to a lot of responses in the first public hearing the discussion document in 2008 was followed up by an additional hearing document (NVE, 2009a).

The suggested new regulation (§3-11) concerning smart metering was as follows (NVE, 2009a):[26]

"The DSO shall install technology for smart metering in every metering point. The metering system shall among other things contribute with data necessary to accomplish change of power supplier and for settlement of network services.

All meter value shall:

a) be registered and stored in the metering point until they are transferred to the central system at the DSO.

b) be stored with a registration frequency of maximum 60 minutes, and

c) be transferred to the DSO at least once a week.

The metering system shall also:

a) be able to store data with a registration frequency of 15 minutes,

b) make it possible to collect meter values instantaneous on request from the DSO,

c) with one second accuracy register the time of and the duration of all instances when the voltage is under 50% of the nominal value, and data shall be transferred from the customer to the DSO,

d) be able to connect and communicate with external equipment, where the communication and the interfaces are based on open and non-proprietor standards,

e) be able to register and store data at the customer site, in case of power outages,

f) be able to prevent misuse of data and that the system prevents unwanted access to the systems both locally and centrally.

If the customer claims it, the DSO shall install metering system for registration of local production. The customer shall cover the extra costs related to this.

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[26] Translation: Hanne Sæle

Metering points with a yearly consumption less than 1000 kWh can be excepted from the requirements for smart metering.

The DSO shall free of charge offer the customer information about their own consumption. The information shall be available via internet. A third-party can with authority from the customer, free of charge get access to settlement data from the DSO."

After the second hearing round in autumn 2009 it was decided to postpone the final decision regarding full-scale implementation of smart metering in Norway. The reason for this postponement was that international standards were described as an important prerequisite to secure a real competition between service vendors, vendors of metering technology and communication equipment and between other vendors of different software systems, and that European standards within this area were expected to be available at the earliest during the first half-year of 2010 (NVE, 2009b).

According to a letter dated 2. July 2010 NVE expect that a decision regarding new regulations can be taken during first six months of 2011, and that full-scale deployment of smart metering can be completed within 1. January 2018 (NVE, 2010a). In January 2011, however, the Ministry of Petroleum and Energy asked the Norwegian regulator to submit a proposal for earlier installation of smart metering technology in Central Norway by 2013. Moreover, the final deadline for the rest of the country should be expedited to the end of 2016. This will be included in the discussion document concerning smart metering that is released in February 2011.

3.20.3 Smart Metering Landscape in Norway

Smart metering has been a hot topic for several years, and it was already in 2002 proposed that all final customers should be offered technology for AMR (Dok 8:139 (2001-2002)).[27] Even if the process for introduction of smart metering technology has lasted for a long time, it did not speed up before 2007. Since then two hearing rounds concerning new regulations have been performed. The first suggested deadline was that AMR should be deployed in full-scale until 2012, but after several delays, it is now suggested that AMR should be deployed in full-scale until 1.1.2018 – provided that new regulations will be completed during the first half year of 2011. The DSOs will then have 6.5 years to change the existing meters with new smart metering technology.

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

[27] Dok 8:139 (2001-2002). "Forslag fra stortingsrepresentant Sylvia Brustad om å legge til rette for at strømkunder over hele landet får tilbud om toveiskommunikasjon mellom strømkunde, strømleverandør og nettselskap", ("Proposition from member of Parliament Sylvia Brustad about an arrange for two-way communication between final customer, power retailer and Distribution System Operator " - In Norwegian) Dokument 8:139 (2001-2002).

Some Norwegian DSOs have already performed 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 final customers. The DSOs are awaiting final requirements from the Regulator – to reduce the risk of sunk investments.

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 the electricity consumption.

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 experience is not common for the DSOs in the distribution grid. If thinking locally the DSOs have therefore less incentive to introduce tariffs that stimulate for demand response and energy efficiency.

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

3.21 Poland

The driver for the implementation of smart metering in Poland are EU directives (especially Directive 2006/32/EC and 2009/72/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.[28]

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, Consumer Federation, Association of Polish Consumers 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 electricity, gas, heat and water supply sectors. It should be supported by newest, cost-effective IT and telecommunication technologies, which improve people quality of life. The Platform will support the research in that area. Secondly, introduce knowledge about innovative solutions in the knowledge-based society development process.

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

Thirdly, initiate the cooperation of “energy coalition” partners. The “energy coalition”, which consists of individuals, social groups, consumers and industry organizations, enterprises and the 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, efficiency energy. Fourthly, disseminate knowledge about innovative solutions to final consumers.

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 organization 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 optimization, protecting 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 commercialization of its researches and technology solutions. The consortium not only wants to cover the Polish energy market but it is going to undertake also international activities.[29]

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:[30]

- limiting increases in electricity prices for end-users through the implementation of new mechanisms for competitive electricity market, in particular the disclosure of price elasticity of demand,
- strengthen energy security – including to improve the quality of 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 show the resulting potential for increased energy efficiency at the level of 6-10%,[31]
- simplify the procedures for amending the energy distributors,

In Poland the PSE-Operator is responsible for preparation “Smart Metering” system to improve security and reliability of polish power system. The scope of the project is:[32]

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[29] http://www.ure.gov.pl/portal/en/1/91/Smart_Power_Grids__Poland_consortium_has_been_established.html
[30] http://www.piio.pl/smart_metering_w_polsce.php
[31] http://www.piio.pl/smart_metering_w_polsce.php
[32] http://www.piio.pl/prowadzone_projekty.php

- global benefits and costs analysis of Smart Metering and DSR (Demand Side Response) implementation",
  - fulfill the obligation of Directive 2009/72/EC,
  - provide guidelines to decision makers,
- developing model of metering data flow on the energy market,
  - design area of responsibility,
  - design the rules of communication,
  - design financial flow,
- developing DSR programs,
  - incentive-based DSR program,
  - emergency DSR program.

Benefits attributed to smart metering for different stakeholders:[33]

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

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

- Use of demand management techniques stimulated by:
  - differentiation of daily distribution bids and electricity prices
  - transmission of price signals to the consumers through remote two-sided communication with electricity meters,
- Information and educational campaigns in order to promote rational energy consumption
- Project of Energy Efficiency Act:
  - Decrease the energy consumption by 9% by year 2016 comparing to consumption in year 2007

[33] http://www.piio.pl/prowadzone_projekty.php

3.21.2 Legal foundation of smart metering services

Work began on the development of legal solutions, which create conditions for the gradual implementation of smart metering. The Energy Regulatory Office is responsible to prepare the legislation package for Ministry of Economy and Polish parliament. It is expected that legislative work will take approximately two years. In parallel PSE Operator works on the system, whose aim is to provide global benefits of the implementation of smart metering and to develop an optimal model for implementing such system.[34]

The Energy Regulatory Office (ERO) is responsible for preparing the necessary regulations. During 2009-2010 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, Consumers' Federation, Polish Consumers' Association, The Polish National Energy Conservation Agency, Consumers' Forum for Electricity and Gas. Many other bodies (administrative, academic and business) have confirmed their readiness to co-operate and support this initiative.
- Education:
  - the Emery Regulatory Office (ERO) web site,
  - press releases and press conferences,
  - content-related conferences,
  - ERO personnel activity on many other conferences and workshops.
- Co-operation related to :
  - Transmission System Operator,
  - Distribution System Operators,
  - Branch Chambers of Commerce,
  - Universities of Technology.

Moreover, the Polish Ministry of Economy has initiated legal acts:[35]

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 has in June 2010 initiated an information platform.[36] Smart meters are also regarded to be a first step towards the implementation of intelligent networks in Poland.

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[34] 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.

[35] Draft law on energy efficiency in Poland - project directed to the parliament; Draft guidelines for legislation implementing a system of protection of vulnerable customers of electricity - a draft framework on 18 February 2010, was discussed at the meeting of the Standing Committee of the Council of Ministers and then submitted for consultation and arrangements established to the Working Group (http://www.piio.pl/regulacje_prawne.php#a2).

[36] www.piio.pl

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 issues, the legal and socio-economic. It also outlines the scope of work and sets out a timetable for full implementation of the system in our country. It is assumed that implementation of the system will take up to 10 years.[37]

An analysis of the PSE Operator show basic conditions for implementation of Demand Side Response (DSR) mechanisms in Poland.[38] The preparation of the project is supported by the National Fund for Environmental Protection and Water Management "Smart energy networks.” Base for DSR implementation is ability to record energy consumption within particular time periods.

Broad business initiatives in the next coming years are:

- 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 energy transmitted to the customers. The entire project is valued at 1 billion PLN, 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, reduction of 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 rapid identification of failure and reduces the time it repairs.

The other energy distributors are a few steps behind Energa. RWE Stoen Operator has launched a pilot program for individuals and develops them in a device designed to further modernize the network measurement. Already at this time all counters that are installed in the operator RWE Stoen are prepared for 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 program is already used widely in industrial customers.

[37] www.ure.gov.pl/download.php?s=1&id=2736

[38] http://www.piio.pl/bszpre_produkty.php

A similar program runs EnergiaPro. The project will cost 10 mln PLN and cover 20,000 customers by the end of next year. Until 2015, the company is considering extending the project to 20% of their customers. The operator sees another advantage of this approach. Intelligent supply network will allow 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, clients will receive higher compensation for the interruption in the supply.

Another company to check the technological capabilities of smart meters system on 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 on the traffic regulation. At present the development plan is under negotiation with the ERO, which determines the size of investment in smart meters development program.

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.

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 for the management of 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 with the installation of smart meters are mainly to implement European legislation. The Regulatory Compatibility Plan agreed by the Portuguese and Spanish governments on the 8th March 2007 foresees a timeline for the establishment of homogeneous meter specifications and minimum functional requirements.[39]

3.22.2 Legal foundation of smart metering services

- **Provision in the 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 for the substitution of energy meters. Previously, a pilot project should be performed. At present, there are no regulations related to a rollout of smart meters.
- **Responsibilities for metering**: Distribution companies (operadores de redes de distribuição) are responsibles at present for metering issues.

[39] Entidade Reguladora dos Servicos Energéticos.

- **Minimum functional requirements**:[40]
  - Active and Reactive measurement in any direction (bi-directional),
  - 15 minutes maximum demand,
  - 15 min load profile for a minimum of 3 months,
  - Up to 6 programmable registers of energy 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 substitution 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 customers including domestic sector and small companies (99% of consumers). 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 year 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 Mill. 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 consumer to know, in real time, the expense of energy of his house, to know where can save energy and to

[40] Entidade Reguladora dos Servicos Energéticos, December 2007

choose for a more efficient consumption. By the end of 2010, around 30,000 low-voltage customers (residential, small businesses and industry) will be connected to this integrated and intelligent electricity system, covering the entire municipality of Évora.

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 is also the regulator for the gas sector (ANRGN). It is an autonomous public body co-ordinated 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 by the Metering Code of ANRE.[41] The installation and maintenance of the metering system could be carried out by any metering operator with ANRE Certificate. 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 (Open Meter Consortium, 2009).

In Romania there are two types of customers (for electrical energy): (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 at low voltage, low power (households) and comprises approximately 8 million metering units. These customers count for 17% from the total electrical energy consume and 24% from the total installed power. The smart metering procedures in Romania can be implemented only 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 parc that has to be modernised, a high ratio of customers on double tariffs with dynamic schedules and a high incidence energy theft which also are arguments for the introduction of electronic meters.

41 ANRE (2002). Codul de măsurare a energiei electrice (Metering Code), 21/06/2002, Bucharest, Romania.

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). However, there are no specific legal provisions for services based on intelligent metering services. The electric energy measurements is described in Art. 60:[42]

1. Electricity sold on the market is measured by the metering service providers/operators using measurement chains, according with 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) consumers.

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 electric energy measurement service for the users of the electric network directly or by using an independent measurement operator named by them, on the condition to fit the costs agreed by the authority in charge.

5. In special situations, when the transport and system operator (TSO) or distribution operator (DSO) do not meet the deadline for installment of the measurement group following the conditions agreed, the providers or the clients could choose an eindependent metering operator to provide this operation on their own expense, and after a previous notificatin of the in charge authority.

Art. 22 demands from the measurement operator to communicate, on request, the measured or processed information to the commercial operator, the system operator, partners for each point of exchange and other metering operators, agreed based on contractual relations.

The most important regulator initiatives impacting SM/AMI are: Definition of a new complex Time of Use (TOU) tariff system for domestic customer in 2000; the last update of this system includes tariffs based on day of week and time of use that requires electronic meters in order to be metered; approval of the first draft of the metering code (this document defines the metering point category depending on energy consumption and power capabilities of the connection point; for every metering point category the minimal set of facilities of the meters are defined; launching internal technical specification (ST22) by DSOs: for example Electrica; new trials on SM/AMI technology inside DSOs; separating distributor from supplier in the unbundling process and the Consumer switching detailed process definition lead to the need of profiling; the first step was to get to experimental use of residual profile all over licensed area.[43]

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[42] Legea energiei electrice (Electric Energy Law), Art. 60 – Măsurarea energiei electrice (The electric energy measurements), Monitorul Oficial, Partea I nr. 51 din 23/01/2007

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

Art. 20 of Energy Law defines the metering operators for each category of points of measurements. The authority names one or more metering operators for each chategory 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 licence or, following the provider agreement, these could be industrial consumers that agree to follow the provisions of the present Code.

For all customers at low voltage, the "meters reading" is performed every 3 months or every 6 months, and the invoice is issued related to the energy consume (either actual or foreseen, according to the type of contract; in case of "foreseen contractual energy consume", the actual reading of the meter information is done yearly).

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 until 2012 a decision regarding "massive deployment" of smart meters in Romania will be taken.

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)).

3 from 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 of 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 type of meters and the total number of clients. This table is referring to the Electrica' customers only. However, at the beginning of 2003, this DSO served more than 80% of the customers in Romania.

Table 3: Smart Metering/AMI evolution in Electrica

Year	Clients	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 synchronized recording, at least once in a day, of the hour by indices on the electric meter in a direct way of through concentrators.
- Art. 79 (1) The indices are kept in the data base for a period of 400 days at minimum.
- Requirements for B-class metering, AMR - **Central measurements level**
- Art. 136 The indices are preserved in a data base for 400 days minimum.
- Requirements for C-class metering, AMR - **Central measurements level**
- Art. 180 The acquired data values are kept in a local data base on the central point, for 400 days at 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 assure at least one recharge terminal for each 1000 prepay electric meters installed and at least one recharge centre for 10,000 installed prepay electric meters, but not less than one centre for each urban place, and one centre for three neighbour villages on rural places.

Table 4: 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
	Braila	1	GPRS		1,219	yes	no
		2	PLC	100	2,344	yes	test
	Buzau	1	GPRS		1,057	yes	test
	Targoviste	3	dial up		1,000	no	no
		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, September 26 - October 1, 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 standardization leads to uncertainties 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.[44]

3.24 Slovak Republic[45]

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.[46]

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 prenos-ova sustava, a.s. (SEPS) (Slovak electricity transmission system, Plc.).[47]

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

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

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

[46] www.enercee.net

[47] www.enercee.net

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

Gas:

- Distribution network provider is obliged to measure a gas supply, install an energy measurement equipment and verify the accuracy of measurement.
- If 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:

- Heat supplier has to measure the amount of supplied heat on each agreed delivery point.
- Contractor is supposed to ensure the verification of designated meter, ensure it against tampering, inform the customer about the replacement of meter, record the data of exchanged meter, perform monthly readings of designed meter and carry a monthly balance of heat production and supply.
- If the customer has doubts about the accuracy of the measured data or measurement equipment, he can ask heat supplier for testing. This is required within 30 days from the official written request.

- Supplier who supplies heat from combined heat and power is obliged to provide extra measurement for the amount of produced heat and the amount of produced electricity.

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 a discussion phase. DSOs gradually install smart meters on voluntary basis preferably for delivery points with the high consumption e.g. in the industry sector or where it is adequate to potential energy savings. There is no central registration of installed smart meters at the state level.

3.25 Slovenia

3.25.1 Policy objectives for the introduction of smart metering

Currently there is no legislation in Slovenia regarding the introduction of smart meters. 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 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 on internal decisions. So far, there have been no serious discussions between the Slovenian stakeholders about the benefits of smart metering for different stakeholders. Moreover, data security, privacy issues and the possibility of time-of-use tariffs have not been discussed in detail.

It can be expected that the main policy objective for Slovenia will be compliance with EU legislation. Other aspects such as support for competition, strengthening of consumer rights or energy efficiency will need further discussions in Slovenia.

In 2008, EIMV[48] (Milan Vidmar Electric Power Research Institute) has carried out an analysis for the rollout of AMI-systems which evaluated the costs and benefits of the systems for household and small business customers[49]. 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 at about EUR 235 million, which is EUR 266 per consumption site.

The assessment of the advantages of the system implementation came to the following results:

- Lower costs for meter readings
- Possibility for Demand Side Manegement (DSM)
- Combined automated meter reading for electricity, gas, water and heat

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[48] EIMV: Elektroinstitut Milan Vidmar, Ljubljana

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

- Possibility for better information of customers about their consumption (Inhouse displays)
- Possibility of accurate monthly billing
- Accurate data enables more cost efficient distribution system planning
- Faster detection of power outages
- Easier integration of distributed generation
- Lower administrative costs for supplier switching
- More accurate consumption planning

In the assessment EIMV has calculated a net present value of approximately EUR 115 mill. The internal rate of return is 10.4 percent and the payback period is about 11 years.

EIMV has carried out another cost benefit analysis in 2010 for SODO d.o.o.,[50] which is the Slovenian distribution system operator. According to information from the author, the new analysis shows better results because of a reduction of costs for smart meters. The detailed results of the study have not been published yet.

At the time being, however, there is still no official cost-benefit analysis as it is required by Directive 2009/72/EC. It depends on the decisions of the Ministry of Economy whether there will be need for another cost-benefit analysis, or the existing one will be accepted as sufficient.

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 household 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 Jan 1, 2008. These meters measure the daily load profiles of the customers in 15-minute-intervals.

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 its 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.

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[50] SODO d.o.o. is a central Slowenian Distribution System Operator which operates the networks of the following electricity distribution companies in the Republic of Slovenia: Elektro Celje, d. d., Elektro Gorenjska, d. d., Elektro Ljubljana, d. d., Elektro Maribor, d. d., Elektro Primorska, d. d. and some closed distribution systems in the Republic of Slovenia.

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).
- Consumer protection: Exact and frequent billing; Energy meters substitution plan, an obligation to install smart meters in all consumers under 15 kW by 2018 (in steps).
- Smart grids: To allow the energy hourly 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 final customer.

3.26.2 Legal foundation of smart metering services

- **Provision in the Energy Law**: Establishment of the meter substitution plan in those users up to 15 kW with the aim of supporting remote management systems. Deadline is 31st December 2018.[51]
- Regulation existing in Spain related to smart meters implementation:
  - RD 1634/2006: Order to the Regulator (Comisión Nacional de Energía, CNE) about Substitution Plan including the Substitution plan for all Spanish residential meter, criteria for the substitution and number of meter to install every year: percentage of the total equipment.
  - ORDEN ITC/3860/2007: Publication of the criteria for the Substitution plan, including that every distributor has to present its own plan and AMM system design.
  - Based on the Royal Decrees a meter substitution plan was established with an obligation to install smart meters for all consumers under 15 kW by 2018. By 31st December 2010, 30% of the contracts from each distribution company below 15 kW should have the smart meter installed. Distribution companies are responsible for the installation of the meters. The schedule of the plan is as follows:

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

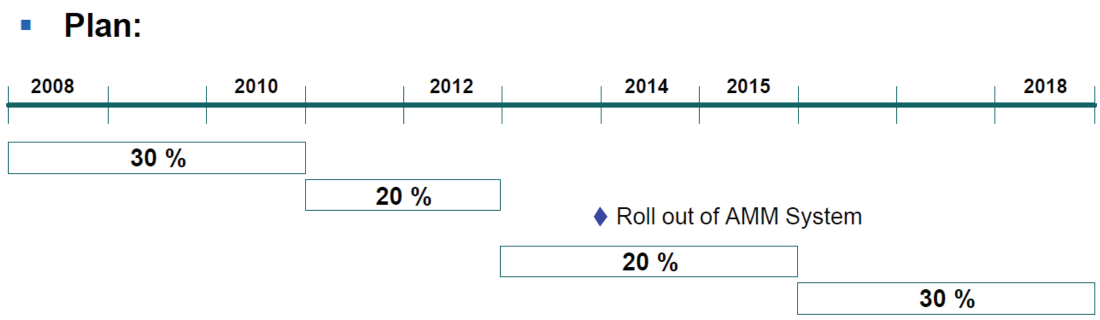

Figure 6: Timeline of Spanish Meter Substitution Plan

- **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 and responsible for the smart metering services. There will be a monthly fee for the meters.
- Minimum functional requirements for the metering system: [52]
  - Electronic meters with remote control available for residential sector. Hourly metering and option for hourly tariff selection ("*discriminación horaria*").
  - Remote management system ("*sistema de telegestión*") is defined as the metering and bidirectional system between meters and distribution companies, with availability of remote access to electric energy meters for reading, energy management, control on the power demand and contract, supply (dis-)connectivity management and others.
  - Update of the previous definition with:
    - An electric energy meter is a device that measures sparely and at the same time active and reactive energy in a circuit
    - Hourly discrimination system is defined as the device or devices that allow to register consumptions in different periods depending on the consumption hour and date
    - Remote management ("*telegestión*"): as the metering and bidirectional system between meters and distribution companies that, with the maximum guarantees of security, allows availability of remote access to electric energy meters for reading, energy management, control on the power demand and contract, supply (dis-)connectivity management and anti-fraud mechanisms.
    - Metering equipment is prepared to: Measure active energy and reactive energy, measure maximum demanded power (15 min 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.

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

- Metering system (AMM) should be able to:
  - AMR: Remote reading of energy and power for billing
  - Remote reading of quality parameters
  - Change of tariffs, periods, contracted power, etc.
  - Remote Synchronization (at least every reading cycle)
  - Meter Software Update
  - Remote reading of events
  - Remote disconnection and reconnection
  - Management of registration and cancellation of household customer
  - Roll out 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 substitution 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 substitution 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 ongoing 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) has installed 22,000 units during 2010 in several main cities of Spanish regions (e.g. Málaga Smart City project), while the target is to install 1.5 million meters by 2011 and 13 million units by the end of 2015. The investment cost is around EUR 142 per meter. 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.
- Iberdrola has started with the installation of approximately 50,000 units in the pilot city of Castellón during 2010 and start of 2011, where it is scheduled the installation of 100,000 units. The complete project involves 11,000,000 users.
- Gas Natural Fenosa has started several pilot projects adding 5,000 units by 2010, checking different solutions available. By 2011 it is expected that 200,000 units are installed. The SCALA project aims at installing 80,000 meters in the Region of Madrid.

- E.ON has installed 134,000 smart meters by 2010, while they schedule to reach 100% of their customers (750,000) by 2015. E.ON develops a tool for real-time feedback to their customers as well as peak management programmes.
- Hidrocantábrico (EDP group) has installed 550 units by 2010 in a pilot action while they are analysing the different solutions for the system.
- More specifically, in Spain the meters are owned by the DSOs or the private households. The second option needs of the approval of the owners if meters are changed to electronic ones, which can delay the implementation of the projects. However, building owners who own the meters are in principle legally obliged to accept the substitution of the meter.

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 electricity consumption. This represents almost 6 times world average and twice OECD average. By requiring monthly readings of all electricity meters, the legislators wanted to ensure that consumers would get more comprehensible energy bills based on actual consumption and to be able to get immediate financial rewards for energy conservation 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 mandate automatic meter reading (AMR) (indirectly) by legislating new national metering regulations. The regulations are only mandatory for electricity meters.

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 government mandated monthly invoicing from 1 July 2009, and this encouraged widespread deployment of remotely readable kWh meters (Vasconcelos, 2008). All metering points should be read monthly and the final 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 final customer switch to another power retailer (Mät, 2008).

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

The new legislation has encouraged widespread deployment of smart meters, which in practice means that by summer 2009 nearly all final customers in Sweden had remotely readable kWh-meters installed. Even though the legislation requires monthly reading, several DSOs have already indicated that they will 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). Further 3.9 Mill. 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 EUR 1.0 – 1.5 bill. (SwedEnergy 2009). There are no mandatory requirements for 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 5.2 Mill. final customers (Badano et al., 2007). About 4 Mill. of these were household customers and holiday houses. At this time there were about 170 DSOs, 100 power retailers and 35 balance responsible companies in Sweden.

The final customer has a contract with the DSO to be connected to and make use of the power distribution network. The final customer pays for this service trough a network 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 final customer has a contract with the power retailer for buying electricity (SEHB 09A-2009).[53]

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

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 final 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 power retailer, DSO and final customer:

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[53] 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/

Power retailer:

- Reduced risks – more stable income
- New products

DSO:

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

Final customer:

- Better price products – possibility to save money
- More detailed information about their own energy consumption gives better control and the possibility to reduce the consumption
- Possibility for analyses and advices for 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 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 final 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). 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 final customers with a fuse description < 63 A (Household 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 cannon 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 turn 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 distribution company. Start an duration time of the power cuts should be registered. The electricity customer can apply for compensation for power cuts of 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 got installed technology for AMR. 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. Despite this requirement several DSOs have implemented smart metering technology that can handle hourly metering of the consumption.

3.28 United Kingdom

3.28.1 Policy objectives for the introduction of smart metering

The Open Meter Consortium (2009) provides the following overview of the present situation in UK regarding the implementation of Advanced Meter Management Systems (AMM Systems):

- Advanced metering mandated for large/medium businesses (electricity Profile Classes 5 to 8), and gas (non-daily metered >732MWh p.a.), to be completed by 2014 (5 year rollout);
- Further decisions awaited from Government on small/medium businesses (electricity Profile Classes 3 and 4, non-domestic unrestricted/Economy 7), and gas (non-daily metered >73MWh p.a.);
- Mandate in place for domestic rollout of smart metering (electricity Profile Classes 1 and 2, domestic unrestricted/Economy 7), and gas <73MWh p.a., with 2020 target completion date (further decisions awaited from Government);
- Industrial and Commercial sites (where demand is >100kW for 3 consecutive months (for electricity), and consumption >58,600MWh p.a. (for gas), are required to have half-hourly metering, or daily-read metering respectively

There are plans for new mandatory requirements to Electricity and Gas (Open Meter Consortium, 2009):

- Electricity
  - Residential meters, installation by 2020 with 27 Million meters replacement.
  - Small/Medium business, installation by 2020 with 2.2 Million meters.
  - C&I meters from 2009 to 2014, 168.000 meters.

  - To provide measured electricity consumption data for multiple time periods, and at least half-hourly, and to provide the licensee with remote access to such data (Code of *Practice 5 or Code of Practice 10 metering);*

- Gas
  - Residential meters, installation by 2020 with 20 Million meters.
  - C&I meters, installation by 2020 with 400.000 meters:
    - To provide measured gas consumption data for multiple time periods, and at least half-hourly, and to provide the licensee with remote access to such data.

Compliance with EU-directives: As regards the cost-benefit analysis required by the Directive 2009/72/EC: In December 2009, the Government published an impact assessment of a nation-wide smart meter rollout for the domestic sector. This included figures for the cost benefit of various levels of functionality for electricity and gas smart metering. The government estimated that in the preferred central communications market model, fitting 26 million homes with smart meters by 2020 would cost around £8,6 billion, at a cost of about £340 per household. However, the cost would be more than compensated for by £14,6 bn of savings in the operational costs of energy companies and lower bills for customers (DECC, 2009).

Consumer protection: In general the UK consumer body has been in support of smart metering. EnergyWatch (which was been absorbed into Consumer Focus) recognised the benefits of eliminating estimated bills and better switching, as well as the savings. As the rollout approaches Consumer Focus is now addressing consumer interests such as privacy and costs for the consumer. The government has recognized the importance of consumer engagement in the national rollout plan (DECC, 2010), and the documents on consumer protection and privacy were welcomed by consumer groups (Ofgem, 2010b; Ofgem, 2010c). However, there still remains some scepticism on how much the rollout will eventually cost to consumers, given the large benefits it will provide to industry.

Exact and frequent billing: As regards the 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 test meters if customers dispute the accuracy of the meter.

Energy efficiency and carbon reduction: The initial consultation document argues that initial government estimates suggest that smart meters could save around 34m tonnes of CO_2 emissions over a 20-year period as people become more aware of the energy they were using. However, energy savings depend on consumers' behavioural response to information and changes to them affect the benefits substantially (DECC, 2009).

3.28.2 Legal foundation and functional requirements

The main energy suppliers, rather than distribution networks, 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.[54]

For the relevant ministry DECC (2010, 25), 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 coordinated by a central data and communications entity (DCC) across the whole of the UK.[55] 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).

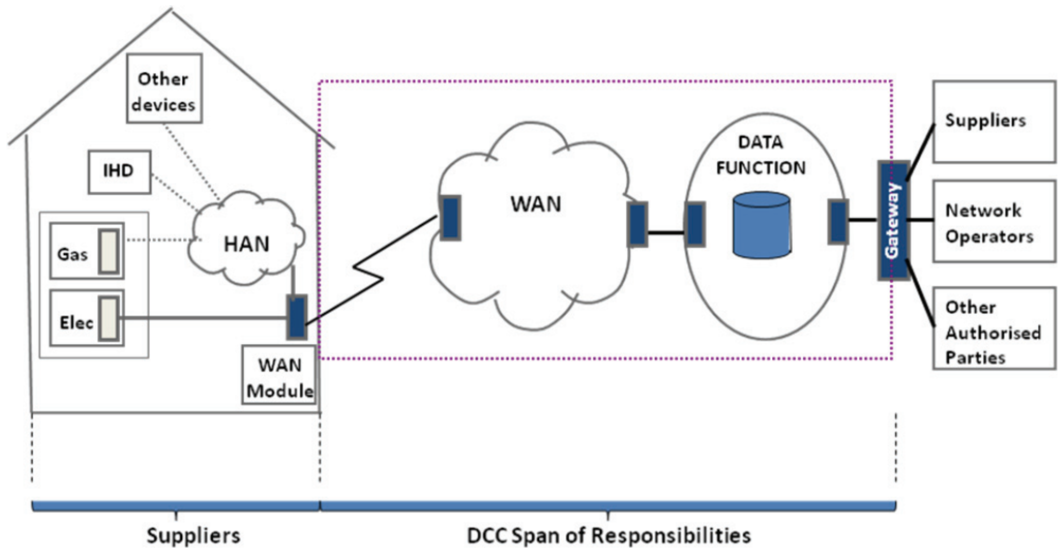

Figure 7: Proposed smart metering system responsibilities (DECC, 2010, 25)

The minimum requirements for meters and displays are not yet finally decided. They are included in the Department of Energy and Climate Change (DECC) and the Gas and Electricity Markets Authority (GEMA) Prospectus document, which sets out proposals for and asks for views on how smart metering will be delivered (DECC, 2010, 22).

The most visible part of the smart metering system for domestic consumers will be the standalone in-home display (IHD). The minimum functional requirements for the IHD should include (Ofgem, 2010d):

- Presentation of information on current electricity and gas consumption.

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[54] BBC News 2nd Dec 2009 (http://news.bbc.co.uk/2/hi/business/8389880.stm)
55 www.renewableenergyfocus.com/view/1752/uk-homes-could-have-smart-meters-by-2020

- Presentation of information on historical consumption so that consumers can compare current and previous usage.
- To facilitate consumer understanding, usage information must be displayed in pounds and pence as well as kilowatts and kilowatt hours and the display must include a visual (i.e. non-numerical) presentation that allows consumers to easily distinguish between high and low levels of current consumption.[8] We are seeking views on whether information on carbon emissions should also be included.
- Presentation of accurate account balance information (amount in credit or debit).
- Capability to display information on both gas and electricity consumption.

The prospectus also sets out the required high-level functionalities of the smart metering systems (DECC, 2010):

Table 5: High-level functionalities of the smart metering systems in UK (DECC, 2010, 22)

	High level functionality	**Electricity**	**Gas**
A	Remote provision of accurate reads/information for defined time periods – delivery of information to customers, suppliers and other designated market organisation	✓	✓
B	Two way communication to the meter system	✓	✓
C	Home area network based on open standards and protocols: Provide „real time“ information to an in-home display, enable other devices to link to the meter system	✓	✓
D	Support for a range of time-of-use tariffs: Multiple registers within the meter for billing purposes	✓	✓
E	Load management capability to deliver demand side management: Ability to remotely control electricity load for more sophisticated control of devices in the home	✓	✓
F	Remote disablement and enablement of supply: To support remote switching between credit and prepayment modes	✓	✓
G	Exported electricity measurement: Measure net export	✓	
H	Capacity to communicate with a measurement device within a microgenerator: Receive, store, communicate total generation for billing	✓	

3.28.3 Smart Metering Landscape in United Kingdom

The deployment of smart metering seems to go swiftly with a clear regulatory push (publication of the Smart Metering Prospectus in July 2010), with also a few major companies already implementing the rollout and start offer services using smart metering technology. For the national rollout, a major central program is established to design and implement new cross-industry arrangements for smart metering, in co-ordination with the programs which industry participants will need to implement themselves (Energy Demand Research Project) (Ofgem, 2010a). The first phase of the UK smart metering program is a joint Department of Energy and Climate Change (DECC) / Ofgem initiative. After finalizing this project, a further regulatory boost for smart metering deployment in UK can be expected.

Centrica (British Gas), Scottish and Southern Energy and EDF have been testing smart metering technology in homes for several years. Four suppliers (EDF, Scottish and Southern Energy, Scottish Power and E.ON) also installed smart meters and in-home displays in households as part of the Energy Demand Research Project (EDRP).[56] The EDRP is an important source of information for the UK Smart Metering Implementation Programme. They have all used different technologies. Other companies, such as British Gas, are known to be carrying out their own independent trials (ESMA, 2010).

Also some suppliers have already begun installing smart meters, e.g.

- British Gas (largest UK energy supplier): 2 million by 2012,
- First Utility: independent energy company and first UK energy firm to provide free smart meters to customers) as a real market implementation.
- nPower: the largest electricity company; have been carrying out independent trials in the Midlands and later 2010 they will carry out further trials in Yorkshire and the North East.
  - nPower has also been trialling “Dynamic Demand”, which is a new technology that allows appliances to automatically adjust their power consumption to account for second-by-second changes in demand on the national grid.
  - They are also installing smart meters for customers with microgeneration technology installed, however more detailed information on this was not found.

[56] 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 result. 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 development within metering service market are key to achieve 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 final 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 the consumers.

Only metering services will provide added value to the consumers.

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 programs 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 web sites 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.

4.1.1 Energy Demand Research Project by Ofgem/DECC | 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 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.

Objective of the services: The Energy Demand Research Project (EDRP) is a suite of large scale trials across Great Britain (Ofgem, 2010a). It seeks to better understand how consumers react to improved information about their energy consumption over the long term. The EDRP is trialling a range of methods of providing customers with improved feedback on their energy consumption.

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 feedback related.

Description of the services: In the trials of a variety *of interventions* that can be divided into the following broad categories:

- more accurate and more frequent billing
- energy efficiency information
- real-time display devices, which show energy use in pounds and pence
- smart electricity and gas meters
- community engagement

These interventions are sometimes used in combinations, so it can be useful to consider themes, rather than trying to draw conclusions about individual interventions.

Billing and information: More than 13,000 households are taking part in some form of billing trial, and nearly 26,000 are receiving energy efficiency information. However, it should be noted that some of these households will be receiving more than one intervention. For example, some households are receiving both historical bills and energy efficiency advice.

Clip- on energy monitors with visual display units: Clip-on energy monitors with visual display units (VDUs) have been given to around 8,000 customers. They enable the household to understand how much electricity they are consuming at any point of time through an electronic display in the house.

In these systems, sensor is attached (clipped on) to a conventional meter, and it then transmits information to a visual display unit, which displays electricity consumption and load, as well as the cost of energy use. However, it is important to note that because these visual display units are connected to conventional meters, not smart meters, they do not communicate remotely with a supplier's billing system and may not show the same units as is being recorded by the customers' meter.

Smart meters: By March 2010 Smart meters have been installed in about 17,000 homes. These are electricity and gas meters that collect meter values on a half hourly basis and transmit the data back to the supplier without the need for the consumer to read the meter manually. Several setups are being tested:

- Smart meters with a remote visual display of consumption and cost information of energy used for both electricity and gas.
- Smart meters with daily consumption information sent to the households' TV
- Smart meters with daily consumption information available on the internet
- Smart meters linked to heat control units which allows customers to control their boiler through a wall panel whilst having access to accurate electricity and gas consumption data

Community engagement: The effects of engaging customers across a whole community, is also being trialled by one supplier. These trials include

- a metered local substation to monitor the community's energy consumption;
- a financial reward of £20,000 for a 10% reduction in consumption at the community level;
- fitting smart meters in participating households in the selected communities;
- energy efficiency advice;
- various community events and energy saving incentive schemes organised at a local level.

Consumer response: There are some preliminary observations available. However, a final report is expected in 2011:

- More frequent billing
  - Changes to the way in which customer are billed are noticed by the majority of customers.
  - Increased frequency of billing was a factor that was noticed in particular, and monthly billing was particularly welcomed by customers.

- However while better billing, i.e. more frequent or accurate, can be an important first step in engaging customers on the topic of saving energy, the key question is whether or not these interventions actually result in changes that produce energy savings.

■ Smart meters

- Enabling the households in the trial to receive accurate bills is the immediate result of a smart meter upgrade and so forms the core benefit of any package of measures offered to householders by energy suppliers.
- However, the new smart meter technology does not necessarily interact with the consumer, and the more accurate bill, in some trials, may not look different to previous bills.
- Therefore the EDRP is trialing the installation of smart metering alone and with a range of other interventions that give information on consumption directly to the householder.
- One of the trials is exploring whether providing households with more sophisticated communications about energy consumption (based on web or television access to the data) produces any energy-saving outcome, beyond any achieved by smart meters and accurate bills. The use of such innovative technology encountered a number of technical issues as well as challenges in encouraging customer participation.

■ Real-time feedback

- Within the EDRP, real-time feedback is principally being tested using in-home visual displays (VDUs), which are linked to either clip-on monitors or to smart meters.
- Feedback can be delivered by sound as well as by sight and it is likely that different customers may have reacted differently to each approach.
- One trial investigates the impact of an energy feedback display that is incorporated into the household's heating thermostat/controller. (This proved to be a difficult intervention to install, given the enormous variety of existing heating controllers and boilers.) However, the *preliminary findings suggest that it might be effective to* integrate energy feedback with existing devices with which people already use in the home

As some of the trialled interventions can be categorized as consumption control services, they are explained in the section on consumption control below.

■ Advice: information and energy saving tips

Trials that have sent households information and tips about how to save energy at home, and no other intervention, have not yet identified any subsequent changes in the mean energy consumption of the households in the trial groups.

There are two potential reasons for this,

- the information provided may not have been read or may not have been communicated clearly.
- the results so far could suggest that information about energy efficiency may not be enough in itself to trigger energy saving.

The consequences of these two potential conclusions would be very different, so further analysis should be conducted on this topic.

- Motivation: financial incentives

One trial combines energy-saving tips with a financial incentive to reduce energy consumption. Households were offered a £10 voucher if they managed to keep their energy consumption below a target defined by their historical consumption.

The effect of this incentive was immediate and dramatic with a pronounced fall in the electricity consumption of the group receiving the intervention. However, once the households had received their reward, their energy savings began to decline and were entirely gone around seven months later.

The community trials also involve a financial incentive. If a community reduces their consumption by 10% for a three month period comparable to the previous year, the community will be awarded a cash bonus.

These communities have cut their electricity use significantly and are on course to receive their financial rewards. Also these trials have produced the biggest reductions in household energy consumption so far observed within the EDRP trials. Further analysis will be required, viewed in the context of the overall EDRP results to identify whether behavioural changes are sustained.

Whilst it would seem that offering a predetermined financial reward in return for energy savings does encourage the realisation of those energy savings, one interesting question is how customers respond when informed of the potential cost savings that can be realised by simply reducing energy use.

Data requirements: Differing, as depending on the trialled intervention

Expected and/or delivered results: Consumer response will be the focus of the final report which is expected in early 2011.

Assessment of the service: The largest and most sophisticated trial currently going on in Europe.

4.1.2 Smart Metering 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 specific, this project has the objective of setting up and running Smart Metering Trials and assessing their costs and benefits, which will inform decisions relating to the full rollout of an optimally designed universal National Smart Metering Plan. In four test groups different forms of feedback to the final customer are tested (monthly billing, bi-monthly billing, in-house displays, overall load reduction). The results of all these trials will feed into a cost-benefit analysis by early 2011, which in turn will inform decisions related to any national rollout of smart meters (Mannion, 2010; Wynne, 2010).

From 1st January 2010, around 5,500 household electricity customers nationwide began using smart meters. The trial participants will also be receiving new “smart bills” which contain enhanced information on their 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). Some participants will also be receiving web access and in-home displays (IHDs) which display (real-time) information on current electricity usage and costs in the home. The electricity trial also contains 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.[57]

Consumer response: The trials will run throughout 2010 and will inform decisions in relation to an optimal design for a full rollout of smart meters. Latest information is that overall progress has been very positive with all key milestones having been achieved. In effect there are 17 test groups (four stimuli such as detailed bills, in-home displays etc.) across 4 different time of use tariffs and a weekend tariff. In total, 5,375 customers were recruited for the residential trial. The initiation of the electricity Customer Behaviour Trials (CBT) for residential and SME customers are due to complete end-2010.

Assessment of the service: This trial is one of the few systematic approaches in Europe that test not only the technical details of a smart metering systems (the technology trials were completed at the end of September 2010 and included testing of the smart metering functionality on different communications layer networks such as power line carrier, wireless mesh (RF 2.4GHz) and GPRS) but have a focus on the benefits for the customers. The results of these trials directly feed the cost-benefit-analysis that is the basis for a rollout of smart meters in Ireland. Whereas in other Member States cost-benefit-analysis are largely based on assumptions, this approach offers empirical results for key political decisions.

4.1.3 British Gas and First Utility market implementations | UK

Target group: Residential and commercial buildings

Objective of the services: Energy savings through information and feedback, better customer care, tariffs are planned upon completion of rollout.

Description of the services: A customer receives an electronic meter (free of charge). The utility promises more accurate bills through AMR, as well as an ability to estimate future bills. Electricity usage is measured every half an hour, gas is measured once a day. The customer has the possibility to switch between credit and pre-pay arrangements without changing the meter. With First Utility the customer also receives a 15% annual dual fuel discount (First Utility);

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

British Gas offers in-home display monitors free of charge showing energy usage per hour/over 24hrs/7 days, the related costs and CO_2 emissions.

Figure 8: British Gas in-home display monitors

Technology used: Landis&Gyr meters, Zigbee wireless standards to link up in-home devices, GPRS two-way communication with British Gas.[58]

Business clients do not receive displays, but the service includes an online energy management service (automatic monitoring and targeting). This energy management service (interface from Energy360^{TM}) gives a real-time overview of the site's energy use showing consumption in simple graphs and tables:

- Allows to monitor, report and analyse electricity and gas consumption across ones portfolio online
- Rank best and worst performing sites by consumption or CO2 emissions
- Energy360 from British Gas promises to help reduce energy costs by at least 10%

First Utility: Monitoring energy usage online in bar charts or line graphs. Compares gas and electricity over months, weeks, days. First Utility uses Google PowerMeter that *receives the data on electricity usage directly from the smart meter and displays it on the personalised iGoogle homepage*. This feature provides near-real-time information on the home's electricity consumption, enabling to see the direct effects of any changes to electricity usage.[59]

Technology used: First Utility uses several different communication technologies including PLC (Power Line Carrier), GPRS, GSM, SMS, PSTN and 868Mhz low power radio and tests with several other radio options. Depending on the individual geographical location it is likely they will deploy either SMS or GPRS enabled electricity meters. Services are based on a set of functionality (accurate billing, load profiles etc.) and not on any particular technology.

Business clients receive an online portal with comparisons day to day, week to week and month to month, a monthly bill, and tariff advice after a period of 12 months.

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58 http://www.britishgas.co.uk/energy-efficiency/smart-meters/smart-meters-explained.html

59 http://www.first-utility.com/home-energy/google-powermeter

Consumer response: As these smart metering schemes are just being launched, there is not much information on consumer responses, apart from the general utility marketing communication saying how consumers are pleased to have new displays and better information.

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 his/her online account.

Expected results: Besides general energy savings associated with smart metering in the literature, there is no data available indicating energy savings. When the utilities start introducing new tariffs, peak load shaving is likely to also occur.

Assessment of the service: Good example for smart metering implementation. Real-time information directly to the customer (via in-home display in the case of gas or Google PowerMeter in the case of electricity) coupled with other information (such as benchmarking, historical consumption, monetary costs, emissions, advice to save energy) us, according to the available literature, the best way to achieve energy savings. However, to fight the “saving effect wearing-off,” constant effort for communication is needed.

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 touch screen 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 Microgeneration and display import/export/generated visuals

All products are designed to work pre-smart (independent & without smart meter) or in a smart meter environment. Pre-smart meter displays provide a opportunity to build engagement amongst consumers since preliminary studies show that consumers 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: A ZigBee 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.

Consumer response and expected results: Green Energy Options Ltd works with the University of East Anglia to study the consumer 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 to participate: 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 consumers, in particular helping 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 durable.

Assessment: The displays may proof to have a significant effect on the behaviour of the consumers. 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 consumers 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

Since 2006, the Dutch energy supplier and certified metering company Oxxio put electric and gas smart metering services into action throughout the Netherlands. Oxxio, founded in 2000 and owned by the British company Centrica, is the fourth-largest electricity and natural gas supplier in the Dutch market, is serving approximately 100,000 residential and small-business customers with an electric and/or gas smart meter. Oxxio is the largest independent energy supplier in the liberalized Dutch market. Known as a "green" energy supplier - since it procures wholesale power exclusively from hydroelectric sources.

Customers with a smart meter can enter a **personal website** to view their actual energy use and energy costs. Oxxio claims that it helps its clients to consume 10% less energy in three years by means of concrete online advice and the smart meter, however there is no independent evaluation of this saving potential yet. The online smart meter service helps clients lower their energy consumption by giving them more insight into their energy use, and is a substitution for the old electricity and gas meter. Oxxio rewards the clients who are able to save 10% less in three years with a cash payment of EUR 300. However, no independent evaluation of this programme is available.

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

Target group: Residential customers

Objective: Energy efficiency, energy savings, information and feedback.

The objective of the research project ”Environmental benefits from full-scale implementation of Smart Metering”[60] at SINTEF Energy Research is to realize environmental benefits related to full-scale implementation of Smart Metering (Sæle, 2010). This will be achieved trough 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 the customers more conscious regarding their own consumption. Increased customer awareness will be increased with use of local exchange of information, load control and in-home display.

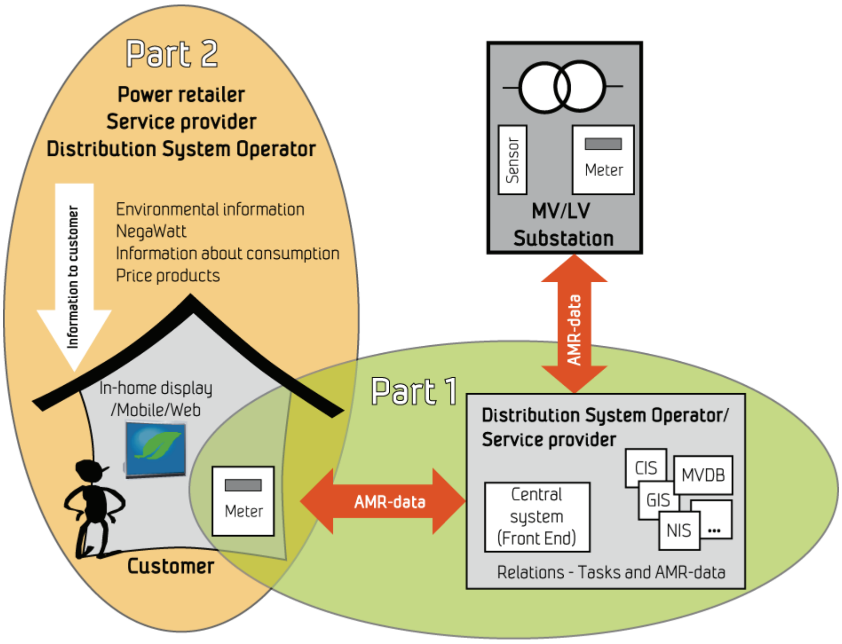

Figure 9: Technical focus within the research project (Sæle, 2010)

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

Description: Within the second part of the research project, several pilot studies will be established in cooperation with local DSOs and power retailers. The pilot studies will include household customers. The main objectives of the different studies are to contribute to energy efficiency as a consequence of making the customers more conscious regarding their own electricity consumption.

As illustrated in *Figure 9* increased consciousness will be achieved through different types of information to the customers.

[60] www.sintef.no/m-ams (In Norwegian)

Examples of in-home displays that will be included in some of the studies are presented in Figure 10.

Figure 10: Examples of in-home displays (Left: eWave – Miljøvakt, Right: Censitel)

The first pilot studies will start up in the autumn 2010. The duration of each study is estimated to one year.

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

Consumer 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.

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 regarding 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.

Within the pilot study different interfaces for exchange of information towards the household customers will be tested. The technology is not the main focus, but rather the type of information that can be presented to the customers. Alternative solutions for such information channels are in-home displays, mobile phones or web solutions.

Assessment of the service: This is a pilot study that will start during the autumn 2010. The duration is one year. 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 perform the metering of the electricity consumption. For settlement of the electricity consumption the customers are performing self-reading of their meter and report this information to the Distribution System Operator. With smart metering technology installed, the customers would get better initiatives for reducing and changing their electricity consumption for example due to price incentives on an hourly basis.

4.1.7 Busch-ComfortPanel by Busch-Jaeger Elektro GmbH | Germany

Target Group: The target group for the Busch-ComfortPanel are home owners. The main aim of the panel is the control of the home automation equipment.

Description: The display is basically a control und entertainment centre, which is also able to display consumption data. It can show the current consumption, the current costs and give a consumption forecast for electricity. This could be displayed in almost real time and additionally annual consumption as well as historical values can be shown. It is planned to display consumption data for water, gas and oil as well. The display also enables the consumer to control single household appliances or to program the appliances. An automatic control of household appliances is possible. The functions of the display are controlled by a touch panel. The data is shown using numeric data or line diagrams.

Figure 11: The Busch-ComfortPanel

Results: As the display is not being offered by an energy supplier as part of a product at the moment, there is no data available.

Assessment of service: The Busch-ComfortPanel is one of the most progressive displays designed in Germany. Not many other displays can also interact with household appliances to remotely switch them on and off. As the display aims at home owners with a high level of home automation, it is in many cases part of a whole home automation system. Because of an estimated price of 2,500€ for the display only, it is assumed that it will not be affordable for an average customer.

4.1.8 EnBW Cockpit by EnBW AG | Germany

Target Group: The target group for the EnBW Cockpit is the private customer. As being part of a product bundle with a variable tariff, a display and, of course, a smart meter, the EnBW Cockpit aims at giving feedback to the customer about their consumption. The product is being offered since 2008.

Description: The data is being transferred from the meter via the dsl router to the central EnBW server and the internet portal. This architecture is shown in Figure 12.

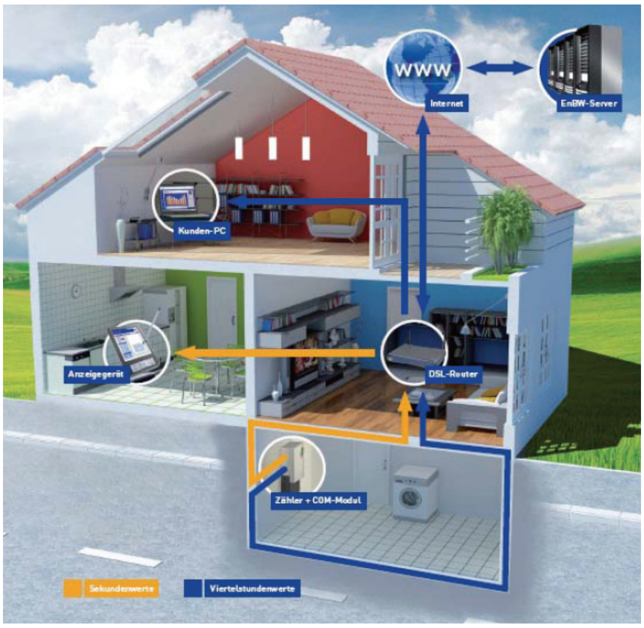

Figure 12: EnBW Cockpit – system architecture (Heeg, 2008)

The visualisation of the 15 minutes values can be displayed on different levels (day, week, month and year). On the pages of the internet portal the load, the costs, the energy consumption and the CO_2 emissions can be shown. To do so a line chart is being used to show the consumption data subdivided by the price levels of the tariff. Even a comparison of consumption data for selected time intervals is possible. In a so called bull's-eye the day's consumption in reference to the price levels is shown. All data can be exported to a CSV data file. As additional services the customer can be informed by SMS or email in case the consumption exceeds a pre-defined value. A screenshot of the EnBW Cockpit is shown in Figure 13.

Figure 13: EnBW Cockpit - Screenshot (Heeg, 2008)

Data requirements: Metering data with 15 minutes intervals are needed to provide the services described above.

Consumer response: The consumer might respond to the feedback by shifting or reducing loads.

Results: EnBW AG does not publish any results regarding the product.

Assessment of service: The EnBW Cockpit enables the customer to analyse his energy consumption. On a very simple and easily to understand layout, the customer can even analyse his CO_2 emissions as well as compare his consumption to historical values. The additional text message or email service may contribute to an even better understanding of energy consumption and especially peak consumption.

4.1.9 Display trio smartbox by EWE AG | Germany

Target group and objective: EWE developed the smart metering product called 'trio smart-box', which will be on the market by the end of 2010. This product includes a smart meter, an internet portal and a display. The target group are private customers. The display should rise awareness of energy consumption and also give detailed information about the price levels of the tariff for the near future.

Description: The display 'trio smartbox' has got a colour display with a 320*240 pixels resolution and integrated system software. It communicates with the gateway via M-bus. The display can visualise the load in Watt and the consumed energy within the last 15 minutes in kWh. It also shows the consumption, the costs of energy consumption and the CO_2 emissions on daily or monthly basis. This can be done for electric energy and gas. The consumption data is being visualized using a bar chart subdivided by the different price levels. Also the daily average consumption and the average weekly consumption are shown. Figure 14 shows the 'trio smartbox'.

Figure 14: Display trio smartbox (Harms, 2010)

Data requirements: Metering data with 15 minutes intervals are needed to provide the services.

Consumer response: The consumer might respond to the feedback by shifting or reducing loads.

Results: EWE AG does not publish any results concerning the product.

Assessment of service: The ‘trio smartbox’ is an easy to use display with great options to analyse the energy consumption. It covers not only the electric energy consumption but also the gas consumption. Therefore it seems to be a good solution for giving incentives to save energy or shift loads. On the other hand it only comes in a package with the EWE smart metering product and therefore will be restricted to customers ordering this particular product.

4.1.10 GreenPocket Mobile by GreenPocket | Germany

Target group and objective: GreenPocket develops white label products for energy suppliers. They offer an internet portal as well as a mobile application for Apple’s iPhone, iPod touch or iPad. The target group for the GreenPocket Mobile application is the private customer. The objective is to raise awareness of energy consumption.

Description: The mobile application GreenPocket Mobile shows the consumption, the costs and the CO_2 emission on a daily, weekly, monthly and yearly basis. The data can be displayed as a block chart as well as numeric values which is shown in Figure 15 and Figure 16. Historical data of consumption, costs and CO_2 emissions can be compared to one another. The mobile application can also display a prognosis of consumption.

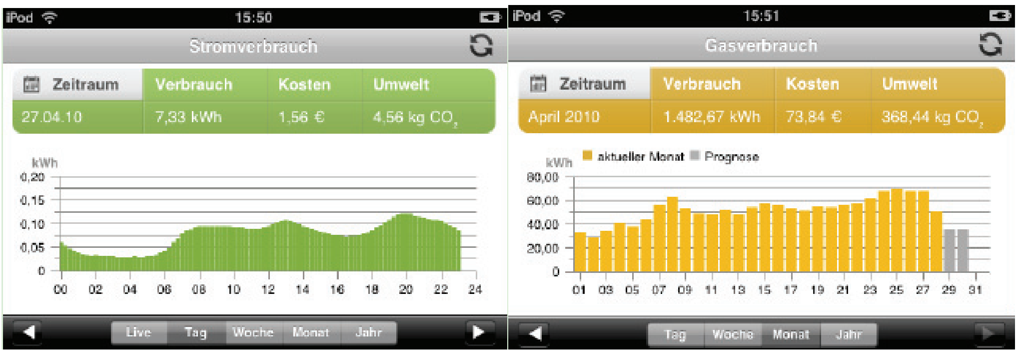

Figure 15: Screenshot 1, GreenPocket Mobile (GreenPocket, 2010)

Figure 16: Screenshot 2, GreenPocket Mobile (GreenPocket, 2010)

Data requirements: The metering data has to be quite detailed (15-minutes values) to be able to use all the options offered by the GreenPocket Mobile option. Before the data is displayed it is tested for quality and plausibility by GreenPocket.

Consumer response: The customer might respond to the feedback by shifting or reducing loads.

Results: The product is at the moment tested by two energy suppliers. Therefore no results are available at present.

Assessment of service: The GreenPocket Mobile application is one of the most progressive ones on the German market. This is mainly due to the simplicity of the service. The important data is displayed in a clear and easy to use way.

4.1.11 Google PowerMeter by Google & Yellow GmbH | Germany

Target group and objective: The target group for the Google PowerMeter are private customers. As most feedback systems the objective is to raise awareness of energy consumption.

Description: Together with First Utility (UK), JEA, San Diego Gas & Electric (USA) and Yellow Strom GmbH in Germany, Google offers its PowerMeter. It is free to use for private customers. The PowerMeter can be installed as a widget on the customers' iGoogle homepage. It shows the energy consumption in 15 minutes intervals. This is done by using block or line charts. It is also possible to show historical consumption data. In addition a social comparison on the basis of the German standard load profile is carried out and shown. Figure 17 and Figure 18 show screenshots of the PowerMeter.

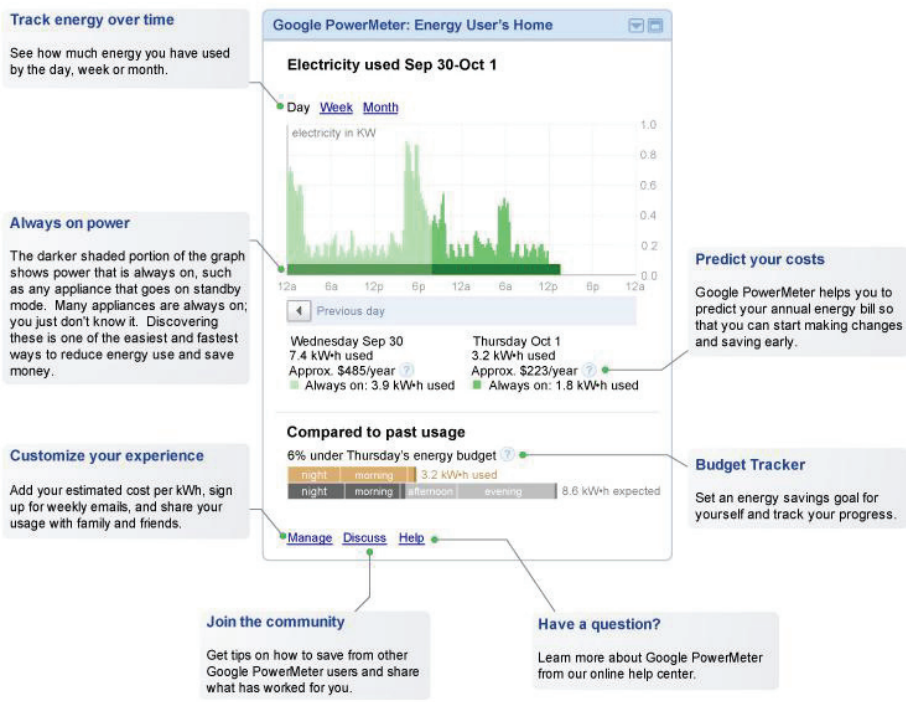

Figure 17: Google PowerMeter - Screenshot (www.yellowstrom.de)

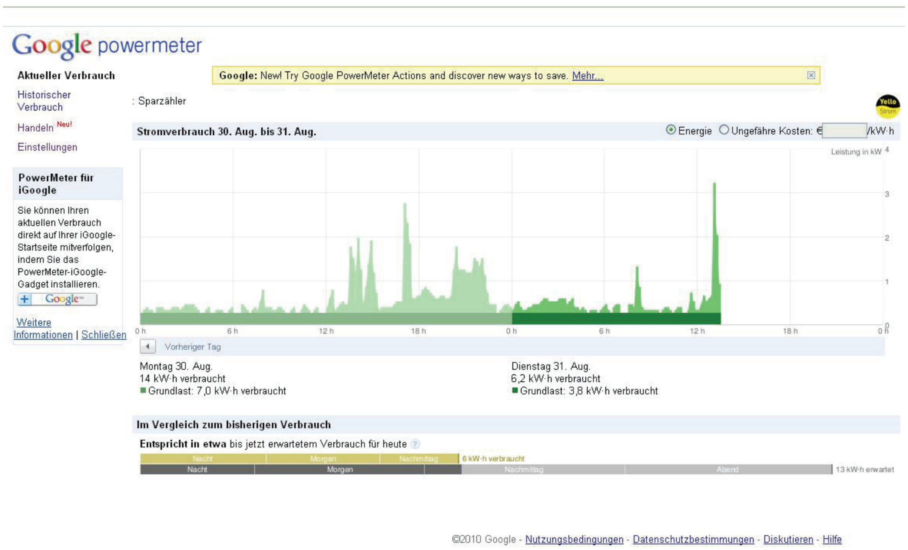

Figure 18: Google PowerMeter – energy consumption by day (www.google.com/powermeter)

Data requirements: As the PowerMeter can visualize up to 15 minutes data, the data should be available in that interval to make most of the possibilities of the widget.

Consumer response: The customer responds to the feedback by shifting or reducing loads.

Results: The product is at the moment run by three energy suppliers. They do not share information about the results of the PowerMeter.

Assessment of service: The Google PowerMeter can visualise the most important data. Compared to other feedback systems the design, the usability and issues of privacy and data protection are on a low level. Nevertheless, the widget has got one main advantage compared to other feedback systems. Because it is situated on the iGoogle site most users will look at the widget every time they use the internet. This is the case when assuming that the iGoogle site is set as the start site of the customer. Therefore the information ‘comes’ to the customer. With other feedback systems the customer has to actively ‘go’ to the information, such as picking a display up, go to the internet portal or starting an app on the smart phone.

4.1.12 District heating AMR | Latvia

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

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 on apartments / houses showing energy consumption and historical consumption and historical benchmarking on monthly level. Also residents are given information on how to save (e.g. temperature control – one degree change means 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

Consumer 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.

4.1.13 EcoreAction | Finland

Ecore is a Finnish AMR end-user service developer company offering utilities customer service systems that utilize the smart metering data. These services can be mostly categorised as information and feedback systems that visualise the metering data for the end-users. Their EcoreAction self-service portal is a web-based system for utility customers. The solution is supplied as a part of the utility’s own web pages, and tailored to match the utilities own visual look

EcoreAction has already been deployed by few of the Finland's largest energy companies, such as Helsingin Energia (“Sävel+” consumer reporting service) and E.ON Finland (“Oma energia" - Own energy consumer reporting service). In 2012, for example, all Helsinki electricity users should have hourly based metering and reporting, which is said to be the most extensive consumption information management system in Finland.

- Target groups: primarily households, but also commercial and public buildings
- Objective of the services: save energy by helping the end-users to gain a better understanding of their personal consumption behaviour (information and feedback), and help utilities to offer better customer service. Also peak load reduction in the future.

Figure 19: EcoreAction website

Description of the services: Meters, communications technology and reading comes from turnkey technology provider Landis+Gyr, e.g. in Helsinki: Gridstream smart metering solution includes meter reading services, smart electricity meters, communications, smart metering software and the integration to the utilitys Electricity Network's IT systems. The communication solution for the utility was optimized by combining 2G/3G communications, Zigbee and Mesh Radio Frequency technology. Landis+Gyr will also be responsible for project management, equipment installation, and training Helen Electricity Network's personnel.[61]

The DSO owns the data and Ecore visualises the data.

Electricity:

- 24/7 self service portal in the web
- A pointer shows in a meter from green to red the consumption and emission levels
- Hour or year level monitoring (week or day also possible)
- End-user can plan their own energy goals, and has their own calendar to mark down actions affecting energy usage

[61] http://www.smartmeters.com/the-news/425-finland-leads-europe-in-smart-grid-development.html

- Consumption forecasts and versatile comparison features (to other users and own use)
- Also tips and advice how to save

District heat:

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

Data requirements: Based on the utility's AMR solution, so hourly-based as regulated. According to Ecore, the data quality is also important in order to create reliable services from the huge amount of data.

Consumer response: No research yet, the service is in use in Helsinki and EON, but developing constantly. More information on this in 2011 and 2012.

Expected and/or delivered results on energy consumption patterns: No known research yet, see the previous point

Assessment of the service: The most advanced SM end-user information and feedback service implemented in large scale in Finland to date, and also at European this is quite advanced. The benefit is that this can be deployed and tailored to different utilities easily, and thus achieve a large scale coverage. When available, customer feedback and results in energy savings on EcoreAction will give very important information on how to implement SM feedback services. Consumption and load control, as well as TOU tariffs would needed to complement the services are coming, but their deployment depends on the utilities.

4.1.14 Energiakolmio EnerControl service and commercial buildings | Finland

For over 10 years, independent of the utilities, Finnish energy service and software company Energiakolmio has offered its EnerControl service to public and commercial building stock in Finland. Now they have internationalized their business and services are spread e.g. to Spain.

- **Target group** public and commercial buildings, usually for the use of building users and managers who make decisions regarding building use
- **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** metering and communication technology varies, usually hourly based meters sending to hub via wireless connection (e.g.GPRS) or cables, and then via GPRS to the service provider. The meters are bought and owned by the building owner and a monthly fee is paid for the services. For commercial buildings usually many meters (up to 20 or so), municipal buildings usually use one per heat, water and electricity.
  - Service via web-based tool

- Mointoring consumption (hour, day, month, year, kWh and kWh/m3), consumption changes from prev year, day/night consumption (to see “Sunday” loads and consumption), max, min and average consumption, long term trend consumption
- 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 aqcuisition (mostly electricity portfolios in the Nordic stock market), balance handling

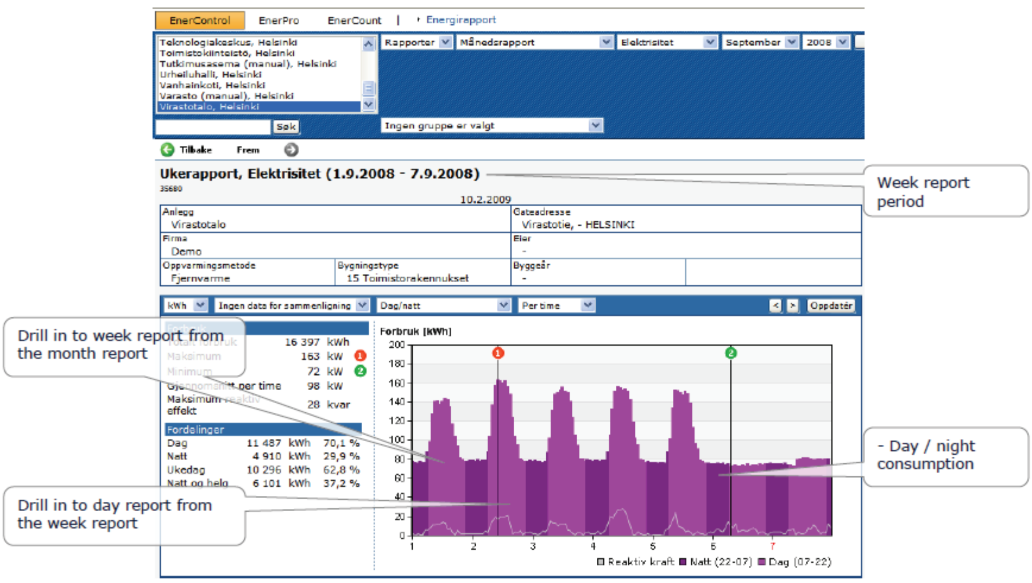

Figure 20: EnerControl website

- **Data requirements:** Utilises hourly metered data and also manually typed data, electricity, heat and water (also gas if used)
- **Consumer response:** The service has been continuously developed for ca. 10 years, and is quite optimized for the public and commercial building segments, where professional building managers use the tool in their every day work. The users and building owners are quite pleased with the system, as it delivers a quite simple but functioning monitoring tool.
- **Expected and/or delivered results on energy consumption patterns:** Several clients, e.g. 2nd largest retail sales chain in Finland, the City of Jyväskylä several others have reported energy savings and savings in energy costs through better energy use management. However, amounts are not specified.
- **Assessment of the service:** Easy-to-use system, with quite basic energy monitoring information and comparison reports. Could have more advice aspects in the system itself to increase the energy saving aspect, rather than just monitoring and comparisons. However this may be hard because the end-users differ quite much, and the separate

tailored advice service is also effective. Also including different TOU tariffs and consumption/peak control services would be a new way to increase customer benefit, savings and peak load shaving. These in fact are likely tocome in the future, as the company recognizes these benefits well.

4.1.15 Vattenfall AMR based services | Finland

Vattenfall has been the pioneer in Finland with AMR installations already from 2005 for all their 390 000 DSO customers. From early 2010 they have offered an online reporting system for also their residential customers, which is the largest hourly-based reporting service in Finland to date.

- **Target group** residential, public, commercial buildings
- **Objective of the services:** energy savings through information & feedback, later may come services for peak demand reduction. They have also very active energy advisory services through their web pages
- **Description of the services offered**: Electricity monitoring in hour, day, month and year intervals in graphs or tables, kWh or Euros.
- **Data requirements:** hour based AMR
- **Consumer response:** Not known yet.
- **Expected and/or delivered results on energy consumption patterns:** Not known yet.
- **Assessment of the service**: The service is clearly still in development phase, as the interface does not function too well as many of the options are still not in use, e.g. changing time period etc.). The reporting system seems to be very elementary, as there is only monitoring, without further visualisation, comparisons, own planning, forecasting, advice etc. compared to e.g. services based on the EcoreAction presented before.

4.1.16 Home metering solutions | Finland

Apart from the solutions for utilities and large commercial and public buildings, new solutions offered directly to homes are emerging.

- **Target group:** Residential buildings (small houses and apartment buildings)
- **Objective of the services:** Energy savings through information & feedback, supporting also peak demand reduction (indirectly).
- **Description of the services offered**: For example, BaseN, and Lamit Ltd. are offering more detailed, appliance based heat, water and power metering services for households and apartment buildings.
  - detailed metering including heat, heat pump and water metering with appliance specific meters, also in real-time
  - based on less than hour intervals, e.g. half hours and minutes.
  - Information with graphs or tables, kWh or Euros, and different kinds of consumption control possibilities
  - Usually online monitoring, but home displays also possible

- **Data requirements:** less than hour based AMR, real-time metering
- **Expected and/or delivered results on energy consumption patterns:** BaseN smart metering system, which is the on of the most detailed energy monitoring system to offered date, is being applied in a pilot by Vattenfall, examining 3 families which take part in a public contest to reduce their energy consumption, and their heat energy and appliance based electricity use can be followed real-time. The goal was to have 5% savings, but after the initial enthusiasm, the energy use has been set to a level of averagely 20% lower than normally. However, this can not be regarded as a exact trial as the number of users is quite small, and the publicity may affect the result.
- **Assessment of the service**: These can be very effective and deliver quite large savings, but the technology is still quite expensive and usually households will not want to invest themselves thousands of EUR in metering systems. Therefore, generalising of these kinds of systems is harder than the less expensive “one-meter per household” systems, where the utility pays for the investment.

4.1.17 Load profile management by AVU AG | Germany

Target group and objective: The target group is business customers, which range from small businesses to large enterprises. The goal is to give suitable advice to the customers, how to shift or reduce peak demand and therefore to save on the energy bill.

Description: In Germany – to calculate the kWh charge – the supplier takes the highest load during one period into account. Therefore the daily prices for energy are subject to the highest load during one period. Reducing this maximum load will therefore account for savings for the energy customer. The load profile management analyses the load profile to address those highest loads. To advice the customer which appliance operations can be shifted in time to reduce those highest loads is also part of this service.

Data requirements: The availability of the load profile is compulsory for this service. Therefore the metering data has to be delivered at least in 15 minutes intervals. This is given by the German RLM meters, which are mandatory by law for customers with an annual consumption above 100,000 kWh.

Consumer response: Because of the advice given by AVU the consumers shift loads or reduce loads at certain times. By doing so, they can reduce their energy costs.

Results: For this specific product the provider does not publish any results or numbers. But the product has been on the market for a long time now and is offered by various companies. This indicates that the advice given based on the load profile analysis provides some advantages for the customer.

Assessment of service: Load profile analysis is a standard tool in Germany to support business customers to reduce their energy bills. It is therefore offered by a lot of companies. The data is available through the RLM metering for customers with a large energy need.

4.1.18 Wattcher – Energy information with conventional meters | The Netherlands

Target group: Households

Description: The Wattcher is a design display that shows a consumers home's total electricity consumption in a meaningful way. When a consumers switches on an electrical device, the Wattcher shows the extra power consumption and gives insight into his energy behaviour and helps save energy. In that respect, the Wattcher is a “strategy that stimulates awareness,” as promoted by it’s developer.

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 with a turning wheel, digital meters with LED pulse, and smart meters). The sensor is connected to the sending unit. Both are placed in the meter closet. 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 consumer.

The Wattcher uses very little energy. The combined consumption of all Wattcher components (sensor, sending unit and display) is less than 1 Watt. The Wattcher comes with Wattcher-online, an on-line saving program that provides additional help and insights into energy saving.

The Wattcher shows:

- Current power consumption (in Watts): how much energy you're using at this moment.
- Daily consumption (in kiloWattday): your total electricity consumption in the last 24 hours.
- Target consumption (in %): daily consumption compared with ones own target.

Assessment of service: An independent evaluation of achieved energy savings is not available. However, 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 has the potential to become ‘the ticking heart of the 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 consumer incentives and direct load curtailment. Here we present pricing models which sets peak/off-peak pricing tiers to provide consumers 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 consumer’s choice based on existing incentive to shift the use of appliances to off-peak hours. However, the choices by the consumer 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

Target group: Residential customers

Objective: 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 power retailer and the customer).

Description: 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 development of new products from the retailers 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 contract "Fixed price With Return" option (FWR), which meets these requirements. In the FWR product Trondheim Energy offers the 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 a part of the portfolio management.

The FWR contract is defined by the local spot price,[62] the contract price and the contract volume. The contract volume is divided over the year according to a profile.

The fact that most domestic consumers 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 21), the retailer seems to have succeeded in presenting the product in a way that people understand.

Figure 21: 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[63].

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-

[62] 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.

[63] The Nord Pool Elspot "system price" is the price initially calculated with no network constraints taken into consideration.

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.

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.

Consumer response: Two questionnaires were answered by a selection of the FWR customers. The main impression from this study is that the customers are focused on own cost savings and follows the power situation through the media. The customer's 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 significant difference between area and system prices.

Results: One of the main aspects in this pilot was to study the price responsiveness compared to the alternative products. Figure 22 shows the load curve for residential customers having Spot Price (Spot), Standard Variable Price[64] (SVP) and FWR contracts respectively for quarterly periods, each category existing of 800 customers.

The three categories follow each other with exception of the 1. quarter of 2006. The customers with the FWR product reduced their electricity consumption with 24,5% in the first quarter of 2006[65], while customers with spot price power products and standard power products increased their consumption with 10,4% and 7,7% respectively, in the same period.

[64] SVP is the default contract for a majority of the retailers. The price may be changed with a 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.

[65] Compared to the consumption in 4. quarter of 2005.

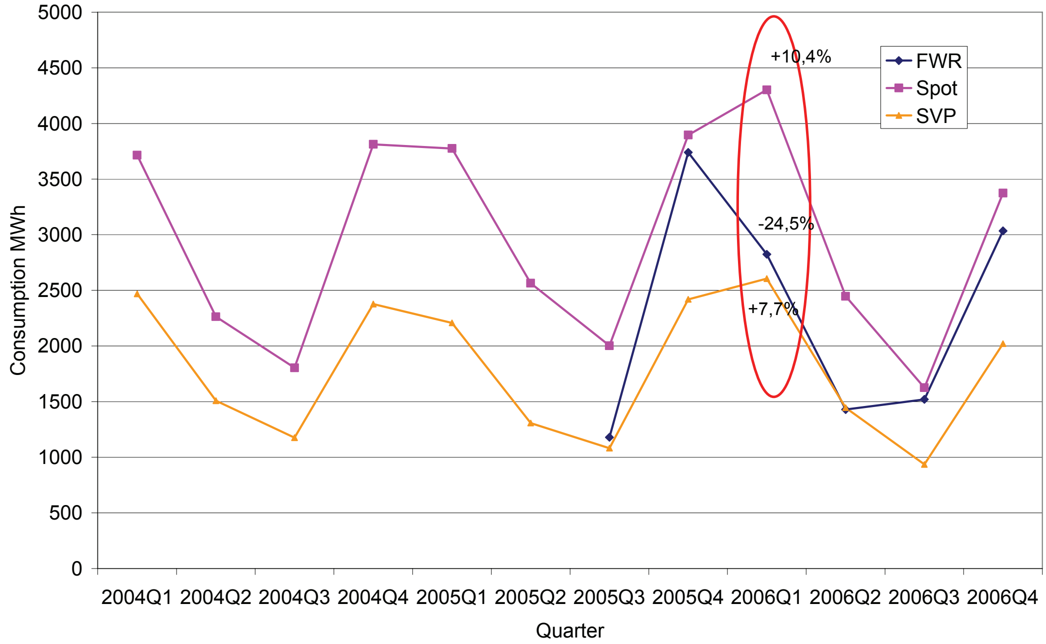

Figure 22: Electricity consumption for groups of customers with different power products (Grande et al., 2008)

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 3. quarter of 2006 when the spot prices were even higher than in the 1. 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 to reduce his 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.

Assessment of the service: This service gives the customers 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 that did only have quarterly reading of their meter. The settlement was performed with use of a yearly profile. With hourly metering of the electricity consumption the customers would have benefit from hourly changes in demand.

4.2.2 Remotely controlled load shifting (Market Based Demand Response project) | Norway

Target group: Residential customers with waterborne space heating system with an electrical boiler or a standard electrical water heater.

Objective: Load shifting, peak demand reduction, information & feedback

Description: 40 household customers with hourly metering of their consumption participated in the pilot. The pilot was performed at Malvik Everk – a small DSO located in Mid-Norway (Grande et al., 2008). Malvik Everk is one of few DSOs in Norway with full roll out 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-prioritized loads[66] were installed.

The ToD network tariff stimulated to load shifting, and Remote Load Control (RLC) via the AMR system was offered as an aid to reduce load and costs in the 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 are coinciding with the periods when high spot prices are expected and when the peak load occurs on a national level.

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 Euros/year, the loss part was 0,875 Eurocents/kWh. The Energy Peak payment was 7,88 Eurocents/kWh[67] and only active 08:00-10:00 in the morning and 17:00-19:00 in the afternoon on work days. The new tariff was calculated in a way that secured 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 from avoiding the high spot prices that normally appear in the same hours in case of energy shortage.

10% of the customers had waterborne space heating system with an electrical boiler of 12-15 kW. The rest of the customers had a standard electrical water heater of 2-3 kW.

Data requirements: Hourly metering of the total electricity consumption. Technology for remote load control of low-prioritized appliances.

[66] Low-prioritized loads are electrical appliances that can be disconnected for a limited period.

[67] VAT excluded

Consumer 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 higher focus. The customers accept remote load control, as long as this does not affect the comfort negatively. Several of the customers have adapted the consumption to the new network tariff by manual efforts, by investing in energy control system and/or by buying fire wood for the winter.

Results: The RLC was carried out in the defined high priced peak hours (Figure 23), 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 of these energy consuming appliances in the peak hours.

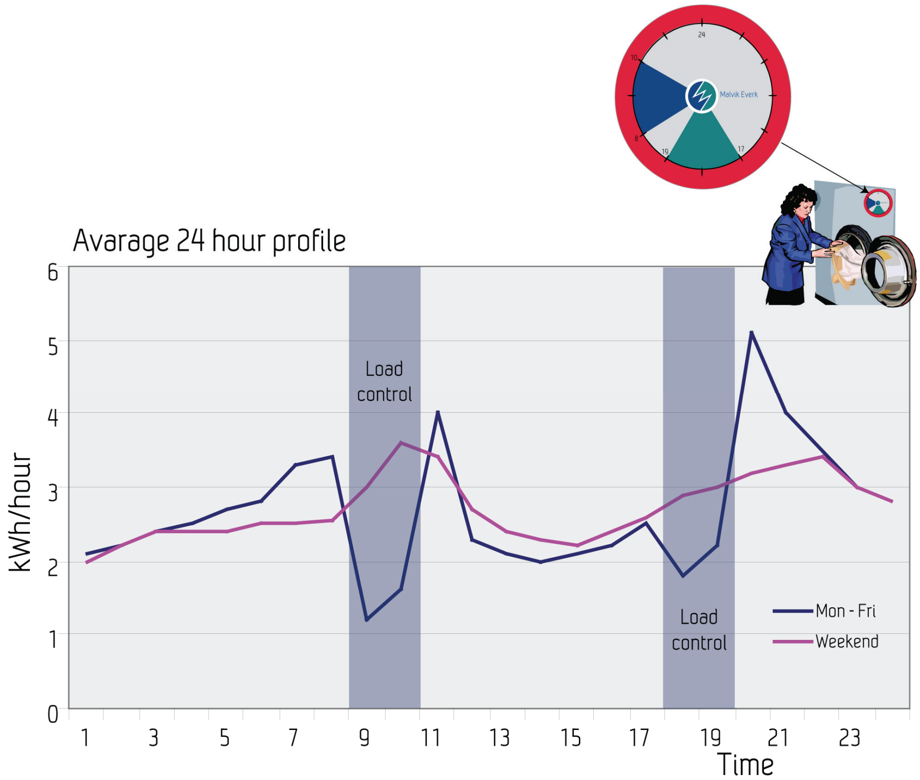

Figure 23: Household load curve with RLC - on working days (Grande et al., 2008)

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 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 6: Average demand response

Customer categories	08:00–10:00	17:00–19:00
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 24 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 in a large scale and included in the Elspot bidding, the price peaks could have been lowered.

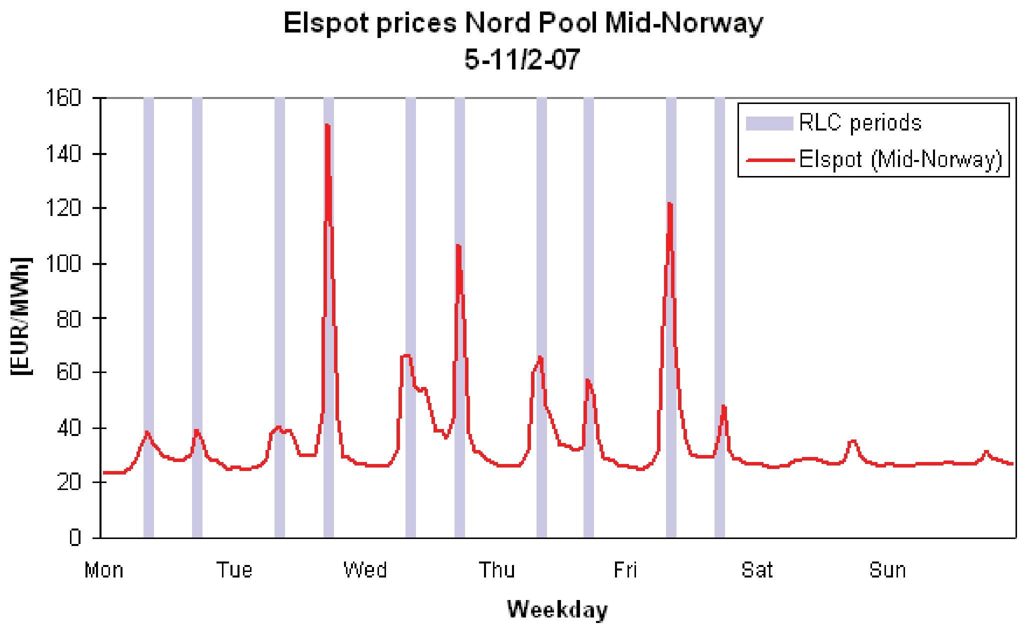

Figure 24: Elspot prices Mid-Norway and periods for RLC in the pilot (Grande et al., 2008)

The remote load control was performed with use of 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 PLC is failure of the communication 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 at each household to reduce the risk for not reconnecting the loads.

Assessment of the service: This pilot shows that demand response/load shifting can be performed trough 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

Target group: Residential customers

Objective: The objective to this demand charge electricity grid tariff was to give incentives to reduce peak consumption.

Description: 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 amount 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 analyse.

This DSO has the following grid tariff options for its residential consumers:

- An *energy tariff* with a fixed annual charge of 300 Euros and a variable energy rate 0,042 Euros/kWh
- A *demand charge tariff* with an annual charge of 12 Euros, a variable energy rate of 0,022 Euros/ kWh, and a demand charge of 82 Euros/kW/year

The demand charge is settled and billed on a monthly basis in the winter months Dec, Jan, and Feb for highest registered hourly kilowatt consumption on working days between 7 A.M. and 4 P.M. (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 consumers chose this tariff without changing their demand patterns, revenues for the grid company would be unchanged. The intention, however, is that consumers 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 consumers that are able to lower their peak demand to obtain a lower electricity bill. Note that in addition to the grid tariff, consumers also pay their power supplier for the energy they use. The rate structure and actual price depend on the actual supplier and rate each consumer chooses.

Data requirements: The 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 25 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 consumer’s demand in that hour. The average reduction of demand due to the DC tariff for all the 9 h in the 3 months in the active window is 5%.

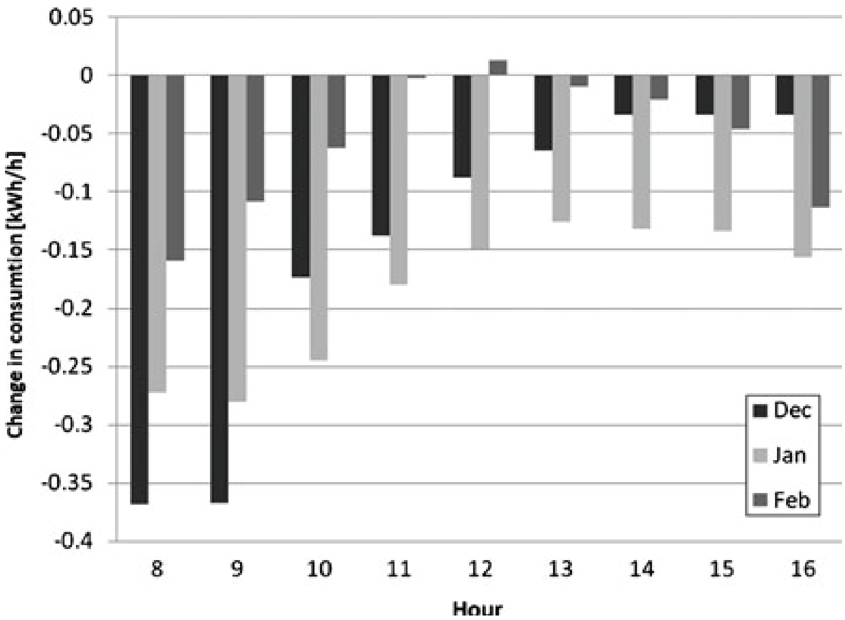

Figure 25: The average change in consumption per customer for each hour in Dec, Jan and Feb within the active window (Stokke et al., 2010)

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 consumers 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 consumers.

Assessment of the service: 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 control method, family homes with electrical heating (MarketDesign) | Sweden

Target group: Residential customers (family homes with electrical heating)

Objective: A demonstration trial performed within the MarketDesign project had the objective to examine the price sensitivity of customers with various heating alternatives (Lindskoug, 2006).

Description: 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 150 Euros when cutting usage by 75% during high price instances. Vallentuna Energi trials promised savings during the winter season 2004/2005 of 110 Euros per annum, to evaluate customer response toward a lower figure.

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.

Consumer response: Along with the customer agreement, tips were offered on how to temporarily reduce electricity usage and 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 summarized 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 0,5 Eurocents 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 0,5 Eurocents 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. 55 Euros 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.

Results: Another important conclusion of the project is that the results have been achieved without the need of new technology having to be installed on 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 26) 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 from last year.

Figure 26: Phase 1 - High electricity price between 8-10 am (Lindskoug, 2006)

The results from the second phase of the trial (Figure 27) are further improves relative 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.

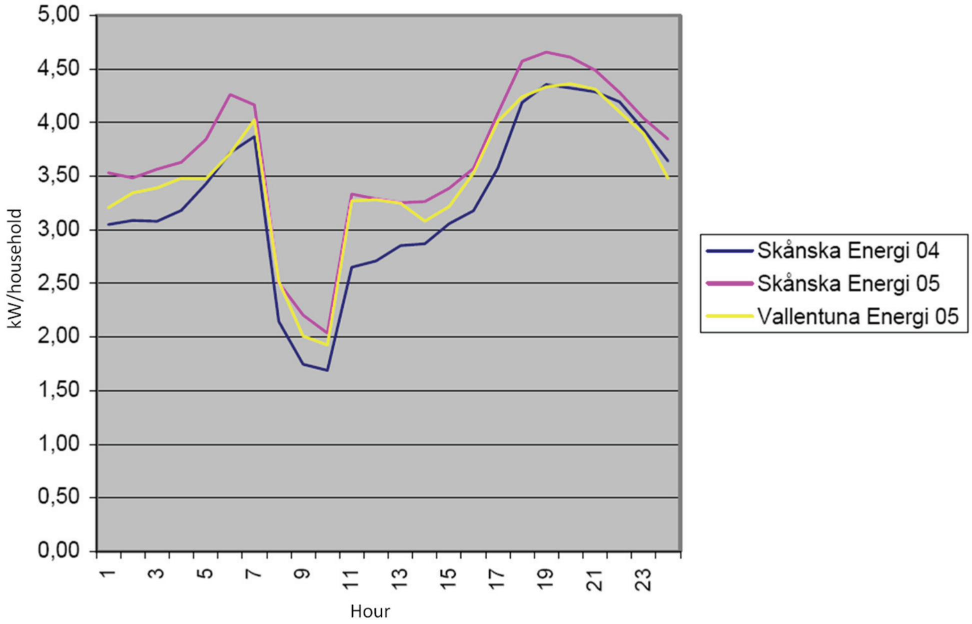

Figure 27: Phase 2 - High electricity price between 7-10 am (Lindskoug, 2006)

Assessment of the service: The household customers have 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

Target group: Residential customers

Objective: The objective of this electricity tariff with differentiated grid fees was to reduce the peak demand. The main objective of the load component in this tariff was to make the 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: 1 January 2001, Sollentuna Energi, one Swedish energy utility operating in the Stockholm area, introduced a new electricity tariff with differentiated grid 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 villas 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.

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.

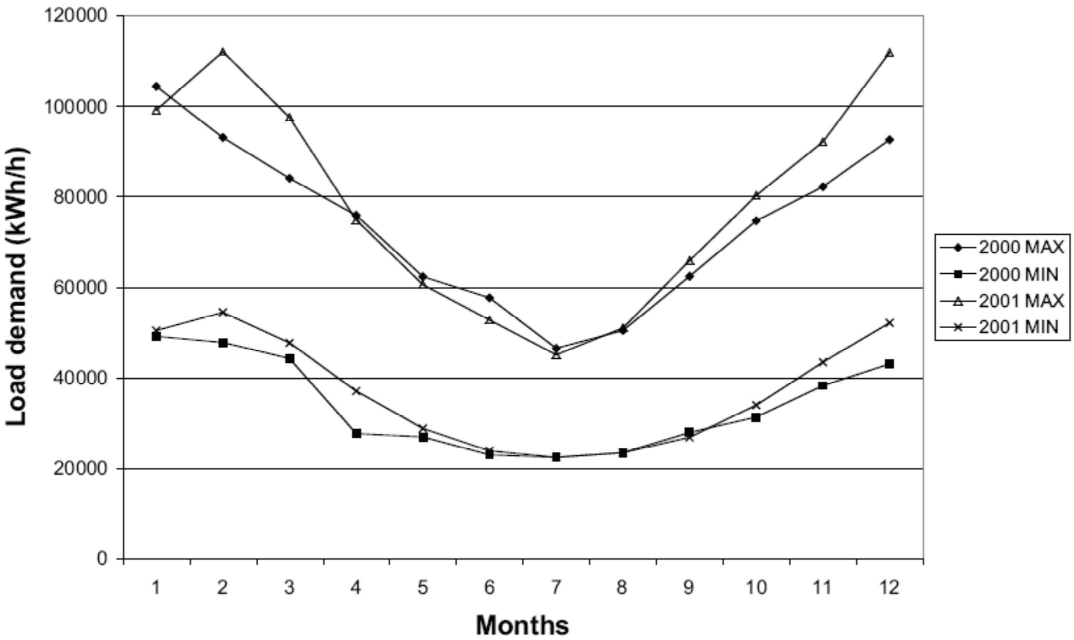

Figure 28: Maximum and minimum 1-hour total load during 2000 and 2001 (Pyrko et al., 2003)

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 were colder. These facts highlight the relationship between climatic conditions and electricity consumption in Sweden, especially for electric heated dwellings.

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.

Assessment of the service: This electricity tariff with differentiated grid fees gives the customers 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 have occurred.

4.2.6 Price sensitive of electricity demand in households | Denmark

Target group: Residential customers

Objective: To realise price flexible demand at household customers.

Description: A trial with the objective to realise 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 Energibranchen, Danfoss A/S, Siemens A/S, SEAS-NVE, Syd Energi and Ea Energianalyse 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 in 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 e-mail 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 specified 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 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 price information is presented in the figure below.

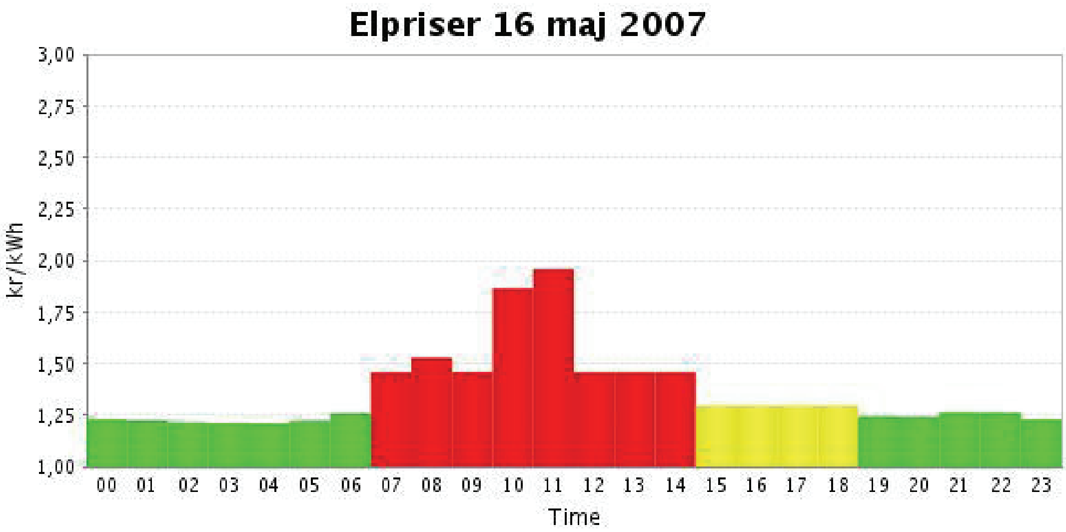

Figure 29: Example of price information (Togeby and Hay, 2009)

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 9-12 in the morning or between 17-19 in the afternoon, but there are large variations.

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.

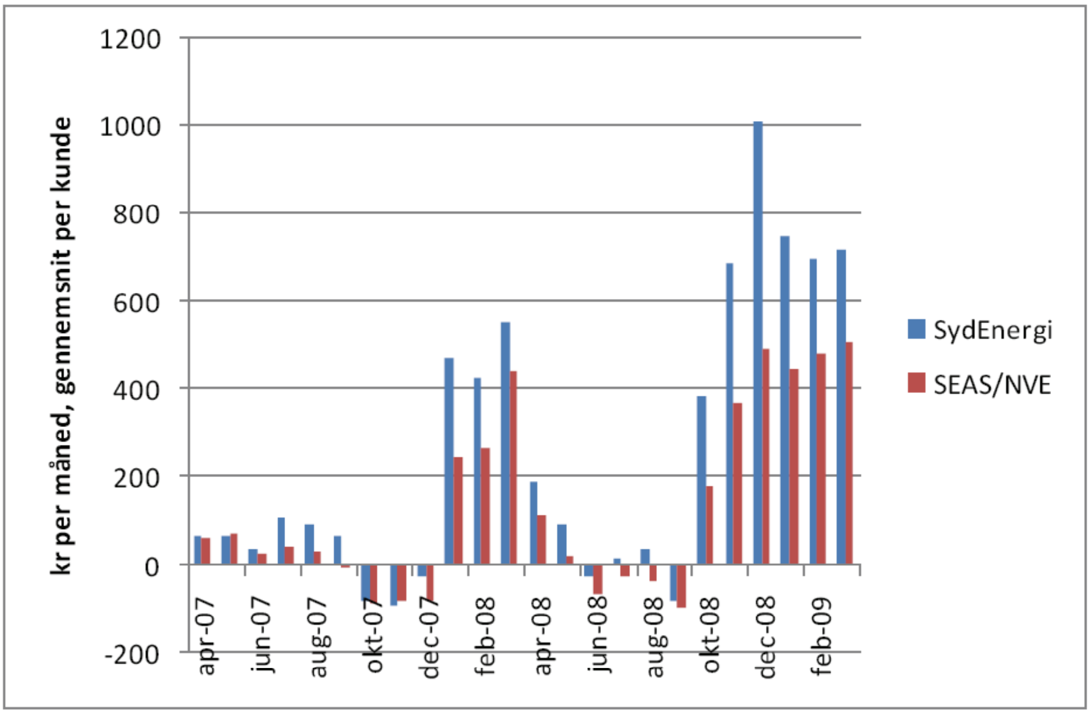

Figure 30: Average savings per month for household customers with installed technology for load control (Togeby and Hay, 2009)

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 retailer, and they buy the electricity from the local power retailer 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[68]. 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 where achieved from the customers that only received price information.

Calculated with great uncertainty, the economical benefit from adapting the demand to the prices is estimated to 13-26 Euros/year, but it was difficult to separate the changes in consumption from the normal changes in the electricity demand.

Assessment of the service: An easy and understandable illustration of the spot prices. The demand response is largest for the customer with installed technology for load control. This illustrate the importance of using technology for remote load control – in combination with price incentives.

[68] http://energitilsynet.dk/tool-menu/english/

4.2.7 Energy Forecast (Energiudsigten) | Denmark

Target group: Residential customers

Objective: The purpose of the project was to investigate whether the customers can be motivated to manual shifting of electricity demand from hours when the electricity is greatest environmental impact to hours with less environmental impact.

Description: 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 daily follow the spot prices for the coming day (Energistyrelsen, 2009).

Different means are investigated during the project:

- Media campaigns
- Energy contracts with spot price
- A box visualizing 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 online reading of electricity meters on hourly basis is implemented. A randomly selected monitoring group of 500 customers is selected and interviewed. Data including the hourly electricity consumption of this group is collected daily as 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.

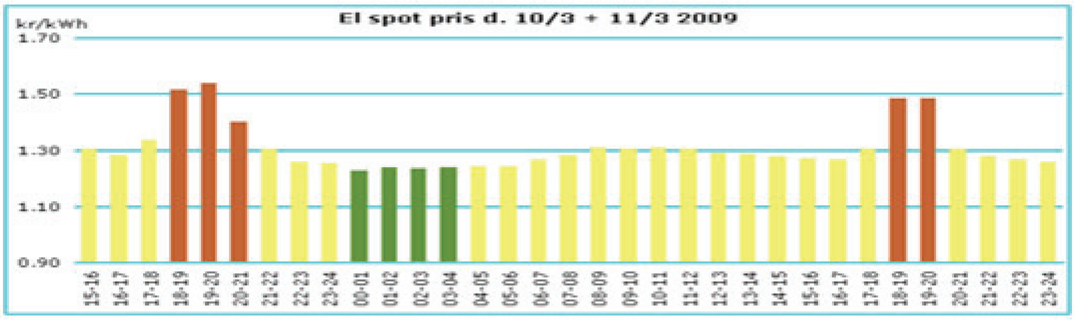

Figure 31: Information about the spot price (Energymap, 2010)

Data requirements: Hourly meter reading of electricity meters

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

Target group: The target group of this project is smaller and medium sized customers, Electrical Vehicles (EV), Photovoltaic (PV) and wind production.

Objective: The objective of this project is to develop and demonstrate in large-scale a generally applicable real-time market concept for smart electricity distribution networks with high penetration of renewable energy sources and active user participation. The concept is based on small and medium-size 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: 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 2011 to 2014.

The project will demonstrate a market concept that is designed for small-scale users by actively involving them in the whole 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 in large- scale with several thousand participants over a 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 involved regions 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, Switzerland

The initiator of the project is Energinet.dk (The Danish TSO), and the Coordinator of the project is SINTEF Energy Research, Norway.

Data requirements: Balancing market information, forecast of consumer price elasticity, customer meter values – 5 min resolution

Expected results: Innovative market concept, Customer segmentation, DER response to price signals, Industrial product development (market place, controllers, communication)

4.2.9 Tempo tariff by EDF | France

Target group and objective: The target group for that product is the standard private customer. The objective of the tariff is to reduce peak loads especially in the winter months and to reduce electricity consumption overall.

Description: The tariff consisted of four regular price levels and two event-price levels. The regular price levels were announced by different colours on the control box (a display), while the event price levels could also be announced by SMS-services, via internet or telephone. The following figure shows the structure of the tariff (Crossley, 2008).

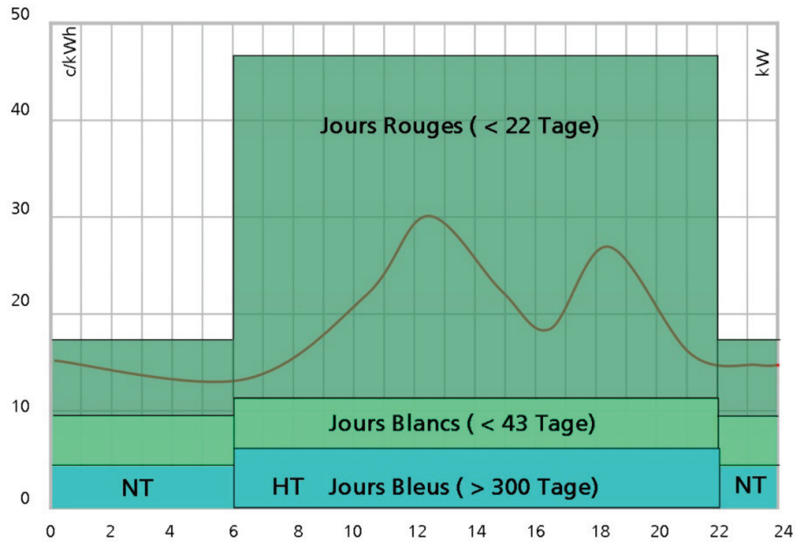

Figure 32: Tempo tariff – structure

The enabling technology for that tariff was a smart meter installed in each household. The communication was done by PLC and via the control box, which was plugged into a power plug.

Figure 33: Information display for the tariff tempo

Information about the tariff and also about the upcoming price levels could be gathered via the internet portal.

Data requirements: To be able to bill the tariff described smart metering data – consumption data in 15 minutes intervals – was needed.

Consumer response: The consumers respond to the tariff by avoiding consumption during peak hours. Thereby they could reduce their energy bill.

Results: Compared to the lowest price level, consumers were able to reduce consumption by 15% on the second highest price level and by even 45% on the highest price level. 59% of the customers were able to reduce their electricity costs by 10% (Crossley, 2008).

In the year 2004 almost 20% of the customers of EDF used the Tempo-Tariff. After the liberalization of the energy market in 2007 the Tempo-Tariff had been withdrawn from the market, because the tariff was tailor-made for the monopoly position of EDF (Crossley, 2008).

Assessment of service: The division of the price in three price levels seemed to be well accepted by the customers. Because of the great share of electric heating in France the potential for shifting loads is relatively high. Therefore the great 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. The high satisfaction level with the tariff is evidence 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 objective for the supplier 'Stadtwerke Bielefeld' is not publicly communicated. Because of the legal situation in Germany, it can be assumed that the product is a marketing product.

Description: The tariff has got four price levels. The following picture shows at which times the different price levels are valid. The whole smart metering product also includes an internet portal, a time of use tariff and an annual bill.

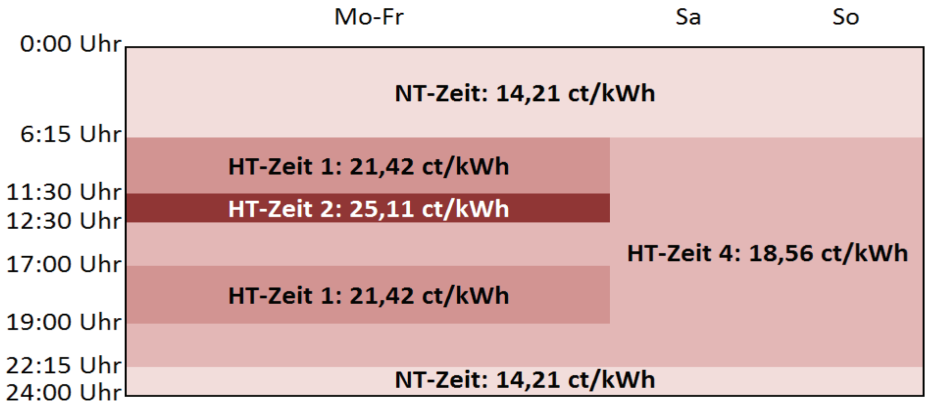

Figure 34: "EnerBest Tariff" Stadtwerke Bielefeld

Data requirements: To be able to bill this tariff, a smart meter is necessary. Further requirements concerning the data are not mentioned within the information. Due to the price levels and their valid times it can be assumed that a 15-minutes interval for the meter data is necessary.

Consumer response: There are no official results. But according to Stadtwerke Bielefeld, not many consumers choose the new smart metering product[69].

Results: There are no official results.

Assessment of service: The tariff shows a large price range between the lowest (14,21 ct/kWh) and the highest (25,11 ct/kWh) price. Therefore the customer might have a strong incentive to shift loads from the times of high price levels into times of low price levels. The four different price levels are very innovative compared to other tariffs in Germany with an average of two to three levels. Therefore this tariff might fulfil its destiny as a marketing tariff. On the other hand especially the highest price level is only valid for one hour per day. This time interval might be too short for customers to adapt to it. Also the time zones offer a lot of possibilities even for working customers to shift loads into cheaper time zones.

4.2.11 Demand Response | Finland

In Finland there is decades of experience on 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).

[69] Conversation with a representative of Stadtwerke Bielefeld at E-World in Essen (09.02.2010).

Apart from this, plans to introduce further TOU tariffs in Finland are not yet clear. These are seen as very interesting new products, especially for electricity sellers and service developer companies, but utilities are uncertain how they will work and what will they mean to their business. Basically the regulation encourages to offer new tariffs when the hourly based meters are on place, and utilities are now watching closely who will open the game.

Generally, in order to have high peak load reductions through tariffs and demand response, it is seen that building systems should be automated to optimize their use in peak-load situations:

- **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 the home automation systems. Along with exact consumption information, the system minimizes 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
- **Consumer response, expected energy savings:** As regards the home automation systems, According to a “Response 2010” report published 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 percent, depending on the nature of the technology used and the consumer’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.[70]
- **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 of 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 & 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.

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[70] http://www.vaasaett.com/2010/06/respond2010launch/

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 one 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 the information, feedback and billing.

4.3 Direct load and consumption control services

Direct load control allows utilities to turn on and off specific appliances during peak demand periods, typically in industrial and commercial enterprises but also increasingly with residential consumers 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

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 pilot was performed in 2007.

Objective: 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 achieving cost reduction.

Description: 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 11 Eurocent/kWh)[71] valid from 07:00 -10:00 and 17:00-20:00 on working days). All customers had hourly metering of their electricity consumption and were advised to have an hourly spot price contract with the supplier.

[71] VAT excluded

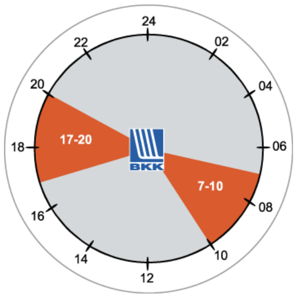

Figure 35: "El-button" Sparresgate (Grande et al., 2008)

To remind the customers of the peak load period, each customer received three magnetic tokens “El-buttons”[72].

Data requirements: Hourly metering of electricity consumption

Consumer 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 the people leave the flat.

Results: The electricity consumption of the 24 customers were metered on an hourly basis and analysed. An average demand profile for working days was calculated for November 2006 (before the tariff was introduced) and February 2007 (after the tariff was introduced) (see Figure 36). The peak load periods are presented in the figure. The calculations are not corrected based on differences in outdoor temperature.

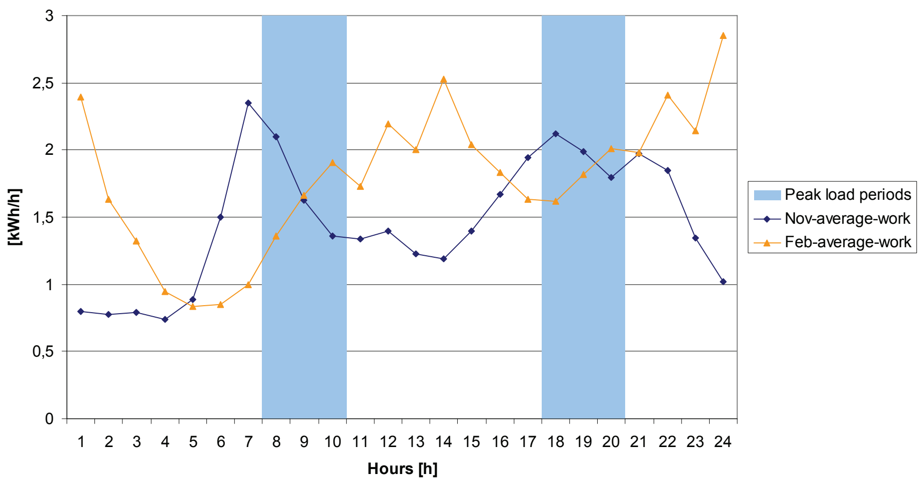

Figure 36: Average consumption for all customers (workdays) (Week 47-06, Week 7-07) (Grande et al., 2008)

[72] 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.

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 during the last 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.

Assessment of the service: This pilot shows that demand response/load shifting can be performed trough 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 prioritized loads controlled by building energy management in an institution (Market Based Demand Response project) | Norway

Target group: Commercial building institution (owned by Statsbygg[73]) with Building Energy Management System (BEMS) installed.

Objective: To test the demand response from introducing a Time of Day (ToD) network tariff.

Description: The possibility for demand response has been tested in an institution (owned by Statsbygg[74]) 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 08:00-11:00 and 17:00-20:00 on working days 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 minimize 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 7).

[73] http://www.statsbygg.no/System/Topp-menyvalg/English/
[74] http://www.statsbygg.no/System/Topp-menyvalg/English/

Table 7: 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
Pavement 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.

Data requirements: Hourly metering of the total electricity consumption

Consumer response: n/a

Results: The demand response achieved after introducing the new tariff is illustrated in Figure 37 and Figure 38.

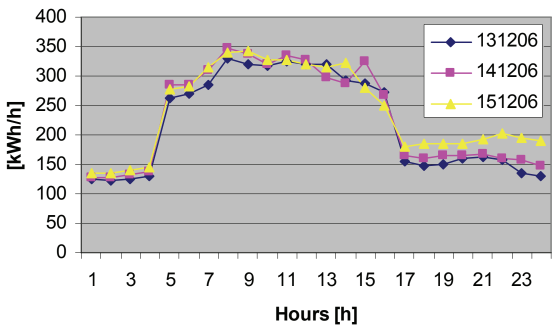

Figure 37: Consumption BEFORE introduction of power tariff (13.-15. Dec. 06)

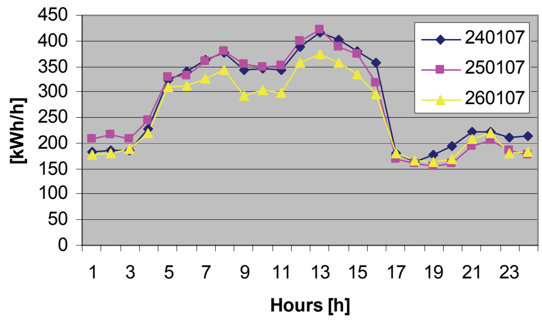

Figure 38: Consumption AFTER intro-duction of power tariff (24.-26. Jan. 07)

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 difference in outdoor temperature. The demand response performed with use of BEMS resulted in a reduced consumption in peak load hours of about 50 kWh/h.

Assessment of the service: This pilot shows that demand response/load shifting can be performed trough simple means – hourly metering, hourly price incentives (Time of Day power tariff) and existing Building Energy Management System.

4.3.3 Low prioritized loads controlled by building energy management in a shop (Market Based Demand Response project) | Norway

Target group: Commercial building (shop)

Objective: To test demand response for a large customer – with use of an energy contract with the spot price on an hourly basis.

Description: The customer utilized 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 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 12,29 Eurocents/kWh[75].

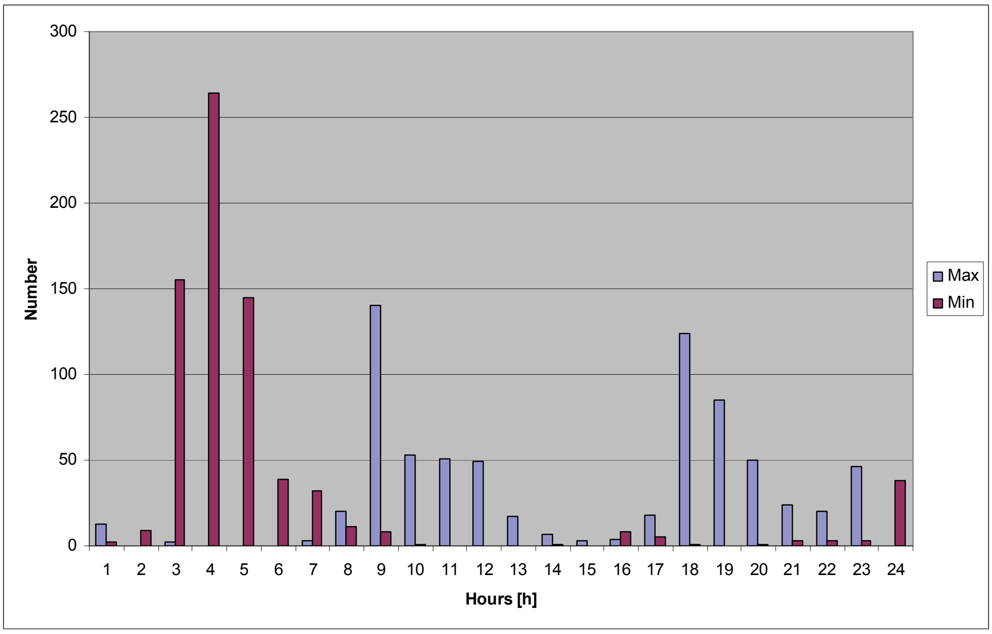

Figure 39: Histogram for the maximum and minimum of the spot price during the day (NO2) (Source: NordPool) (Grande et al., 2008)

[75] In this calculation the 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 working days and weekends.

Data requirements: Hourly metering and hourly settlement of the electricity consumption.

Consumer response: n/a

Results: An example of demand response at the shop is presented in Figure 40. The darkest curve represents the demand the week before the actions were activated (week 20). No actions where 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.

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 switch them off when other appliances were started. The heating was on for 05:00-07:30 and 09:45-20:00. (The first day of week 20 was Whit Monday and the shop was closed.)

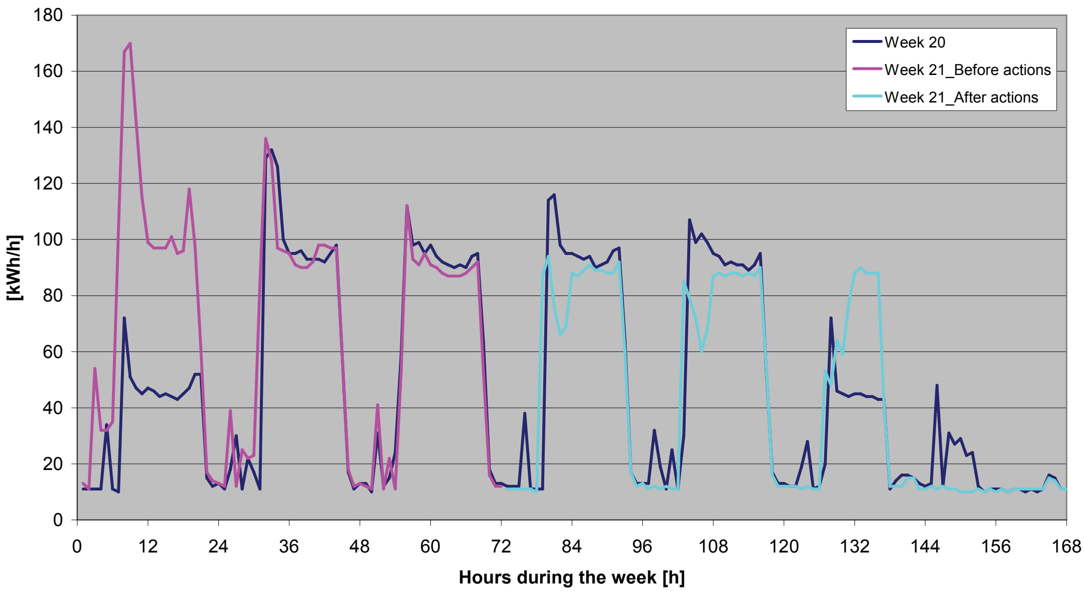

Figure 40: Electrical consumption before and after actions for demand response (Week 20 and 21 – 2008) (Grande et al., 2008)

Assessment of the service: This pilot shows that demand response/load shifting can be performed trough 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

Target group: Residential customers with direct electrical heating connected to Jönköping Energi (the local DSO).

Objective: 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: 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 – 33 Euros per annum. The customers were grouped under the same network station and the installed measuring equipment carried out readings at 6-minute intervals.

By utilizing 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 the lowest. On one such instance, January 22, 2004, the outside temperature at the time of reduction was –15°C.

Data requirements: To implement this service it is only technology for remote load control that is necessary, but measurement on a customer level will make it possible to give information about the response for each customer.

Consumer response: One result from the trials has shown that the installations carried out in the early 1990's 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.

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.)

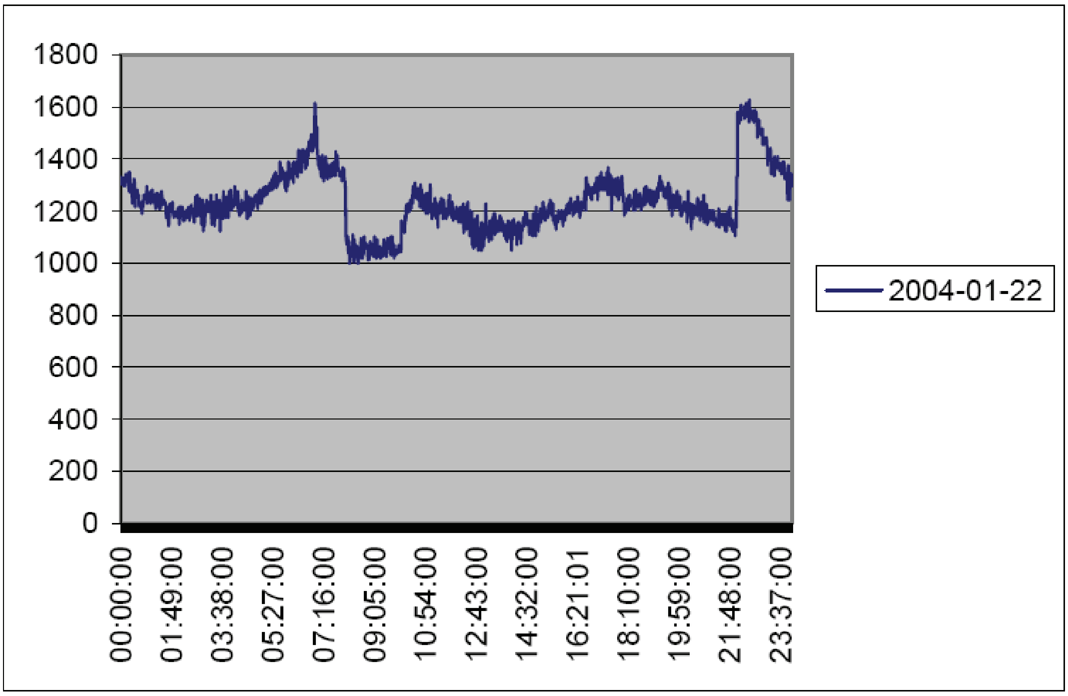

Figure 41: Control on 22 January 2004. Outside temperature -14,6 °C. Controlled load approx. 280 kW. Remote control performed between 8-10 am (Lindskoug, 2006)

In this trial the total demand was measured only in the substation – for 200 household customers in total, from which 50 participated in the trial. No measurements were performed at the customer level. With measurement on the customer level, it had been easier to analyse the response per customer, and not in average per customer.

Assessment of the service: 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 target group were customers with night heating or water boilers. The objective was to have a better load control in the grid.

Description: In the Czech Republic there have been double-tariff products on the market enabled by using two traditional meters. By a limited amount of customers with accumulated night heating or water boilers remote ripple-control systems or long-wave radio are being used to control the load. These systems have been installed in the 1970s. Since the liberalization the operation of the ripple-control has been donated to the local electricity distributors. As those are not participants on the electricity market, the system is not being used to its full potential. Replacing this demand side management by smart metering based technologies is being evaluated (ESMA, 2010, 48).

Data requirements: No data required.

Consumer response: There is an automatic response by night heating devices and water boilers.

Results: The load connected to the ripple-control system accounts up to 2,500 MW. This represents about 10-15% of the maximum grid load at winter days.

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 might determine the potential for direct load control based on smart metering.

4.3.6 Plugwise | The Netherlands

Target group: Households and SMEs

Description: Plugwise does not allow direct load control. However, it helps to reduce standby consumption. Plugwise has developed and produced wireless systems for energy management and appliance control to help users understand their energy consumption at a device level and reduce their energy bill.

Data requirements: Each Plugwise system consists of a set of plugs that can be put between a socket and the appliance plug. The plugs store power consumption data and transmit them to the Plugwise Source software installed on a consumers personal computer, using a wireless ZigBee-mesh network. The software shows the data in clear overviews and well-organised charts.

Consumer response: The Plugwise system has been 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 you can create switching schemes for appliances connected to the plugs.

3. Create virtual power groups and switch them wirelessly: with the software a consumer can combine plugs in power groups and switch them wirelessly.

Results and assessment: The service has the potential to conveniently reduce standby consumption, increase the awareness of electricity consumers and be a starting point for a smart home. However, an independent evaluation of the achieved savings is not available. Following the decision in Dutch parliament on the smart metering rollout plans, the government has also decided to start up a national evaluation of the energy saving potential. The saving potential of various smart metering services can be checked by independent sources within two years.

4.3.7 Direct load control | Finland

Up until early 1990's, utilities implemented direct load control with business clients. However, as the distribution and selling are unbundled this has became harder. It is seen undesirable for the DSO to control the load if e.g. energy seller requests this, even if its based on a contract with customer. Currently only heavy industry is doing load control to minimize their energy prices.

Yet load control issues are studied, and saving power capacity, money and emissions through peak load reduction is seen as an very interesting option, and also a possible business area (e.g. load savings bundled and sold forward to utilities that this way avoid investments in new capacity). For example, in a pilot study for electric heating (which covers altogether 600 000 apartments in Finland), the common controllable power for 6133 houses was found to be 20 MW during cold winter days.

4.3.8 Market-based electric heating load control with remotely read meters | 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 the national level, the service has also potential in lowering the electricity system price and emissions from coal and peat using peak load production.

Description of the services: The developed model consists of a centralized load shifting service utilizing 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 current remotely read electricity meters have a two-way data transfer connection, a load control facility, and often in two-rate time of use tariff sites there is also some connected controllable load. The service is based on a load control model for harnessing the features of the current remote meter systems to better serve the needs of the electricity market. In this, the Helen Electricity Network's controlled night-time product, with current systems and equipment were used as a developing platform for the load control system. The objective was to have no need for separate equipment or system acquisitions by the DSO company or the customer.

The sites have a water-circulated, full storage electric heating system, with a possibility of supplementing it with other heating methods. The input powers of the systems vary between 20 and 50 kW. The ripple control-like command of the product, based on the heat requirement was replaced with the new system, taking the price information of electricity into account.

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, it can be also 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 according to actual heat requirement).

The system will be introduced in pilot sites during 2010 in eight metering sites of Helen Electricity Network, and the testing of the system under a normal operating situation will continue to the heating season of 2010 – 2011 (ENETE-project 2010).

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.

Consumer 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 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 70 MW of controllable load through this kind of service.

The benefits gained from load control are substantial compared with its investments. The benefits can be further improved by optimizing the time frame of heating with respect to each metering site, for example, in accordance with the heating needs detected from the hourly energy series.

Development costs of the load control system were carried through the ENETE project work. Separate equipment investments were not required. The costs of the program processing the initial data were approx. EUR 2000. The annual costs of data transfer are in the region of EUR 0 - 1 per metering point, depending on the system operator's service contracts 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 electric energy 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 theoretic 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 declined 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 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 utilizing this kind of service when supplied with the new metering technology.

Assessment of the service: The service has considerable potential in cutting peak load consumption. The system is a quite simple centralised load control, with no need for separate equipment or system acquisitions by the electricity distribution network company or the customer - as long as there are modern remotely read electricity meters with a two-way data transfer connection and load control functionality. Thus the system can be introduced by any electricity distribution network company using modern measurement data management and remote reading systems. 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.

4.3.9 Energy Demand Research Project (EDRP) | UK

Smart meters with an alarm which alerts the user when certain electricity consumption levels are exceeded. Although these can be seen as *indirect* methods for control, we felt best to include them in here:

- One of the trials involves a visual display that includes an alarm if daily cumulative electricity consumption goes over a threshold set at 6% above the household's typical consumption for the time of year.
- Another trial group has received the display without the alarm.

Consumer response: Customer feedback on VDUs includes a *dislike of alarms that sound too frequently*, a *welcome for a distinctive 'traffic light' indicator on displays*, and *preference for energy use to be expressed in money rather than in kilowatt-hours*. However, it is clear that different individuals prefer different features. Therefore the effectiveness of these devices might be determined by the quality of the design and functionality.

5 List of References

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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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