Smart electricity metering as an energy efficiency instrument: Comparative analyses of regulation and market conditions in Europe

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Abstract

The new European Directive on Energy End-use Efficiency and Energy Services (ESD) (EC 2006/32, 2006) states the importance of installing metering and billing systems allowing consumers to regulate and steer their consumption. Extra information provided by these "Smart Meters", is proposed as an important technological innovation to improve energy efficiency. In the next few years the European energy markets will face a challenging task – implementation of Smart Metering systems for small and middle-size customers. The public policies and implementation paths of Smart Metering today vary across Europe from full-scale implementation to very limited.

Implementation of Smart Metering systems provides a technological basis, which makes it possible to implement new market-based products and services encouraging the Final Customers to save energy. Electricity suppliers and Distribution System Operators play a key role in a full utilisation of the energy saving potential from Smart Metering, but need a benefit for doing this. These new market opportunities could provide this benefit.

Introduction

During the previous 10-15 years several Distribution System Operator (DSOs) in Europe have conducted small and middle-size pilot test and voluntary installations of Smart Metering. Among those the Italian ENEL Distribuzione SpA, which has rolled-out and commissioned almost 30 million smart meters and is widely considered to be the industry's flagship. Two recent European Directives, one on Energy End Use Efficiency and Energy Services (ESD) and another on Measuring Instruments Directive (MID) have raised the Smart Metering-related debate to the European level. Article 13 in the Energy End-use Efficiency and Energy Services Directive states the importance of installing informative metering and billing systems allowing consumers to regulate and steer their consumption (EC 2006/32, 2006). Extra information provided by informative metering, is proposed as an important technological innovation to improve energy efficiency. In the next few years the European energy markets will face a challenging task – implementation of Smart Metering systems for small and middle-size customers.

The paper presents a brief overview and analysis of regulatory and market conditions for Smart Metering in a selection of European countries. Further the paper provides examples of innovative energy-saving products and services, which are enabled by Smart Metering. Finally the paper discusses the main driving factors and challenges for implementation of Smart Metering in Europe. The scope of this paper does not include technical barrier as for example interoperability of meters or communication protocols. The paper uses regular definitions of electricity market actors, which are adopted and used by the European Commission (EC 2006/32, 2006).

Smart Metering in brief

WHAT IS SMART METERING?

Even though the term Smart Metering is frequently used today; there is no a commonly agreed and concrete definition of what Smart Metering actually is and which functions it includes. Accordingly, there are no clear definitions of different attributes of Smart Metering as, for example, quality and reliability of it, which makes it difficult to set precise requirements for Smart Metering. Development of more elaborated and clear definitions of terms related to Smart Metering is one of the research tasks in project European Smart Metering Alliance (ESMA), which is initiated under support of the Intelligent Energy Europe (IEE) program. In ESMA project metering industry and research organisations cooperate to exchange best practices in the field of smart metering in Europe. The paper is based on the initial findings of the project.

In the present paper by electricity Smart Metering is meant a metering device along with supporting systems and infrastructure for transfer and management of metered data, which register timely electricity consumption, periodically or on request, in more details that a conventional one and transfers metered data to the Distribution System Operator or other market actor for monitoring and billing purposes. Smart Meters can have optional functionality as, for example, remote control of customers' electric loads, registration of voltage deviation and other parameters. Automated Meter Reading (AMR) is often used as a synonym of Smart Metering.

The most commonly used frequency of reading metered data or resolution is one hour, but metering with other resolutions varying from 15 minutes to a month is also in use. Furthermore, choice of appropriate frequency for reading metered data for different customers' groups is still under discussion in several countries. Higher resolution of metered data will normally mean higher investment and operational costs, but will also extend possible application areas. The frequency of the data transfer from a meter to an actor responsible for metering usually depends from the communication carrier and usually varies from daily to monthly.

BENEFITS OF SMART METERING

Implementation of Smart Metering provides several advantages for various actors in the electricity market. It is very comprehensive topic, which cannot be presented in details in the scope of the present paper. Especially interested readers are advised to read deliverables from ESMA project[1], where these issues will be studied. As the key advantages, which are relevant in the present paper can be mentioned:

Smart Metering enhances energy saving

Smart Metering provides continuous information about actual electricity consumption giving Final Customers better control of their use of energy by following and adjusting their consumption patterns, identification of abnormal consumption of energy due to, for example, malfunctioning equipment or poor house's insulation and further improving of the situation.

Smart Metering also provides technologic basis for Electricity Suppliers, DSOs and possibly other market actors to offer Final Customers new products and services, which will encourage energy saving.

Providing of correct and timely billing to Final Customers

The EU Commission emphasises in its ESD Directive the importance of providing actual energy consumption data to customers and correct and timely billing, based on this data. Smart Metering obviously enhances possibility to do it.

Improving competition and efficiency in energy markets

Changing of electricity supplier in a deregulated electricity market is a complicated technical procedure, requiring exchange of different data, including metered data for the switching Final Customer, between several market actors. One of the core functions in Smart Metering is a possibility to request accurate metered data from a metering point at any time. It allows to shorten or possibly to automate energy supplier switching procedures and to reduce costs of it. It also makes it easier for Electricity Suppliers to gain metered data for potential customers and make better electricity contract offers to them. Smart Metering diminishes technical barriers between national markets and makes it easier to establish international electricity retail markets in the future. Smart Metering improves identification of electricity losses in distribution networks, including theft and wrong meter readings.

It is however necessary to mention that Smart Metering requires considerable investment costs for purchase of the equipment, its installation and commissioning. The future operation and maintenance costs of the equipment should be also considered. Additionally the experience shows that collection and management of metered data require skilled and well-trained personnel in order to maintain high quality of the metered data. Profitability of Smart Metering of implementation of Smart Metering is normally assessed through cost-benefit evaluations and depends from a number of various factors including type of equipment, its functionality, appropriate communication carriers, implementation scale, number of customers, type of area (urban or rural) organisation of the process etc. During the recent years it has been a clear pattern showing decline in investments and commissioning costs, making cost-benefits evaluations more and more favourable for implementation of Smart Metering.

Implementation of Smart Metering in Europe

UNITED KINGDOM (UK)

Reform of the electricity sector in England and UK was the first one and has attracted most attention, creating a reference point for the whole industry. In the UK all aspects of utility metering have been unbundled and opened to competition. The Supplier is responsible for metering and is required to contract with a meter asset provider, a meter operator and a data collector. These contracts are entered into on behalf of the customer. These contracts can be let to separate companies but also, where Suppliers have retained their own meter operations, can be supplied in-house. In theory, customers are at liberty to install their own meters but this is discouraged.

1. The deliverables will be published at the project's homepage: http://www.smart-metering.com

Table 1 Consumption patterns in the Nordic countries. Source: (Oland, 2006)

	Denmark	Finland	Norway	Sweden
Number of households	2.624.300	2.800.000	2.303.000	4.481.000
Total electricity consumption in households	9,7 TWh	18,6 TWh	31 TWh	36 TWh
Electricity consumption pr. Household	3.682 kWh	6.800 kWh	15.200 kWh*	8.000 kWh

* Including summer houses and cabins. Source: NVE

Automated metering with half-hour resolution is used for customers with capacity over 100 kW, however implementation of smart metering for small customers is being actively investigated by the UK Government. It has broadly accepted that customers will respond positively to more information but is not certain about the levels of response or how well they will be sustained. The government has initiated a customer response trial with £ 10 m matched funding. These will begin early in 2007 and will run for 2 years. The major electricity Suppliers are expected to be involved in these trials. The government is currently consulting on billing and metering aspects of the ESD. The UK Government has been very specific that the purpose of the trials is to assess the level of response of customers when provided with more usage information and the extent to which this will be sustained. The main purpose of the trials is to provide evidence for the implementation of Article 13 of the ESD (Department of Trade and Industry, 2006). It is anticipated that the trial will examine a number of different approaches to delivering greater energy efficiency and the technical implementation issues of smart metering will be a minor topic.

Smart metering is proving difficult to implement in the UK due to the unbundled market and Suppliers are anxious about stranded assets if they invest in more costly meters only to lose the customer to a competitor. This relates to both the lost asset value of the existing meter and the potential for new meters to be 'stranded' when a customer changes Supplier. The Suppliers have launched an exercise to agree within the industry on a common smart meter specification and interoperability rules to overcome this challenge. The purpose of this is to provide for the transfer of the meter asset when a customer switches Supplier. This would be made possible by ensuring that the new meters are functionally identical, regardless of manufacturer so that Suppliers are able to adopt the meters without having to visit the site. This is the subject of a consultation exercise led by the Energy Retail Association[2].

The delays in implementing smart metering have resulted in an interest in customer electricity displays that do not link to the utility meter. These use a split coil current transducer linked to a wireless display and can provide customers with instantaneous information on their power consumption plus limited profile information. As they do not measure voltage they cannot mach the utility meter for accuracy but they can be installed independently of the meter system. Two examples are the Electrisave and the CurrentCost units. Ideally, over time, these displays will be linked to the utility meter but, in the meantime, may give some guidance on how customers will respond to such information.

NORDIC COUNTRIES

The Nordic countries are very close geographically, have similar climate and share a common Electricity Exchange (NordPool). The deregulation process path differed from country to country, yet all four national electricity markets are fully liberalised today and have similar organisational structure of the national electricity markets. At the same time the electricity consumption figures differ significantly from country to country mostly due to traditional domination of electric heating in Norway and to lesser extend in Sweden as it is shown in Table 1.

The Nordic countries work on implementation of a common initiative of a deeper integration of national markets, which was stated in Declarations of the Nordic Energy Ministers[3] in Akureyri (2004), Narsarsuaq (2005) and in Bodø (2006). This initiative will most likely result in establishment of a common Nordic retail electricity market, which will require introduction of common settlement routines for non-hourly metered customer (NordReg, 2006). This initiative may encourage implementation of smart metering systems since it will allow DSOs to reduce costs for the settlement routines.

Denmark

From the 1st January 2003 hourly metering was a mandatory requirement for metering points with an annual consumption exceeding 200.000 kWh/year. After the 1st January 2005 the limit was lowered to 100.000 kWh/year. This means that approx. 9.000 new customers (metering points) have been equipped with hourly metering. At present approximately 30.000 customers have hourly metering and they consume approx. 48 % of the total electricity consumption.

The grid companies are allowed to further reduce the declared levels for hourly metering if the company can offer the service to its entire grid area and the service can still be handled by an electronic switch in a simple and secure way. In the long term all metering points may be subject to hourly metering – first step might be to lower the boarder for hourly metering to e.g. all customers using more than 25.000 kWh/year. Self reporting of the yearly electricity consumption is standard for households. Internet and phone systems for reporting are widely used as supplement to mailed reporting. Six utilities have decided to invest in automated meter reading systems, corresponding to 13 % of the total number of meters. Many utilities are planning similar projects. The association for grid companies, Danish Energy, has formulated it as a strategic goal that all end-users should have automated meter reading (with hourly metering) before year 2014. Investments in meters are paid by the grid companies. These companies are closely regulated by the authorities. Investments must be done with the existing economic regulation.

2. http://www.energy-retail.org.uk/smartmeters.html

3. http://www.norden.org/

Finland

In Finland there are about 3.1 million metering points today. A small number of metering points are connected to the high voltage transmission network and are hourly metered. The consumption places that are equipped with main fuses of over 3 x 63 A must have hourly metering. DSOs are responsible for metering in Finland, but the meter reading can be conducted either by the network operator, the electricity supplier or the customer.

The number of metering points in the distribution network with main fuses over 3 x 63 A is about 54.000, having total electricity consumption 6 TWh/year. From these about 27.000 are already hourly metered (4,5 TWh/year). It is estimated that it is possible to decrease the main fuses from over 63 A to 63 A in about 7.000 metering points especially in town areas. Therefore there sill remains about 20.000 customers over 63 A without hourly metering.

Full-scale implementation of hourly metering becomes very relevant in Finland. Compensations for power supply interruptions (over 12 hours) are now included in the billing in Finland. Thus registering of voltage interruptions and perhaps even some basic power quality characteristics may be required for the billing meters of the future. Implementation of DRR schemes will also require hourly metering and possibility to remote load control. Additionally it is estimated that about 25 % of the existing meters should be replaced due to expiring of their lifetime. VTT Technical Research Centre of Finland carried out a survey in 2006. The answers covered 74 % of all the consumption meters in Finland, and 18 % of these or 398.000 meters were already in AMR in 2006. From this it can be assumed that there were likely over 500.000 meters in AMR in 2006 in Finland. Furthermore according to the responding DSOs 61 % of all their meters will be in AMR in 2015.

Several Finnish DSOs, including Vattenfall[4], Fortum and several smaller companies have already committed or are evaluating big AMR projects.

Norway

There are several arguments, supporting construction of Automated Meter Reading (AMR) in Norway. Energy saving possibility is probably the most obvious one. This is mainly caused by direct electricity heating, which is commonly used in Norway, what makes electricity consumption in residential sector very high: in average it is around 16.000 kWh/year pr household (Statistics Norway, 2005), while a single family house uses approximately 25.000 kWh/year. Several years with low precipitation and accordingly high electricity prices have further enforced this argument.

All metering points in Norway should be read at least once a year, while Final Customers with annual consumption higher than 8.000 kWh should be metered at least quarterly, or alternatively every second or every month. The most common way of manual metering is self-reading by the Final Customer. The response rate of self-metering varies between the different DSOs, from 61- 90 % and the missing data are estimated. The metered data are reported using the DSO's web page, telephone or postcard.

Regulation about mandatory hourly metering for all Final Customers with annual consumption over 100.000 kWh was introduced on the 01.01.2005, and 4 % of all metering points and about 60 % of the whole electricity consumption in Norway are hourly metered today. Additionally, any Final Customers can require hourly metering of the electricity consumption from its local DSO, even if its consumption is below the mandatory threshold. In this the Final Customer should cover the costs for installation of technology, limited upwards to 2.500 NOK (300 Euro). Approximately 10 DSOs have already built AMR voluntarily for all their customers, while several big DSO have already budgeted full-scale implementation of AMR systems within next five years.

Public discussion about mandatory implementation of hourly metering or other implementation alternatives has been going on in several years in Norway. The future strategy will be most likely clarified already during 2007.

Sweden

In Sweden it is normally the DSO that performs the meter reading. In cases, when the DSO due to circumstances cannot read the meter, the metered data will be estimated. The estimation will be normally based on the previous year consumptions (Svensk Elmarknadshanbok, 2005). The estimated data can be collected 2 years in a row; the third has to be read due to requirements in the consumer law. During the reporting to the Final Customer and the Electricity Supplier, it should be stated that the metered data has been estimated.

From 1 July 2006 the limit for hourly metering is lowered from 200 A for all metering point with a fuse subscription of 63 A, this is expected to increase a number of hourly metered customers by 50.000 – 70.000. From 1 July 2009 all metering point should be read monthly and the Final Customers should be invoiced based on their real consumption. These requirements were initiated by consumers' organisations, demanding a better billing from DSOs. The new legislation means in practices that by summer 2009 all Final Customers in Sweden will have AMR. Event though the legislation requires monthly reading, several DSO have already indicated that they will prefer hourly metering and reading.

THE NETHERLANDS

In the Netherlands, as part of the liberalisation process, domestic metering has been made a responsibility of the customer. The customer is obliged to buy or lease a meter from a recognized metering company. From the start of the liberalisation process daily or monthly metering was required for larger customers (> 3x80 A). For small customers (< 3x80 A) the meters are read once a year through self reporting by the customer and once in three years by utility staff. For this range of customers, in practice metering is mainly done by the metering company of the incumbent utility. There is one new utility that also provides metering services (Oxxio). Oxxio has introduced smart meters that are read daily, through a GPRS-connection. The incumbent utilities are currently performing field tests with the provision of smart metering to domestic customers.

In response to continuing complaints from household customers about administrative problems in the switching process,

4. It is possible to follow installation of AMR meters at Vattenfall's homepage www.vattenfall.fi. By the time of writing this paper, it were 202.987 AMR meters connected to their system.

in the beginning of 2006 the Dutch ministry of Economic Affairs announced that for the small customers it wants to close the metering market and make installation and maintenance of the meters again a regulated task of the distribution network operators. Through a covenant with the ministry of Economic Affairs, the distribution network operators should introduce smart meters at all 7 million households in the Netherlands within a 6 years' period. This should facilitate better handling of customer switching, better fraud detection and improved customer energy efficiency. As a basis for this covenant, the utilities are developing a Netherlands Technical Agreement (NTA 8130) setting minimum standards for smart metering, as well as a business model for the introduction of smart metering (DTE, 2006). In December 2006, the ministry of Economic Affairs announced that it expects to introduce a bill about smart metering before the summer of 2007. This would require the introduction of smart metering to all customers within the period of 2008 to 2014. A final version of the NTA 8130-2007 should be issued before 30th April 2007, after confirmation by the Ministry of Economic Affairs.

PORTUGAL

In 2001 Portugal started to open their electricity market by joining the Single Iberian Electricity Market (Mibel) and allowing big Final Customers with annual consumption over 9 GWh to change electricity supplier. Since that the market has been opening step by step and by the end of 2006, change of supplier should be allowed to all customers. The power market is unbundled and the distribution network on the Portuguese mainland is dominated by a single company EDP Distibuição. The DSO is responsible for installation and operation of electricity meters. It is usually the DSO that performs the meter reading, but each consumer can also do the reading and communicate it to the DSO. Whenever it is impossible for both parts to perform the reading, the metering data will be estimated. The dominant DSO in Portugal promotes payment on account, which consists in a regular two month payment that. By the end of a year, the account's balance is settled according to the real consumption, therefore interfering with each consumer perception on its energy consumption data.

Smart metering will allow the access to detailed energy consumption, by the DSO but also by each consumer. It may be structured in a web platform that might be accessed on-line and indicate on-time metering data. This would facilitate a better monitoring and control of energy consumption, allowing, for example, a day-to-day control of the best energy contract, and energy and costs savings.

POLAND

Poland has been gradually deregulating its power market since 1998. The process includes opening the market where all customers can shift their electricity providers (for households from 01.07.07) and unbundling of generation, transmission and distribution services. The process has met several obstacles, where the so-called long-term contracts are the most important one (URE, 2006). The transmission system is operated by the Polish Power Grid Company (PPGC), while there are more than 30 distribution companies (DSOs). Poland has a very well developed district heating network, which provides space heating and hot water, especially in urban areas. The district heating covers a considerable part of the primary energy demand in Poland.

The smart electricity meters are entering the market in Poland but on the voluntary basis only. There are no law obligations and no initiatives regarding this question. The distribution companies install in many cases meters being fit to transmission of the data on energy consumption. Adequate equipment, remote control and measuring system can be installed always when the client (especially this with annual consumption over 100.000 kWh) wishes this, but it has to participate in the cost of installation of the system and necessary devices. The remote readings and servicing of the system are then done at the charge of Distribution System Operator (the Final Customer do not pay any money). Interest to installation of Smart Meters for measuring electricity consumption enhanced by existence of high energy losses in distribution networks.

LATVIA

The deregulation process was started after adoption of the Electricity Market Law in 2005. The country's main utility AS Latvenergo is going through an unbundling process, which should be completed in 2007. The high voltage and distribution networks have been separated from AS Latvenergo into two new companies, respectively AS Sadales tikls and AS Augstsprieguma tikls. AS Sadales tikls has more than a million Final Customers.

The major part of the Final customers use electro-mechanical meters, while customers, having electricity capacity over 100 kW use electronic meters, normally without automatic transfer of the metered data. All Final customers – residential, commercial and governmental institutions should on the first day of every month make meters reading and send this information to Latvenergo. There are several possibilities for sending information to Latvenergo: web page[5], SMS, fax or e-mail.

Private persons have their electricity consumption books, where they should write down their meters data the 1st of every month. For large companies, Latvenergo requires twice a year to give in a 24 hours load chart for all that period. But in the reality not all companies follow this requirement, mainly because they do not have enough personnel to carry on this task.

Latvenergo analyses received data about electricity consumption, and if some consumer has not provided the monthly data then he will receive a warning letter. If the consumer still will not provide the data or pay the bill, after having received the warning, then Latvenergo inspectors will go on with consumer disconnecting from the grid. To encourage all electricity consumers to give data and pay on time there is penalty to the amount of 0,15 % per each day of delay in payment.

5. http://www.latvenergo.lv

Table 2 Implementation of Smart Metering across Europe

Country	Deregulation stage	Present requirements to hourly metering	AMR status	The main AMR drivers
UK	FU*	Capacity > 100 kW	Voluntary installations, mandatory requirements are under evaluation	Better service to customers, requirements for consumers' authorities
DK	FU	Consumption > 100.000 kWh pr. Year	Voluntary installations, mandatory requirements are under evaluation	Reduction of electricity settlement costs, better service
FI	FU	Capacity > 63 A	Voluntary installations, mandatory requirements are under evaluation	Reduction of electricity settlement costs, better service
NO	FU	Consumption > 100.000 kWh pr. Year	Voluntary installations, mandatory requirements are under evaluation	Energy deficiency on a national level, reduction of electricity settlement costs, better service
SE	FU	Capacity > 63 A	Voluntary installations, mandatory monthly reading from 2009	Requirements from consumers' authorities, Reduction of electricity settlement costs, better service
NL	FU	Contractual capacity > 0,1MW***	Voluntary installations, mandatory Smart Metering expected from 2008-2014	Better service, energy efficiency targets, customer retention
PT	TR**	No requirements for mandatory hourly metering	Voluntary installations	Energy efficiency targets
LV	TR	No requirements for mandatory hourly metering	Voluntary installations	Energy efficiency targets

* Fully unbundled electricity sector; ** Electricity sector in transition; *** Metered values per quarter of an hour are required.

SUMMING UP

Table 2 presents a brief overview of implementation of Smart Metering in Europe.

Smart Metering enables energy saving: examples of new products

There is a strong focusing at present with smart metering on the technology of the metering systems. This may be a wrong focus as the metering is simply an enabler for new energy products. The old electromechanical meter is sufficient for sales of kWh's, with perhaps two tariff rates or even more elaborated products, provided that load profile for a given customer is relatively standard and can be estimated. The new technology that has become available does, though, offer to support implementation of a whole range of new product offerings. Given that Suppliers and DSOs are going to come under increased public pressure to promote energy saving, implementation of these products will improve their reputation among customers. However, there has been very little development of such products. This session illustrates how Smart Meter's functionality can be utilised in products, which encourage energy savings.

REMOTE LOAD REDUCTION IN HIGH PRICE PERIODS (NORWAY)

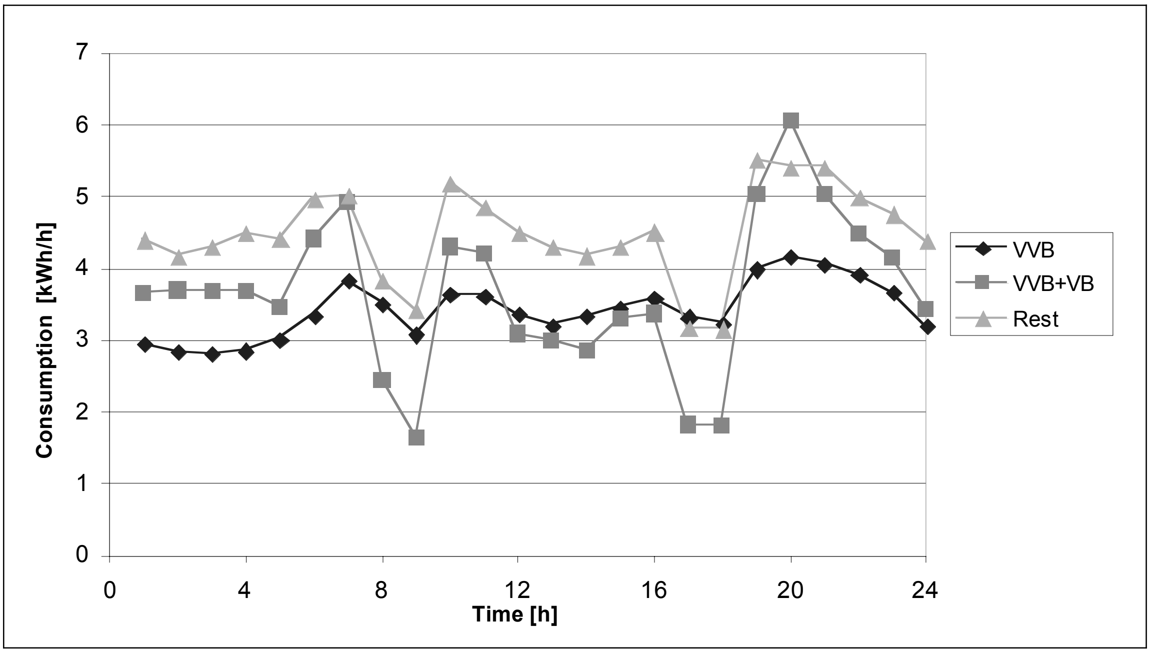
Malvik Everk is a local DSO in Norway, which has voluntary installed Smart Metering to all its customers. The company currently carries on an automatic collection of metered data on monthly basis. Since the installed technology allows metering with one-hour resolution, the company studies how this functionality can be utilised. Several previous projects have shown that Final Customers are willing to adjust their consumption according to external price signals as for example distribution network Time of Use Tariffs (ToU) or electricity spot price. At the same time medium and middle-size customers, especially residential customers, whose money saving benefits are fairly small, would rather prefer an automated adjustment of consumption. Electricity spot prices on Nordic Electricity Exchange (NordPool) vary on hourly basis, so it is necessarily to register customers" electricity consumption at least with one hour resolution in order to document actual load reductions and bill the customer accordingly. Based on this, Malvik Everk in Norway has started testing of several new products:

- Time of Use distribution network tariff with two hours high load price periods pr day (08:00–10:00 in a morning and 17:00–19:00 in afternoons)
- Electricity contract, based on electricity spot price
- Remote load reduction in high price periods

The remote load reduction is done by disconnection of low priority electric appliances, usually water heaters for tapping water (VVB) and space heating (VB).

Results of remote load reduction are presented in Figure **1**. The diagram shows load profiles for:

- Customers, who disconnect water heaters for tapping water (VVB) for load reduction
- Customers, who disconnect water heaters for tapping water and for space heating (VVB+VB) for load reduction



Source: SINTEF Energiforskning AS, project MabFot

Figure 1 Load profiles for customers with remote load reduction.

Table 3 Fixed price electricity contract with a sell-back option (Example)

	"High price and normal consumption" (1)	"Low price and excess consumption" (2)	"Very high price and low consumption" (3)	"Extrem. high price and low consumption" (4)
Consumed volume [kWh]	20 000	25 000	15 000	15 000
Actual spot price [Euro]	0,04	0,02	0,06	0,12
Spot price settlement [Euro]	20000*0,04=800	25000*0,02=500	15000*0,06=900	15000*0,12=1800
Financial settlement [Euro]	20000(0,03-0,04)= - 200	20000(0,03-0,02)= 200	20000(0,03-0,06)=-600	20000(0,03-0,12)= 1800
To pay [Euro]	600	700	300	0
Price pr. kWh [Euro]	0,030	0,028	0,020	0

- Customers, who disconnect other type of equipment for load reduction (Rest)

Since it is an ongoing pilot project it is still too early to evaluate how this product contributed to overall energy consumption. It is however interesting to mention that almost 80 % of customers have not noticed any discomfort due to remote load reduction.

FIXED PRICE ELECTRICITY CONTRACT WITH A SELL-BACK OPTION (NORWAY)

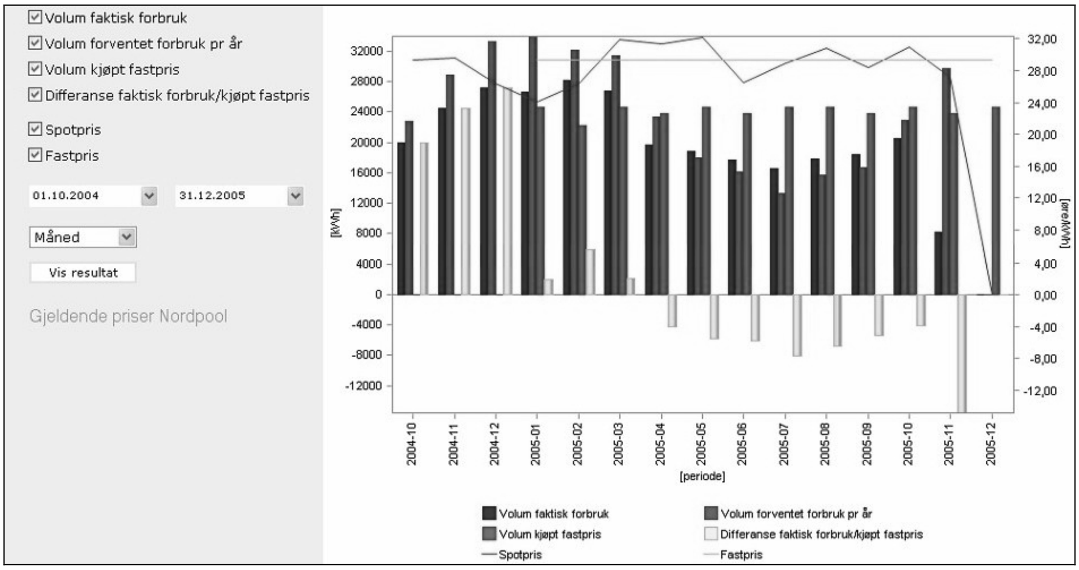
It always has been a difficult task to create strong enough incentives for Electricity Suppliers to promote energy saving products simply because these products make Final Customers to consume less electricity and therefore reduce Suppliers' revenues. The next product is an attempt to resolve this conflict of interest and providing benefits for both Electricity Supplier and Final Customers.

The product has been developed and introduced to the market by Trondheim Electric Utility (TEV). The main difference from regular price-related electricity retail contracts is that this product offers Final Customers to purchase a certain **volume** of electricity at a fixed price.

The Final Customer is billed according to the final settlement for each time period, which consists of two different parts: financial and spot price settlement.

- The financial settlement is similar to the one, which is used for financial contracts on the Nordic Electricity Exchange (NordPool). The volume, which was earlier contracted at a fixed price (not the actually consumed one), is settled against the NordPool's system price during the delivery period. If the system price was higher than the fixed price for the contracted volume, the settlement is positive and the customer receives a financial benefit. If the actual system price has been lower than the contracted one, the settlement will be negative, meaning that the customer receives an extra cost.
- The spot price settlement is based on hour-by-hour settlement of the actually consumed volume against the spot price in the given area. (Norway has several spot price areas).

Then data from the both settlements are put together and the customer is billed according to the final figure. In practice it means that if the customer consumes the previously contracted volume and the spot price has been high, he will be billed according to the contracted fixed price. At the same time, if the customer reduces his consumption during high price periods,



Source:www.tev.no

Figure 2. Customer's homepage with electricity consumption data.

he will save money since the difference will be in practice sold back to the market. If the customer exceeds the agreed volume, the difference will be purchased on the spot market. This is illustrated in four cases in Table 3. For the sake of simplicity, the example uses round figures as electricity prices and the system price is equal the spot price.

Example: In the example a Final Customer purchases initially a volume of 20.000 kWh at a fixed price 0,03 Euro pr kWh.

The example shows that if the actually consumed volume of electricity is equal the contracted one (20.000 kWh) the customers pays the contracted price, even though the actual spot price was higher. In the second example the spot price has been low and the customer has an excess consumption, so he has to purchase the gap at the spot-marked. In the third case the price has been twice as high as initially contracted and the customer reduced his consumption from 20.000 to 15.000 kWh. The result is that customer pays only a 0,020 Euro pr kWh, which is only one third of the actual spot price. In the fourth example, the spot price has been extremely high, but by reducing his consumption from 20.000 to 15.000 kWh the Final Customer pays nothing (!) for the electricity.

This type of contract encourages customers to save electricity, especially when the spot price is high. At the same time the contract is very favourable to the electricity supplier, since it diminishes the existing volume risk, which is present in traditional electricity contracts, related to price and not to the volume. In this way this contract resolves the existing conflict of interests between a Final Customer and electricity supplier, when electricity saving reduces revenues for the supplier. In many ways this is an attempt to transfer the existing financial contracts from NordPool to Final Customers.

Initially this contract was developed, and still works best for customers with hourly metering, so the customers can adjust their consumption according to development of spot price. NordPool is a so-called "day ahead market", so the spot prices are available one day beforehand. The product is also offered to customers with manual reading. In this case the consumption pattern is estimated according to load profiles, but in this case the opportunity to follow spot prices is missing.

TEV offers this product to customers on a regular basis today. The main challenge is to give sufficient price information to the Final Customers both when it comes to the electricity price and the consumption. TEV uses individual web pages for their customers, where they can follow their consumption patterns and development of the spot price.

Discussion and Conclusions

The first and probably the most interesting conclusion is that the present situation and the implementation plans for Smart Metering differ significantly from country to country. Clearly, it is a result of different national factors, including climate, consumption patterns, deregulation path etc. At the same time, even in the Nordic countries, where national electricity sectors are in many ways very similar and cooperate closely, there are quite different requirements and plans for implementation of Smart Metering.

It is unlikely that these differences will diminish in the close future, considering that Energy Services Directive does not provide very concrete definitions and implementation requirements.

CHOOSING A RIGHT SMART METERING SOLUTION

Several European countries are currently undergoing a public debate, discussing plans for installation of Smart Meters. Installation of Smart Metering for all customers in a distribution network means committing a considerable investment for a DSO or other market actor responsible for metering. The main challenge is to choose a technical solution, which will function the next 10-15 years and will meet the future market requirements. The core functionality – reading and transfer of metered data should correspond the future products. The two examples described previously of new products and services, for example, will require hourly (or better) metering in order to function in a best way. Electricity metering with weekly or monthly resolution will diminish the potential end-users' flexibility, which can be enabled by these products. Some of the Smart Meters can be upgraded for in order to improve their metering resolution, but not all of them.

The core functionality of Smart Meters can be extended with several optional features as, for example, load remote load control or metering of outages and voltage deviations. On one hand investing in multi-functional meters will increase the potential benefits, including energy efficiency. On another hand the multi-functionality increases both capital and operational costs. It is also not necessarily true that this multi-functionality is going to be fully utilised by DSOs in the close future. Considering that usually by the end of the day it will be Final Customers, who are paying these costs via distribution network tariffs, several Regulators have already raised a question whether it is justifiable to install costly meters, which may not be fully utilised in the future.

DRIVING FORCES

Before deregulation, when national electricity markets were dominated by regional electricity monopolies and the electricity tariffs were more or less constant, there was no need for Smart Metering. The new market-based pricing of electricity on the deregulated markets require Smart Metering due to new pricing models and settlement procedures, which are necessary to change electricity suppliers and to ensure competition between them. Growing electricity price volatility has made household customers to pay more attention to electricity consumption, especially in Nordic countries. It is interesting to mention that for example in Sweden it were consumers' organisations, requiring timely and correct billing, were the main driving force behind implementation of new metering requirements. Growing electricity consumption, both in energy and capacity encourages implementation of new Demand Response schemes, which are also requiring more precise and timely metering.

FINANCING

Financing of implementation of Smart Metering is another important issue. It is common that the initial investment is done by the actor responsible for metering (usually DSO) and later gradually recovered via distribution network tariffs. (In practice it will vary from country to country, according to regulation of DSOs). At the same time it is expected that Smart Metering will provide several public benefits, as improving energy efficiency and respectively energy balance, better functioning and a more flexible electricity market. Installation of Smart Metering can be considered as an improvement of public infrastructure. Therefore it has been commented, for example by Norwegian Electricity Industry Association (EBL), that investment burden of Smart Metering should be shared between electricity industry and public authorities (Valestrand, 2006).

Future work

The major part of the above mentioned challenges are common for all countries across Europe. At the same time it is difficult to see a common Smart Metering implementation strategy in Europe. There is no any considerable cooperation related to Smart Metering between electric utilities on the European scale. It is necessary to support the harmonised implementation of Smart Metering across the European Union and thus maximising the potential benefits of it, especially with regard to energy efficiency.

In order to resolve this issue it is necessary to create a European Smart metering community, involving all appropriate stakeholder groups that can develop and share best practice and establish a clear understanding of the Smart Metering and its potential amongst all stakeholder groups. It is also necessary to establish strong links between the Smart Metering community and other related fields such as Demand Response and Renewables and ensure that needs of these other fields are accounted during the implementation of Smart Metering schemes.

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Glossary

AMR	Automated Meter Reading
DSO	Distribution System Operator
EBL	Norwegian Electricity Industry Association
ERSE	Energy services regulatory authority of Portugal
ESD	Energy End Use Efficiency and Energy Services Directive

ESMA	European Smart Metering Alliance
GPRS	General Packet Radio Service
IEE	Intelligent Energy Europe
Mibel	Single Iberian Electricity Market
MID	Metering Instruments Directive
NordPool	The Nordic Electricity Exchange
NordReg	Forum for Nordic Market Regulators
NTA	Netherlands Technical Agreement
NVE	The Norwegian Water Resources and Energy Directorate (Regulator)
OFGEM	Office of Gas and Electricity Markets (Regulator)
PPGC	Polish Power Grid Company
R&D	Research and Development
TEV	Trondheim Energiverk (Electric Utility)
ToU	Time of Use (tariff)
VB	Water heater for space heating
VVB	Water heater for tapping water

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