MARKET BASED DEMAND RESPONSE. END USER INVOLVEMENT AND EXPERIENCES FROM NORWEGIAN PILOTS

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ABSTRACT

This paper summarizes the main activities in a Norwegian project (2005-2008) focusing on demand response in periods with shortage in the electricity market.

The following 4 pilot tests, demonstrating different alternatives of response to Time of Day (ToD) network tariffs and energy price, are described on a principle basis:
1. Remotely controlled load shifting
2. Fixed price contract with return option
3. Automatic load reduction when spot price exceeds a predefined limit
4. Advanced load control in housing cooperative.
The main objective of the tests is to explore the customer acceptance and the load curve impacts of the economic incentives given.

Active market participation requires frequent metering. Cost effective deployment of technology for automatic meter reading is one of the main objectives of the research. A short description of the main aspects with regard to remote metering and load control options are given in the paper.

INTRODUCTION

The forecasted shortage in both peak load capacity and energy in the coming 5-10 years will challenge the efficiency of the Nordic market structure. Increased demand side participation in the spot and balancing markets is a central aspect that will need to be addressed. After the 2002/03 winter with high prices caused by low precipitation, the Norwegian Ministry of Petroleum and Energy issued a White Paper on the security of supply. Improved end-user contracts and efficient use of Automatic Meter Reading (AMR) and Remote Load Control (RLC) were among the various measures to mitigate a tight future energy situation.

This is the background for the "Market Based Demand Response" project, which is running from 2005-2008. The project is organized in two main work packages: "Increased Demand Side Price Elasticity " and "Improvement of Technology", and build on the knowledge from previous projects testing different AMR systems and the load curve impact of price signals [1, 2, 3].

DEMAND RESPONSE IN THE NORWEGIAN POWER MARKET

With exception of minimum volume requirement there are no restrictions with regard to demand side participation in the organized markets: The Elspot and the Balancing Market, operated by the Nordic Power Exchange (Nord Pool) and the TSO (Statett SF) respectively.

The demand response (DR) in these markets has different characteristics:

- Load reduction in the Elspot market is initiated by the 24 hour spot price setting for the day ahead. The Elspot prices are published from Nord Pool around noon, which means that the potential DR is known from 12-36 hours before the hour of operation.
- Load reduction in the Balancing Market is initiated by call from the National Control centre when steady frequency / time deviation occurs in real time operation. Requested regulation has to be performed within 15 minutes. (The Reserves Option Market (ROM) [4] introduced by the TSO in 2000 has been a catalyst for end user involvement in this market.)

POTENTIAL BENEFITS

Active market participation from the demand side will lead to load reduction in periods of shortage, which will reduce the need for investment in new production and/or transmission capacity.

In a shortage situation with steep bid curves can a small price dependant load reduction result in a substantial drop in price [5], and in some cases avoid rationing and secure an initial balance in the day ahead market. Adequate demand response in the peak hours will not only reduced the high prices, but also the average price over the one week period. This means that all customers would benefit from the reduced price, and the customers who are contributing by systematic load reduction, would have an extra benefit due to the reduced consumption in these hours.

The following potential benefits for the involved actors can be achieved:
Customer: The flexible customers will improve their energy economy when consumption is reduced in periods with high prices.

Distribution System Operator (DSO): Demand Response can reduce bottleneck problems in the distribution system, and the DSO can benefit from reduced system losses by load reduction in the peak hours. Customer satisfaction can be increased and AMR/RLC services for customers and/or suppliers can be commercialized in the future.
Power Supplier: The customers are free to change supplier, which stimulates a more efficient competition. Development of new and attractive contracts for electricity with incentives for load reduction when the prices are high, is therefore in the interest of the suppliers. There is also a potential for reduction of the volume risk in high price periods.
Transmission System Operator (TSO) is among other tasks responsible for facilitating a well functioning electricity market. Active customer participation is a part of this.
Technology manufactures/ vendors: A great volume of smart meters is expected to be installed in a few years horizon. Development of new commercial products like Automatic Demand Response (ADR) schemes might additionally have a large international market potential.

PILOTS

In the Nordic deregulated power system all customers have separate tariffs for the energy and the use of the network. The energy part is based on a contract between the supplier/retailer and the customer. This contract can have a fixed price for a defined period or a spot related price. The design of the network tariff can vary within the framework defined by the Authorities as a part of the monopoly regulations.

The "Marked Based Demand Response" project includes several pilot tests involving the utilities and partners in the project. The main objectives of the tests are to explore the customer acceptance and the load curve impacts of hourly based tariffs and automatic load control schemes. The main principles of four of the pilots are described below. The final results from these tests will be reported in the second half of 2007.

Pilot 1. Remote controlled load shifting

This test is carried out among 40 residential households in an area with full roll out of AMR to all customers. The objective of the local DSO is to test the possibilities of handling hourly metering from households and to establish voluntarily remote load control of the water heaters via the AMR system. The RLC is offered as an "aid" to reduce load and costs in the peak hours.

The customers are advised to buy the energy on an hourly spot price contract. Additionally the customers are offered a Time of Day (ToD) network tariff consisting of the following parts: firm payment + loss payment + energy peak payment (active 08-10 in the morning and 17-19 in the afternoon on work days during winter)

The loss payment is calculated as the cost of the network losses (~10 % x spot price)
The energy peak payment (~8 cent/kWh) in the tariff is calculated in a way that secures that the costs for a "normal user", defined by the average load curve for the customer group, is unchanged on yearly basis.

This means that the responsive customer, reducing his load in the predefined hours, would benefit from the tariff, while customers doing nothing would have the same network costs over the year. The responsive customer would additionally have a benefit from the high spot prices that normally appear in the same hours in case of energy shortage.

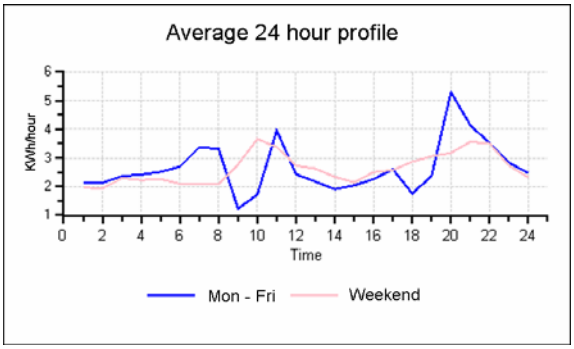

Figure 1 Household load curve with RLC on working days

The RLC is carried out in the defined high priced peak hours as can be seen on the figure 1. The customers are also equipped with a small watch-like magnetic token, the "El-button", that should be placed on dishwasher, washing machine etc. to remind the households to avoid usage of these energy consuming appliances in the same hours.

Pilot 2. Fixed Price Contract with Return Option

This pilot is focusing on the incentives for load reduction given by the energy contract from the supplier. A contract that transfers the spot price directly to the customer is considered as the best solution with regard to reflecting the current power situation. Only 25 % of the Norwegian households have this kind of contract. The others have some variant of firm price contracts.

A new innovative energy contract, developed by the Norwegian supplier TEV, is the basis for pilot 2. The contract is called *Fixed Price with return option* and secures a predictable electricity cost for a certain volume to the customer and guaranties a buy-back price equal to the spot price. This means that the customer has a strong incentive to reduce load in high price periods.

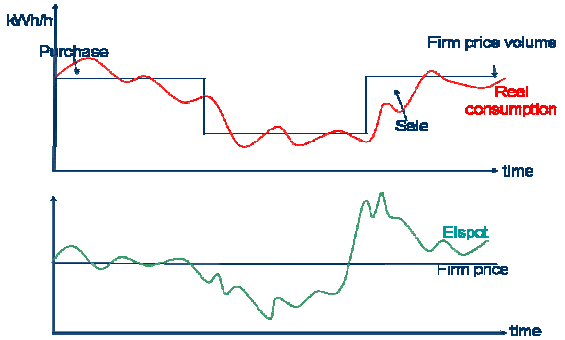

Figure 2 Example of volume and price distribution over the period

The customer buys a fixed volume at a firm price, as illustrated in figure 2. The volume is distributed over the period (normally one year) according to a profile. Deviation from the volume leads to sale or additional purchase referred to the current price in the Nord Pool Elspot market. The fixed volume is a financial contract that is settled with reference to the real volume and the running forward prices at Nord Pool.

The contract, which in this pilot is accepted by 2500 residential customers, is regarded as win-win; reducing the risk for the supplier and giving the customer possibilities to reduce the electricity bill considerably compared to normal non volume based firm price contracts.

Pilot 3. Automatic Demand Response referred to electricity Spot Price

Spot price customers with hourly metering tend not to be interested in paying attention to the variations in the spot price from day to day. This is the background for introducing and testing an automatic scheme disconnecting selected low prioritized appliances at predefined price levels in the Elspot marked. The test will be carried out in cooperation between a technology vendor, a supplier and commercial customers.

The spot price is known 12-36 hours before the hour of operation, which makes it possible to program an automatic ADR scheme in advance. For effective use, a web based interface is recommended.

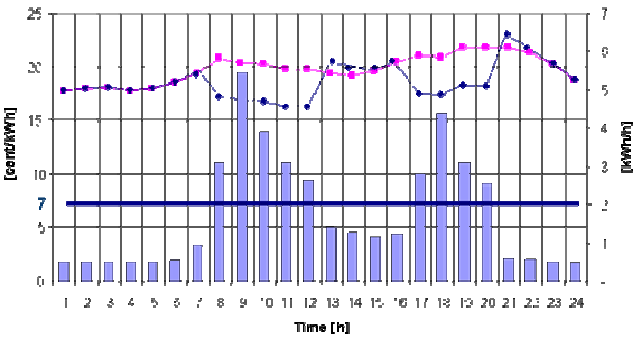

Figure 3 ADR referred to the Elspot price

The ADR criterion is illustrated in Figure 3. The figure shows the spot prices for a winter day, where the prices in the morning and afternoon hours were much higher than average spot price. The pink square dotted line is the hourly consumption for a household. This customer has a contract with the supplier that implies disconnection of selected appliances when the spot price exceeds 7 cent/hour. In this example the spot price turns out to be above this level for 9 hours of the day, which means that the selected appliances are automatically disconnected at 08:00, reconnected at 13:00, disconnected at 17:00 and finally reconnected at 21:00 in the evening. The blue diamond dotted curve indicates the response.

The test application collects prices from the day ahead market, Nord Pool Elspot, from the Internet or the Nord Pool FTP server. The prices are compared with the contracted spot price levels for RLC of the selected appliances within the defined time frame (e.g. 07:00-11:00 and 17:00-20:00) and disconnection and reconnection of loads are scheduled and performed automatically without involvement of the customers.

One of the main advantages of ADR to day ahead prices is that the expected volume of load reduction at a certain price can be estimated more easily and thereby can be bid into the market. Price dependant bids in the Elspot will be one of the main challenges in this pilot.

Pilot 4. Advanced load control in housing cooperative

The cooperative includes 24 flats, which are equipped with a programmable home automation system. The local DSO offers the customers a ToD tariff based on the same principles as described for pilot 1. The main aspects of this test is to monitor the initiatives taken by the residents with regard to the utilisation of the available technology options, and by that achieving cost reduction.

STATUS TECHNOLOGY

Demand response in the spot or balancing markets requires frequent (preferably hourly) metering and/or load control.

AMR – hourly metering

Norwegian regulations require hourly metering of all customers with a yearly consumption above 100 000 kWh. As a result over 60% of the total yearly consumption (125 TWh/year) is hourly metered. About 100 000 of 2.5 million measuring points are covered with AMR.

The same requirement applies in Denmark. In Finland, consumption places equipped with main fuses of over 3x63A must have hourly metering. In Sweden, the limit for hourly metering is a fuse subscription of 63A. In addition all customers in Sweden shall be at least monthly metered after 1 July 2009.

The DSOs are responsible for collection and quality assurance of metering information, i.e. they are the natural actors for establishment of AMR. The Norwegian Electricity Industry Association (EBL) is working for a full scale establishment of AMR. A decision with regard to metering requirements for smaller customers is expected before summer 2007.

Different actors may benefit of AMR, like the DSO, the power supplier and the customer. In addition AMR may have socio economic benefit as described above. However, so far the DSO has financed establishment and operation of AMR.

The AMR technology consists in most cases of a terminal at the customer side and a communication system between the customer and the "Front End" at the DSO. The typical components of an AMR system are market with yellow in figure 4. The AMR system provides data to the Meter Value Data Base (MVDB) and the Customer Information System (CIS).

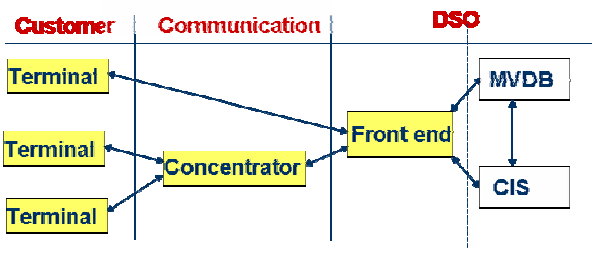

Figure 4. The AMR system

Establishment and operation of AMR systems require different type of knowledge, especial in technology, but also in law, logistics, organisation, etc. In Norway there are many small DSOs with limited capacity to be updated on all necessary topics themselves. There is a need for guide books to achieve efficient deployment of AMR technology. Guide books will be worked out in the context of the running project, both at a national and a Nordic level through a Nordic AMR forum that is under establishment.

AMR technology is not standardised, i.e. it is not possible to combine components (terminal, communication, front end systems) from different vendors. In the project a detailed description of the need for information exchange in different situations is worked out. The description will be a basis for further discussions regarding standardisation. However, the Norwegian market for AMR technology is too small, and standardisation must be performed at least at a Nordic level. Relevant Information exchange with the EU/SAVE project called "European Smart Meter Alliance" (2006-2009) is additionally secured via SINTEF who is a partner in this project

Remote and Local Load Control

Load control can be carried out of via most AMR systems or alternatively in separate remote or local systems.

Additional technology or at least recoupling of circuits is normally required at the customer side, when RLC is a part of the AMR system. This means extra costs added to the cost/benefit calculations.

Several separate control systems are available for load control. A web based system using radio control of selected appliances is tested in the project. Advanced control and simple thermostat or time relay systems are also relevant options.

CONCLUSION – FURTHER WORK

The pilot studies presented in this report will continue until summer 2007. Questioners and load curve studies will be analysed in order to find the impact of the tests with regard to the customer reactions and the actual load reduction in the shortage periods. The results will be input to further development of demand side response to prices in the Norwegian power system.

Further deployment of AMR technology to smaller customers is expected in the next years. Information exchange between DSOs and development of guide books for those who are about to start large roll out projects, will be a basic part of the further work in the project. The question of standardisation in the AMR system will be followed up in a Nordic and a European context.

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