Energy efficiency services as a tool for commercial development in competitive markets

Helle Grønli, SINTEF Energy Research
Klaus Livik, Powel

1. SYNOPSIS

Over time, deregulated electricity markets often cause capacity scarcity, which gives incentives for promoting load management and energy efficiency as commercial customer services.

2. ABSTRACT

When electricity markets are deregulated, traditional utility functions are normally unbundled into regulated and competitive functions. Experience from Scandinavian deregulated markets shows that unbundling of functions and retail rates introduces new incentives for the different market participants and hence changes incentives for procuring load management and energy efficiency. Distribution companies, for instance, can avoid costs related to capacity expansions through advanced information services, new tariff structures and new types of technology (e.g., different types of Smart-house technology). Electricity suppliers, on the other hand, are interested in offering customer services of similar character based on profit potentials and strategies for business diversification. In a study, the potential for peak power reduction of Norwegian end users has been estimated to 33% of available capacity. This potential offers possibilities for cost savings for end users, distribution companies and system operator as well as new business areas for electricity providers. Although the incentives for offering customer services promoting load management and energy efficiency differ, experience shows that the customer services offered by different market participants are complementary. Energy efficiency potential can, in other words, be found within and in the interface between different companies representing the unbundled functions. The challenge is to facilitate and promote energy efficiency between organisational and regulatory borders.

3. INTRODUCTION

In the regulated world, energy efficiency and load management were taken care of through Integrated Resource Planning (IRP). This meant that motivation for energy efficiency was integrated throughout the value chain, including generation, transmission, distribution and electricity provision. Deregulation, implying unbundling of traditional utility functions into regulated and competitive functions, introduces new incentives for the different market participants, and hence changed incentives for procuring Demand Side Management (DSM). Load management and energy efficiency therefore require new approaches. The question to be asked is whether deregulation removes the motivation for, and investments in, DSM.

This paper discusses the incentives for load management and energy efficiency in deregulated electricity markets based on Norwegian experience. Through a five-year project, incentives and potential for utilising customer flexibility[1] have been mapped and analysed. The paper argues that deregulation, combined with the continuous development of new customer services and technology solutions, eventually will give increased focus on load management and energy efficiency across organisational borders. The paper discusses different market participants' incentives for load management and energy efficiency in the deregulated electricity market. It describes a pilot study, which tested the response of various customer types to a range of technical and financial measures. The paper then describes the study that the paper is based, after which the results are summed up. In our discussion, we argue that our empirical findings point to new approaches for commercial development related to load management and energy efficiency.

4. CAPACITY RESTRICTED MARKETS PROVIDE NEW INCENTIVES

One of the drivers of deregulation worldwide is existing overcapacity in generation, transmission and distribution. Promoting reduced electricity prices through competitive mechanisms normally motivates deregulation[2]. Lower prices, among other things, can initially be achieved through the reduction of overcapacity and better utilisation of the existing system. In general, the European electricity industry currently has considerable overcapacity. In a system with overcapacity, incentives are low with regard to energy efficiency. The reasons for this are:

- Electricity prices are pushed downwards by competition, reducing the interest of the consumers in energy efficiency.
- Better utilisation of the existing system – represented by increasing electricity sales as much as possible within the existing capacity – gives better profitability in capital-intensive industries such as the electricity industry.

Hence, in a situation of overcapacity energy efficiency will be a side effect of the market participants' positioning and product development rather than a purpose in itself.

Overcapacity existed in the Nordic electricity system when deregulation was introduced in Norway, Finland and Sweden in 1992, 1995 and 1996 respectively. However, less than 10 years after competition was introduced, capacity problems occur several times during a year in generation and transmission in the Nordic electricity system. The main reasons for this are:

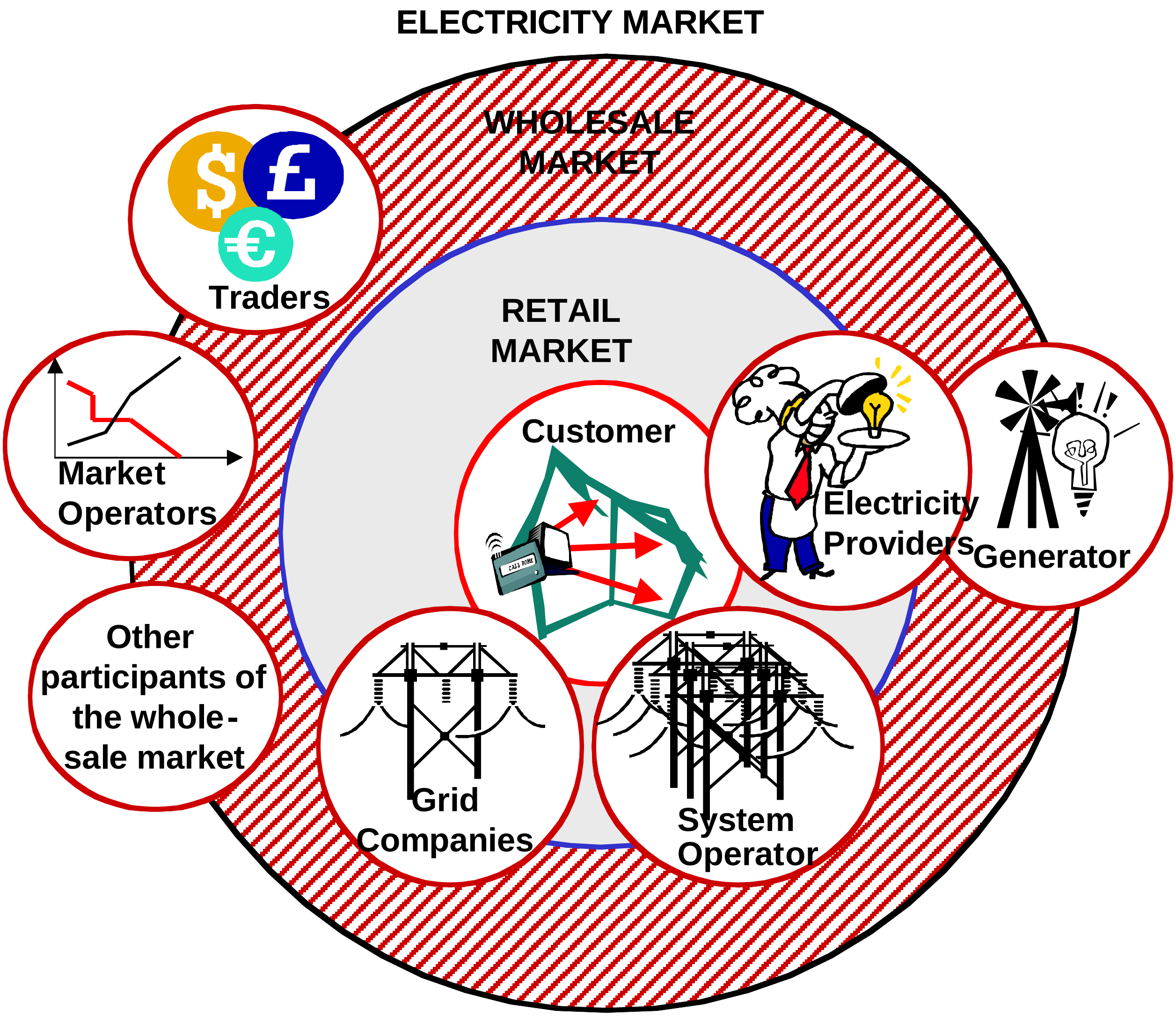
- Deregulation, combined with increased environmental considerations, stopped further expansion in generation.
- Stand-by generation, which became unprofitable with deregulation, was closed down.
- Consumption continues to grow at a steady rate.

While the Norwegian electricity consumption increased 11.1% over the period 1991-1998, the installed capacity increased only 2.8% (Statistics Norway, 2000). On average the installed capacity increased 107 MW pr. year over the period 1991-1998, while the peak load increased by 340 MW pr. year. Available capacity in Norway is approximately 85% of installed capacity, depending on precipitation. This development has particularly consequences during peak periods, typically during daytime in winter. During peak demand periods, operating reserves are between 3-5% in Norway. The same trends are seen in the neighbouring countries, where environmental considerations even push for the closure of existing nuclear power stations. This situation has resulted in increased focus on the demand side in solving the capacity scarcity problems.

The described capacity consequences from deregulation are general. Even if prices are high during peak hours, uncertainty related to future profit has as a consequence that generators might not be willing to invest in peaking capacity that is only needed occasionally (Doorman, 2000). The same types of capacity problems can be seen in California. In California, the market design causes the majority of the customer base to be sheltered from the skyrocketing wholesale prices caused by lack of capacity, leaving less room for customer response. In California, "Stage One Electrical Emergency" is declared when operating reserves are between 5-7%. This means that load management is implemented through voluntary curtailment of power. "Stage Three Electrical Emergency" is declared when operating reserves are less than 1,5%, which means that rotating blackouts are implemented. "Stage Three Electrical Emergency" has been implemented several times during the first months of 2001.

In this setting, several market participants would be interested in offering load management and energy efficiency in a well functioning retail market. Figure 1 shows the different market participants of a deregulated electricity market.

Figure 1: Different market participants of a deregulated electricity market



In a competitive market the customer will be in the focus, as illustrated by Figure 1. The market participants in direct contact with the customer are the electricity provider, the grid company and the system operator. (In this context, grid companies include all voltage levels.) These are the participants that have business-based incentives in utilising customer flexibility through load management and energy efficiency. The market participants illustrated in the outer circle of Figure 1 have no direct contact with the end users. Therefore, these participants have little interest in load management and energy efficiency as such. Incentives for load management and energy efficiency in capacity restricted systems are to be found with:

- *Customers:* Customers are motivated by the potential of reducing energy costs, the possibilities of freedom of choice and new customer services. With increased customer adoption of distributed generation the possibilities related to Demand Side Bidding (DSB), peak pricing and Smart-house technology[3] become even more interesting for the customers.

- *Electricity providers (suppliers)*: The electricity provider would be motivated by the possibility of diversification into new, profitable business areas and customer services that would increase customer loyalty. This is particularly the case in the electricity industry where customers pay little attention to the basic product and where profit margins are getting slimmer and slimmer.

- *Grid companies*: Grid companies are motivated by reduced marginal losses, improved utilisation time, postponed investments and improved quality of service. The grid companies' incentives will, however, be influenced by the design of the regulatory model (Grønli *et al.,* 2000).

- *System operator:* The System operator is motivated by the possibility of improved operational reliability through including the demand side as a reserve for peak power reduction and for provision of ancillary services.

These potential benefits can only be realised through involving the customer through market-based mechanisms. This includes:

- Dynamic price signals reflecting electricity spot prices and dynamic grid tariffs.
- Demand Side Bidding, including the customers in the bidding processes in the organised markets. Customers can participate in the bidding processes either on their own account, or through a third party.
- New customer services involving Information Communication Technology (ICT), such as Internet, direct communication and Smart-house technology. A whole range of multi-utility customer services such as alarms, load control, cable TV and Internet access can be combined.

5. DESCRIPTION OF THE STUDY

In the study, the potential for peak power reductions has been mapped for groups of residential customers, commercial customers and power intensive industries in Norway. This potential has been investigated through pilot case studies (measurements), questionnaires and model simulations. Conceptual investigations have furthermore been an element of the project. The pilot case studies of the project includes:

- *Estimation of potential reduction of peak demand:* The power intensive industries were studied separately, while residential and commercial customers were grouped together in estimating the total potential for peak power reductions. Different load categories such as water heaters, ventilation, cooling and metallurgic processes were shut down through pilot case studies. Meter values for different end-uses, together with questionnaires investigating the customers' willingness to provide peak power reductions at what price, form the basis for estimating the total potential for peak power reductions in these groups of customers.

- *Time of Use (TOU) tariffs:* The implications of introducing TOU tariffs for different customer groups have been investigated through measuring the aggregate individual customer consumption. 208 residential customers in Trondheim participated in the project, of which 104 formed the control group, while the other half received seasonal tariffs with a price difference of 3:1. The case study lasted for a period of three years. 20 commercial customers in Trondheim received tariffs with seasonal and day and night variations. Measured load from years prior to the study formed the reference for this group. The customers were measured for a period of three years. 20 houses in Moss also received tariffs with seasonal and day and night variations in combination with variable electricity prices. These customers were measured for a period of two years. In addition to measuring these customers' load, the customers' responded to questionnaires.

- *Smart-house technology*: Three different types of Smart-house technology have been tested in the project: The home automation system "ITP Power" (Sæle *et al.*, 1999), the Internet-based load control by "Ebox" and the TV-set box "Home Pilot" (Livik *et al.*, 1998).

  199 residential customers tested the "ITP Power" system. These customers were located in 9 different grid companies' geographical regions. Household consumption prior to and after the installation of "ITP Power" was compared to measurements of a representative control group from the same time period. "ITP Power" is a plug-and-play product that consists of a master unit controlling a set of nodes. The individual nodes control the load of specific appliances. The end-uses tested in the pilot studies include water heaters, floor heating and electric panel ovens. The grid companies involved managed the "ITP Power" system, although the customers have the possibility to overrule this control manually. Customers with "ITP Power" installed as well as the grid companies participating in the pilot case studies replied to questionnaires.

"Ebox" was installed in 17 households. "Ebox" is a plug-and-play product that controls one particular node. The user can program "Ebox" through Internet or manually directly on the box. Electric panel ovens were controlled by the means of "Ebox" in the study. The participants of the study were interviewed individually with regard to functionality and user satisfaction.

"Home Pilot", which is a TV-set box offering Internet services and home automation, was installed with 15 customers. Both electric panel ovens and light were controlled in this case study. Questionnaires mapped the functionality and the customers' perception of the system.

The technology installed was paid for partly by the supplier of the different systems, and partly by local grid companies.

6. POTENTIAL FOR CUSTOMER FLEXIBILITY

The combined short-term theoretical potential for peak power reductions for residential and commercial customers has been estimated to 4,000 MW compared to a total system capacity of approximately 23,000 MW. Most of this potential can be utilised for several hours at a time, and is particularly found in relation to water heaters, refrigeration and space heating. Capacity implications of reconnecting customers, and customers' willingness to reduce peak power, have not been taken into consideration in the theoretical estimate. Taking into consideration these aspects, a conservative estimate for peak power reduction for residential and commercial customers is 1,700 MW. However, reasonable use of Smart-house technology can increase this potential through taking into consideration the implications of reconnecting customers. With current technology solutions, this potential can be realised with costs starting from 2.4 EURO/kW and upwards[4]. (The costs of load management will vary quite extensively depending on type of customer and appliance.)

The corresponding potential in the power intensive industry has been estimated to 3,500 MW. This potential can be activated within 15 minutes notice, and can be utilised for periods exceeding 2 hours at a time, without causing large operational disturbances for the industrial production processes. As a consequence of recurring capacity scarcity in the Norwegian system, the system operator Statnett opened the real-time (regulating) market to large industrial customers in 2000. Compensation is given for stand-by reserve as well as pr. MW available on demand:

1. The large industrial customers participating in this market sign contracts with Statnett implying that the customers receive 11,000 EURO/MW pro year for stand-by reserve. This contract obligates the customers to submit bids to the system operator on the quantity made available. The bids determine the quantity that the customers are willing shut down, at which price.
2. When the customers are called on according to their bids, a market clearing process determines the price pr. MW. The customers being called on in this process receive the market-clearing price pro MW load shut down.

At this point, 670 MW has been made available from the large industrial customers to the regulating market, although there has not been a need for this capacity yet. Through the questionnaires, a similar potential for peak power reductions has been estimated to be available at a price of 3 EURO/kW through bid-based processes.

Hence, the estimated theoretical potential for peak power reductions on the demand side totals 33% of system capacity in Norway. This potential is related to the existing energy systems of the customers. The long-term potential might be higher than what is available in short-term, taken into consideration the fact that space heating is the main use of electricity of most customer groups in Norway. More flexible energy systems, as well as distributed generation, might reduce the peak power demand in the long run, particularly in response to customers being exposed to high peak prices in a competitive system with recurring capacity scarcity.

The customer flexibility can be achieved through several means, including Smart-house technology and time differentiated tariffs. The results from the different pilot case studies show:

Time of Use tariffs

The load of the 108 residential customers in Trondheim with seasonal tariffs did not change considerably compared to the control group. However, 75% of the involved customers are living in apartment blocks with limited possibilities for alternative heating. The single-family houses with alternative heating installed reduced the peak power by approximately 5%. Simultaneously with introducing the TOU tariffs, both the test group and the control group were given information on how to achieve increased energy efficiency. In addition, these customers started receiving monthly bills based on monthly measurements as opposed the former quarterly bills based on estimations of annual load. These two latter aspects probably had more implications on energy consumption than the tariff structure.

The combined seasonal and day and night tariffs that were tested in Moss gave a reduction of peak power in the evening of up to 12% compared to the control group. The peak power in the morning was not changed considerable in the pilot case. Through the survey, dryers, dishwashers and washing machines were mentioned as the most relevant appliances for these customers in adapting to TOU tariffs.

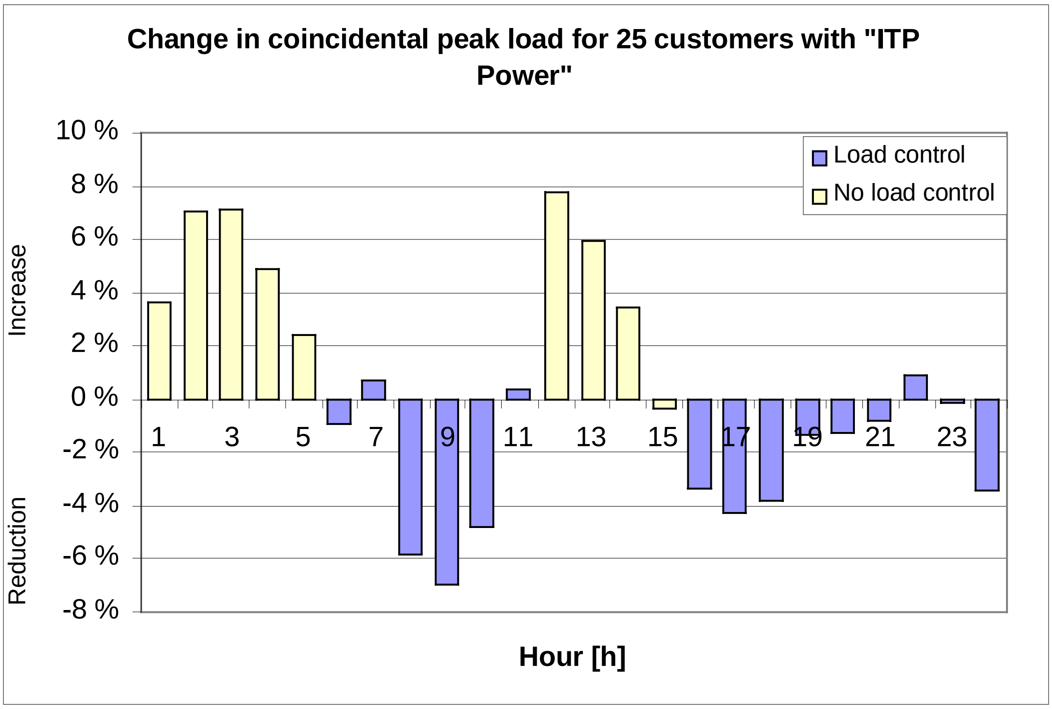
In the case study involving 20 commercial customers, 13 adapted in response to the TOU tariffs, which were differentiated by season as well as day and night. The peak demand of the 13 commercial customers responding actively to the price signals was on average reduced by 5% and 2.8% in respectively the first and the second year of the study compared to the reference year. Explanations of the reduction the last year can be several: Change of operational guard, increased activity and less follow up activity from the utility. Some customers achieved up to 12% reduction. Simulations of load profiles show that 8% can be considered as a reasonable potential for office buildings with electric space heating. The load factor for the same group improved on average 3,8% the first year, and 4,8% the second year.

The commercial customers of this pilot case involved different types of businesses, such as bakeries, schools, dormitories and offices. The response of the customers to the TOU tariff therefore varies. One could find customers shifting load, customers reducing the energy consumption as well as customers switching to alternative sources of heating. The bakeries moved parts of the consumption to night time, and reduced the peak power during daytime between 20-40%. One of the schools reduced the overall temperature during daytime, without reducing the comfort of the users. Another company replaced the water heater with a new and more energy efficient one. Changing the routines for ventilation and heating was also a way of adapting to the TOU tariffs in the project.

Smart-house technology

Testing customers' electricity use in response to Smart-house technology was also included in the study. Measurements related to the pilot case studies involving "ITP Power" shows that this type of technology can give peak power reductions of 1-2 kW for a one-family house, which is 13-25% of the average peak demand of this customer group. Figure 2 shows the change in peak demand for the customers with "ITP Power" installed compared to the control group for an average day and night over the study period.

Figure 2: Change in coincidental peak power demand[5] over the day and night for single-house customers with "ITP Power" installed



Negative values in Figure 2 show lower peak demand for the customers with "ITP Power" compared to the control group while positive values show higher peak demand. Figure 2 indicates that in periods where "ITP Power" controls the load ("Load control" in Figure 2), peak demand is reduced. The results of Figure 2 were found in one geographic region involving 25 customers of one of the grid companies participating in the study. Similar results can be found for the other geographical regions involved.

Depending on how many facilities to be included, the cost of the "ITP Power" currently is:

- Master node including communication system: 110 – 145 EURO pr. building.
- Nodes for controlling individual end uses: 84 EURO for a package of two relay nodes or 120 EURO for a package of three relay nodes.

7. FINDING BUSINESS POTENTIAL IN ENERGY EFFICIENCY AND LOAD MANAGEMENT FOR DIFFERENT MARKET PARTICIPANTS

Different market participants can find business potential in offering customer services that are similar in appearance. Some of these customer services are profitable for individual market participants, while other customer services are profitable only across organisational borders. Figure 3 illustrates which energy efficiency related customer services different market participants would find interesting.

Figure 3: Joint interests among market participants to offer energy efficiency related customer services

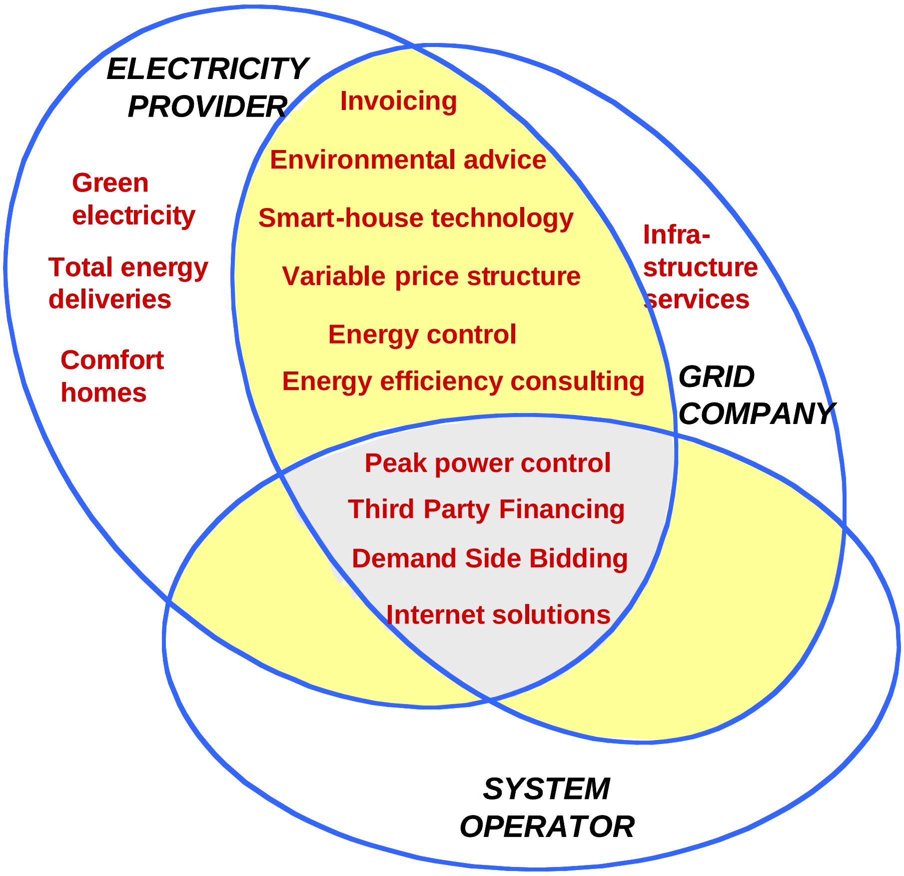


Figure 3 illustrates that both electricity providers, grid companies and system operators would be interested in offering products such as peak power control, Third Party Financing (TPF), DSB and Internet solutions (such as e-commerce and broadband) in a well-functioning retail market when there is capacity scarcity in generation and transmission. Other customer services are interesting for grid companies and electricity providers but not the system operator. Examples of that are variable price structures, Smart-house technology and invoicing services. Some customer services, on the other hand, are of interest of one of the market participant only. Finding business solutions for customer services that are of benefit to several market participants but costs too much for one participant to offer on its own is of particular interest.

The electricity provider can find business potential in combining different price products (such as spot price products vs. fixed price products) and Smart-house technology that automatically can control the customers' energy consumption. An example of an electricity provider already offering this type of service is the Norwegian energy company Statoil together with Elink – the producer of "Ebox". Customers sign up for Statoil electricity for a period of one year, giving Statoil the opportunity to gain loyal customers, pursue a branding strategy and an image of being a total supplier of energy related services. The electricity contract is based on variable spot price plus a premium of approximately 0.003 EURO/kWh. The customer pays 90 EURO pr. "Ebox" through this deal, which is a 40% rebate of the ordinary price of this plug-and-play node.

The combination of variable price structures and Smart-house technology is attractive for grid companies as well. By providing incentives for peak clipping through the price structure, e.g., by offering TOU tariffs, dynamic tariffs or compensation when disconnecting appliances, Smart-house technology can be used to respond to these price signals either automatically or on demand from the grid company.

Grid companies might be interested in offering Internet services that provide tailor-made information on the customer's electricity consumption and advice on how to achieve reductions in demand in order to release capacity in the existing grid. Electricity providers, on the other hand, can be interested in offering the same products as add-on services in order to get loyal customers and increased profit through differentiated products. For instance, the Swedish electricity provider Vattenfall offers a free Internet based analysis of your house's energy consumption and advice on how to reduce it. A branding strategy would be the motivation for this, where an attractive web site is used to spur interest in Vattenfall's total range of customer services.

DSB is another example of a service that all three market participants would be interested in offering. The electricity provider could offer DSB in order to aggregate and act on behalf of several of its customers to bid in to the system operator's real-time market, earning a premium on this service. The incentives for the grid companies and the system operator would particularly be on the cost side, but could be seen as a separate business area as well. 65 different types of customer services with perspectives of energy efficiency already offered in the market can be found in Livik and Morch, 2000. Table 1 gives a brief description of some.

Table 1: Description of some customer services with aspects of energy efficiency (Livik and Morch, 2000)

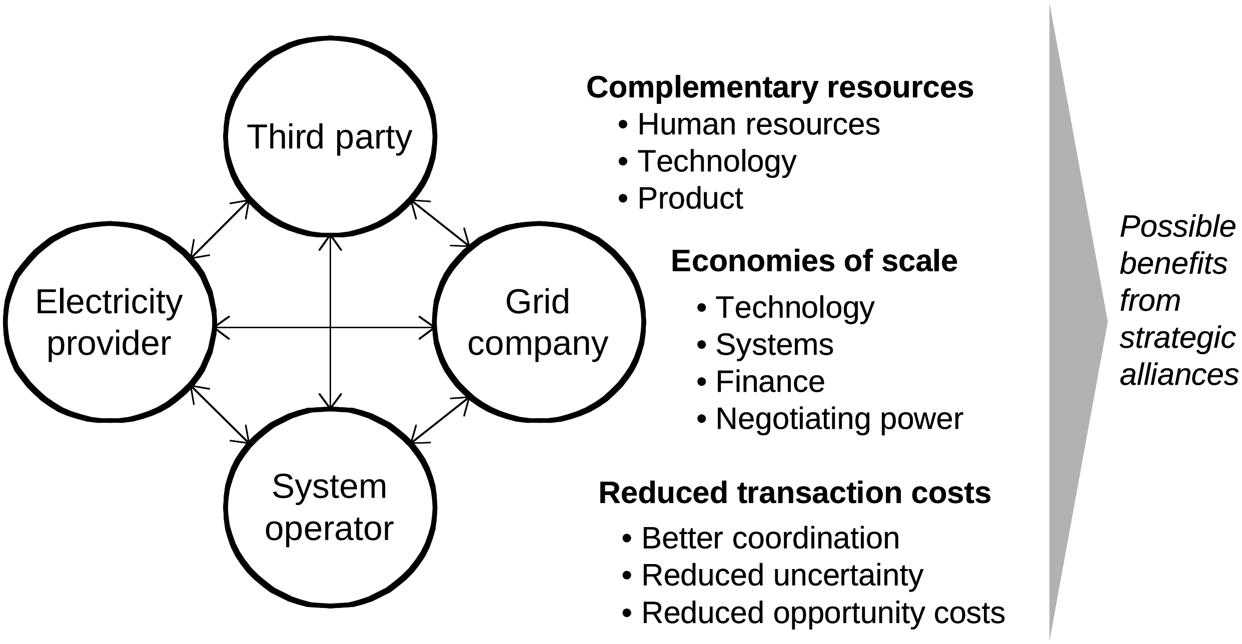
Main feature	Description	Assessment
HydroMax (Hydro Energi)	The product provides customers with continuous online price update about different energy carriers. On-line price calculations.	Energy efficiency Cost savings Environmental
BKK Mail (BKK)	Energy-service software package with data update via email. The package provides customers with additional information on the electricity market.	Energy efficiency Cost savings
Energy kiosk (Interkraft Energi)	An interactive tool for all customers for analysis of efficiency in energy use	Energy efficiency Cost savings Environmental
Energy Performance Contracting (EMC Engineers Inc.)	Third Party Financing service. Electric utility installs new energy equipment, operates and maintains over 5-10 years. Payment is done in form of monthly fees over the contracted period.	Energy efficiency Cost savings Environmental
Delivered Heat (Vattenfall)	Energy service related product, providing customers with 3-5 years contract for heating, cooling, steam, ventilation etc.	Energy efficiency Cost savings Environmental

In a competitive electricity market, with unbundled competitive and regulated functions, the fact that benefits can be found across organisational borders might cause some problems. The total potential benefits might be large enough to justify big investments, for instance in technology, across organisational borders, while the benefits for one participant only would not justify the investment that is necessary. There is a free-rider problem, where the external benefits exceed internal benefits. This requires new approaches. Through strategic alliances the market participants can be able to offer new customer services that benefit all partners – both through sharing investments and in offering complementary services. Third parties might also see business potential in releasing the possible gains in the interface between different market participants.

8. STRATEGIC ALLIANCES TO ENHANCE ENERGY EFFICIENCY AND LOAD MANAGEMENT

As mentioned in Section 5, strategic alliances and third parties are important for customer services related to energy efficiency and DSM. Strategic alliances can range from formal to less formal structures, such as mergers, joint ventures and contracts for single projects. Figure 4 shows the possible benefits from strategic alliances.

Figure 4: The possible benefits from strategic alliances related to energy efficiency and DSM



Strategic alliances can be entered between all market participants of the retail market, e.g., grid company–electricity provider, third party–grid company and electricity provider–electricity provider. The possible benefits from the strategic alliance would, however, differ depending on the type of alliance. Co-operation can give benefits due to complementary resources, economies of scale and the possibilities of reduced transaction costs:

- The partners can have complementary resources with respect to human knowledge, technology, systems and products. This means that the partners can achieve positive synergies through combining their resources in an alliance.
- The partners can achieve economies of scale through joint technology, systems, financing and negotiating. This means that the partners can save costs by joining their operations rather than operating as separate companies.
- Through a strategic alliance, partners can reduce the transaction costs by improving the co-ordination in between them and the customers, by reducing uncertainty in doing business with each other and by reducing the costs of strategic behaviour in relations with each other.

A strategic alliance between an electricity provider and a third party offering Smart-house technology can be beneficial due to the fact that the partners offer complementary products. A strategic alliance between system operator and a grid company might be motivated by economies of scale in sharing investments in customer communication systems, and in that way increase the possibilities for both participants to control peak demand. A strategic alliance between a grid company and an electricity provider might be motivated by economies of scale in technology development. An example of this is co-operation in developing Business-to-Business e-commerce solutions that facilitates energy efficiency related customer services.

9. CRITICAL FACTORS OF SUCCESS

In order to get to a state where energy efficiency and load management services are tools for commercial development in a competitive market, several critical factors of success have to be fulfilled:

- A market design allowing for retail access for the customers has to be in place. This includes mechanisms allowing customer response to price signals. In other words, customers must be exposed to price signals and the possibility to respond and participate in DSB. DSB can imply third party aggregation for smaller customers, and participation directly in the market for larger customers.

- The regulation of grid companies is important. In Norway, for instance, grid companies are regulated through revenue caps that are adjusted annually for grid expansions based on load growth multiplied by a factor of 0.5. This provides twisted incentives for promoting energy efficiency, DSM and distributed generation. The reason for this is that load growth as an adjustment parameter gives incentives for increased energy sales for the grid companies.

- ICT solutions for automating customer response and improving the companies' internal and external data interchange are crucial. Technology is needed in communicating price signals in an efficient way to customers, and in order to settle customers according to their response. Smart-house technology will facilitate automatic response from customers, e.g., as a consequence of price changes.

- Customer focus is important. Unless the customers are offered customer services that they find attractive, they will not respond to the offer. Both electricity providers, grid companies and system operator need to pursue customer focus in a deregulated electricity market.

10. CONCLUSIONS

Promoting energy efficiency and load management is still valid in a deregulated electricity system. However, incentives for doing so have changed from the regulated world, and new approaches are needed. Scandinavian experience shows that energy efficiency and load management are of particular interest in systems with scarce capacity. New business potential can be found, and the procurement of load management and energy efficiency will to a large extent be market driven. New customer services will include aspects of energy efficiency and load management, particularly in combination with ICT and delivery of extended services. Products based on ICT will be particularly important in that respect, such as Internet services, direct communication and ICT based appliances. ICT will be a driver for energy efficiency in the future, where also distributed generation will play an important role.

11. ACKNOWLEDGEMENTS

The Norwegian Research Council, the Norwegian Electricity Association as well as Norwegian utilities have funded the project.

12. REFERENCES

Doorman, G. (2000): "*Peaking capacity in restructured power systems*". PhD thesis, Norwegian University of Science and Technology, 2000:100.

Jordanger, E.; Grønli, H.: "Deregulation of the electricity supply industry – Norwegian experience 1991-2000". SINTEF Energy Research, TR A5285. 2000.

Grønli, H.; Wangensteen I.; Uthus, B. O.; Hoff, B. A. (2000): "*Adjusting for grid expansions in incentive-based regulation*". IAEE European Conference, Bergen 2000.

Livik, K.; Morch, A. Z (2000): "*Customer-profiled products and services in energy utility industry -Assessment of products and services- phase* II". SINTEF Energy Research, TR A5125. 2000.

Livik, K.; Schade, J. Ø.; Landmark, C.; Sæle, H.(1998): "*Smart customers in smart homes. Experience with TV-set top box for Internet services and home automation functions*". DistribuTECH DA/DSM Europe '98, London October 1998. Conference proceedings (CD-rom).

Statistics Norway (2000): "*Statistical yearbook of Norway 2000*". www.ssb.no/english/yearbook/.

Sæle, H.; Livik, K., Uggen, K. (1999): "*Home automation experiences with new technology for business based load management in a deregulated power market*". DistribuTECH DA/DSM Europe '99, Madrid October 1999. Conference proceedings (CD-rom).

13. END NOTES

[1] Customer flexibility is defined as the customers' ability and willingness to change energy consumption in response to price signals. This includes load shifting between periods, load reductions and replacing one type of energy carrier with another.

[2] Deregulation introduces market-based mechanisms for determining prices. In situation with overcapacity market prices will be lower than in situations with scarce capacity.

[3] Smart-house technology in this respect includes communication-based technology that automatically manages load for the customer.

[4] In a parallel project, "Ebox" was installed in the control circuit of an electric boiler. 40 kW was controlled this way, resulting in a cost pr. kW of 2.4 EURO.

[5] Coincidental peak power demand means the aggregate peak power demand of all customers connected to a grid.