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Examining and proposing measures to activate demand flexibility on the Nordic wholesale electricity market

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1 Introduction

1.1 Background

Most consumers and businesses in the Nordic countries use electricity when they need it – with little or no consideration to the price of the electricity. Keeping the lights on is something that is considered to be the role of electricity utilities. As a result, electricity utilities need to have enough generation capacity to cover whatever demand at all times. As demand increases, more and more expensive generation units are taken in to use to fulfil the demand, raising the cost of generation and the price of electricity.

Demand flexibility means that electricity users reduce their consumption or shift their consumption to some other time. Usually the term is used when demand is adjusted as a response to high prices or as a response to a situation with inadequate generation capacity.

Electricity system designers have very early recognized the role of flexibility as an important compliment to balance supply and demand at all times[1]. If only supply is adjusted, spikes in demand and future demand uncertainty lead to high generation capacity needs, and to high prices. Demand flexibility reduces the need for capacity investments, and reduces the overall investments need for the energy system, and reduces the prices of electricity. Also, if there is no demand flexibility, then the market is more vulnerable for variations in the supply side, for example in the form of power plant failures or increased wind power production.

During the winter of 2009–2010, the Nordic market witnessed high spot price spikes. Prices reached unprecedented levels of over 1 000 €/MWh at some instances, compared to typical price levels of less than 100 €/MWh. In monetary terms, value of one single hour of electricity use for Nordic consumers was over 60 million euro, compared to typical less than 6 million euro[2]. Although the price spikes were exceptionally high, high prices have persisted also in the past, for example in 2001 and 2002–2003[3]. Consequently, the possibilities for demand flexibility have been analyzed from a national perspective in many studies[4].

Demand flexibility can have a sizeable impact on the spot price especially during high price situations. Simulations have showed that even a small increase in demand flexibility could in some situations substantially cut price peaks.[5]

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[1] See e.g. Hobbs, B. F. et. al, Estimating the flexibility of utility resource plans: an application to natural gas cofiring for SO2 control, Power Systems IEEE Transactions, Volume: 9, Issue: 1, Pages: 167-173, 1994.

[2] As many consumers had financial hedging contracts to protect against price spikes, the actual short-term cost for consumers was lower.

[3] See e.g. Bergman, L., European electricity market integration: The Nordic experiences, 2003.

[4] See e.g. Finnish ministry of employment and the economy, Sähkön kysyntäjouston edistäminen (*In Finnish*), 2008.

[5] See e.g. Gaia, Nordic electricity peak prices during the winter 2009–2010, 2010.

Demand flexibility has other socio-economic and environmental effects. Reduction of electricity demand in the industry means also that the industrial production is reduced, reducing the economic output[6]. For the environment, demand reductions displace the use of fossil fuel generation for maintaining the quality of electricity supply. Demand flexibility is especially important when demand exceeds available capacity only a very limited length of time. In such cases, it is beneficial to seek short term demand reductions in place of additional supply investments.

High electricity prices in the winter of 2009–2010 initiated public and political discussion in the Nordic countries about the functioning of the Nordic electricity market. Reasons for high prices were discussed in the Nordic Council, and studied on a request by the Nordic Electricity Market Group (EMG)[7]. On the basis of the political debate Nordic Energy Regulators (NordREG), the relevant Nordic authority, has been actively following up on the reasons of the high price peaks and the possibilities to improve the functioning of the market.

1.2 Goals and scope of the study

NordREG has found that real price elastic behaviour of electricity users can be seen as one of the key improvements of the market functioning. This study has been commissioned by NordREG to examine and propose actions for promoting demand flexibility on the Nordic wholesale electricity market.

The study aims to create a comprehensive picture of some of the reasons behind the current lack of demand flexibility and by what tangible actions demand flexibility could be increased. The study presents recommendations on how the functioning of the market could be improved. Actions which can be influenced by Nordic policies, rules and recommendations are especially identified.

The impact of the actions on different market players is described. The impacts of the actions are also quantified as far as this is possible in a study with this scope. The scope of this study is the Nordic area, but with a focus to Sweden and Finland.

In the context of this study the demand flexibility which is analyzed is the displacement from consumption from peak hours to less critical hours or peak cutting for a few hours at a time as illustrated in Figure 1.1. The analysis of long term demand flexibility or reaction to long term high prices is not within the scope of this study.

[6] For the industry, if electricity prices are too high for production, it can hurt their competitive position in the long term.

[7] Nordic Council, Order of Business, 19 Aug 2010. EMG is a group consisting of the representatives of the Nordic energy ministries.

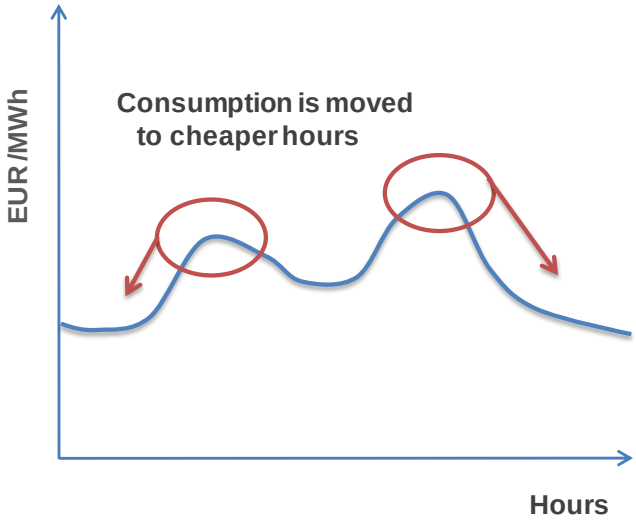

Figure 1.1. *Simple illustration of the variation of hourly electricity prices over one day, and how consumption can be moved from peak hours to less expensive hours.*

1.3 Methodology

Demand flexibility is influenced by a variety of factors, which have been analyzed through the framework in Figure 1.2. Demand characteristics are different for households than for large consumers. Large consumers are considered to have high enough electricity costs that they can motivate their own measures to increase demand flexibility. On the other hand, households and SMEs need solutions from service providers. Several elements influence how demand flexibility is shown in the spot market.

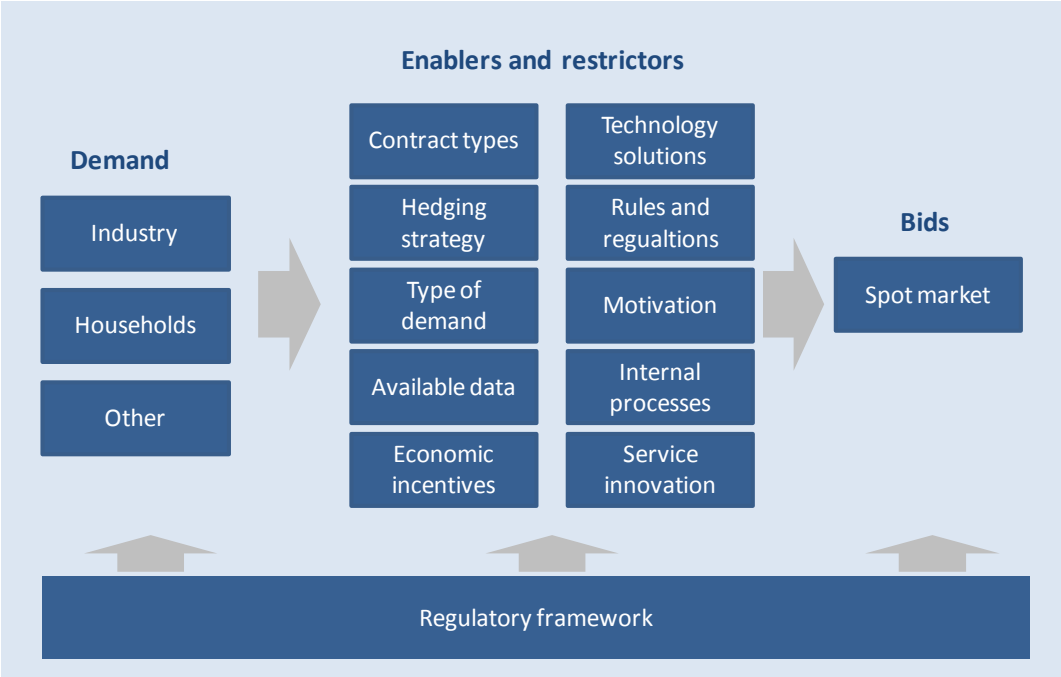

Figure 1.2. *Enablers and restrictors influencing entry of demand flexibility to the spot market.*

The analysis was performed as a combination of desk study, survey sent to spot market participants and interviews of key market players, authorities, regulators as well as technology suppliers. The desk study was performed using existing, publicly available, data and reports. The survey was sent to over 100 Nord Pool spot and Elbas market member contact persons. The Interviews gave a deeper insight into the views of the market parties and different stakeholders on the reasons behind the lack of demand responsiveness, possible obstacles and views on how flexible demand could possibly be promoted.

The work has been directed by a steering group consisting of all the Nordic energy regulators, headed by Timo Partanen from the Finnish Energy Market Authority. Other members of the steering group have been Henrik Gommesen from the Danish Energy Regulatory Authority, Jon Sagen and Vidar Slettehaug from the Norwegian Water Resources and Energy Directorate, and Margareta Bergström from the Swedish Energy Markets Inspectorate. The work has been carried out by an independent Finnish expert organisation Gaia Consulting Oy who is responsible for the content of this report. The analysis and modelling of the demand flexibility was performed by Professor Jussi Keppo from the University of Michigan, with assistance from Iivo Vehviläinen from Gaia Consulting Oy. Additional analysis was done by Marika Bröckl and Elina Virtanen from Gaia.

2 Current demand flexibility on the Nordic market

2.1 Nord Pool market structures

Electricity trade in the Nordic market is mainly handled through two power exchanges. Nord Pool Spot is the market place for physical electricity that traded 282 TWh (71 %) of the 398 TWh of physical consumption in the Nordic countries. Financial contracts are traded in NASDAQ OMX Commodities, were the trading volume was 1 204 TWh, and the exchange cleared a total of 2 108 TWh.

Nord Pool day-ahead spot market price formation is based on a voluntary competitive equilibrium model. Generation, consumption, as well as import and export are balanced for a single day and separately in each of the 24 hours in advance.[8] One interpretation of the balancing model is that with it the social wealth is distributed correctly between the suppliers and the consumers[9].

Spot market price is used as the basis for the settlement of financial instruments on the Nordic market. Financial instruments can be used to reduce the economic risks of the spot price fluctuations or for the purposes of making profit with trading. It is essential for the functioning of the financial electricity markets that the spot price gives reliable price signals for all market participants.

[8] The spot price mechanism is described in detail e.g. by Nord Pool Spot in www.nordpoolspot.com.

[9] Originally credited to P.A. Samuelson, Spatial Price Equilibrium and Linear Programming, American Economic Review, 42, 283–303, 1952.

Bids for spot electricity are made in advance and there is no guarantee that the generation or demand are going to be on the same level during the delivery hour. The Nordic market has two after spot market mechanisms, the Elbas market and the balancing market.

Elbas is a intra-day market where electricity can be traded up to 1 hour prior to delivery. Market participants can use Elbas market to change their net electricity positions for the delivery hour before the delivery hour. The traded volume for Elbas in 2010 was 1.6 TWh, i.e. much lower than for spot electricity. Figure 2.1 describes the timeline for the different markets.

Figure 2.1. *Timeline for the operation of the different markets.*

In the balancing market, the physical electricity system is kept in balance at all times by the national Transmission System Operators (TSO). Market participants with physical regulating capacity can bid their capacity to the balancing market. If and when the power system is not sufficiently in balance during the delivery hour, the TSOs activate bids from the balancing market. Potential imbalances are settled after the delivery hour.

In addition a part of the equation is the peak effect reserve reserved by the Finish and Swedish TSOs for constrained situations. The effect reserves are activated if there is not enough capacity for a market based spot price. The effect reserves can be added to the price curve at this stage. The price cross is reached as a result, but the capacity is not supposed to influence the market based spot price. The spot price if formed by the highest existing bid at the Spot market.

The general idea has been that the reserves should not compete with commercial bids. The effect reserves have previously been reserved for TSOs. Bidding of the same capacity into the spot market has not been allowed in Sweden, where disconnectable loads are included in the effect reserves. Some industrial consumers would have liked to bid it to spot market.[10]

2.2 Benefits of demand flexibility

If there is no demand flexibility, then the spot prices are determined by the availability and pricing of supply. Demand will also vary for instance because of variations in outside temperature. With current supply structure, this will lead to rapidly rising prices when the supply situation becomes tighter and more expensive generation is taken into use, see e.g. the illustration in Figure 2.2. More price sensitive bids by consumers can reduce the need for most expensive generation forms and reduce high prices.

[10] For the following winter, 2011, rules for Svenska Kraftnät effect reserves will be changed so that a share of the disconnectable load can be bid into the spot market, where it will thus also impact pricing.

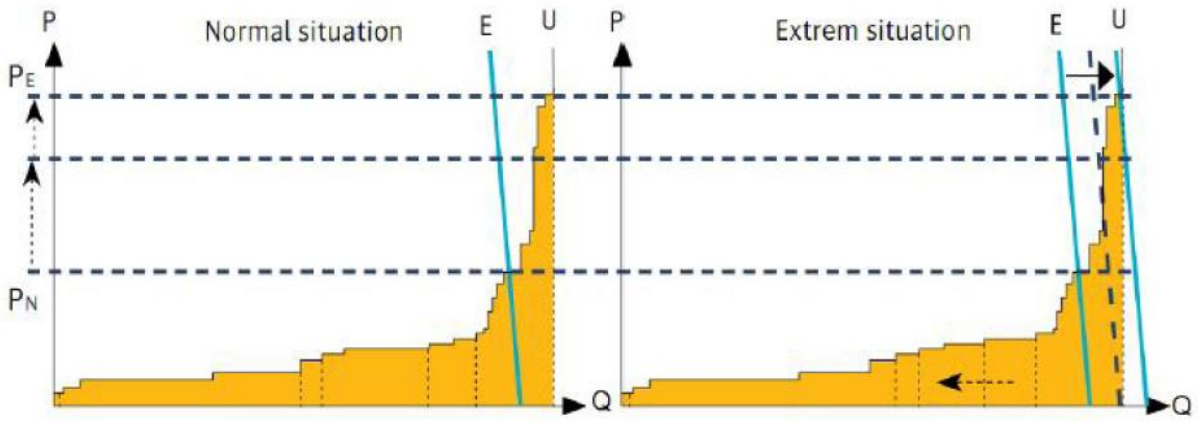

Figure 2.2. *The influence of demand reductions on the production curve in situations with high demand.*[11]

The possibility to exercise demand flexibility enables consumers to accept the exposure to spot prices. The consumer can eliminate the risk for high prices by reducing demand when the prices are high. This will lead to on average lower prices compared with the fixed price contracts, which include an insurance premium against high prices. Further, retail companies can reduce their financial risks, if they offer such contracts to their customers.

Demand flexibility exercised by the consumers reduces the possibilities for high spot prices, and reduces average spot price volatility. This should create additional benefits for consumers in the financial electricity markets. Lower volatility and reduced risk for high prices can reduce risk premiums in the pricing of financial electricity contracts.

Increased demand flexibility reduces the need for investments into peak power capacity. Also the financial incentives for new investments are reduced, because high prices are lower and occur more seldom than if demand flexibility is not exercised.

From an environmental point of view demand flexibility reduces the need to run peak power generation capacity, which is typically mostly fossil fuel based. However, depending on the production and e.g. the industrial processes involved, demand flexibility can also introduce some adverse environmental effects or risks.

Demand flexibility increases competition in the spot market. The increased competition would be especially visible in the high price range, where competition from the supply side is more limited than in the typical price range.

[11] Picture modified from Energimarknadsinspektionen, Halvårsrapport om elmarknaden oktober–mars 2009/2010, EI R2010:09.

2.3 Demand flexibility in the Nordic market structure

In the current Nordic market structure, the willingness of market participants to reduce their consumption should preferably be reflected already in their spot bidding. The whole Nordic physical market structure is built on the assumption that the spot price formation balances the interest of the suppliers and consumers. Also, the Nordic financial markets are based on the assumption that spot prices are a reliable indicator for the value of spot electricity to the market participants. The demand for flexibility will further increase as the share of non-flexible generation such as wind power or nuclear power is increased.

It is technically and contractually possible for some market participants to activate demand flexibility only after the spot market prices are determined. Combined with clever financial trading strategies, these participants can then benefit from demand flexibility on the after spot markets[12]. Such behaviour risks the credibility of the spot market as the indicator of the value of electricity, and should be of concern at least for the market place, if not the regulators.

So far the demand flexibility in the Nordic market is very much underutilized for various reasons, which will be analyzed in the following section. Some of it is activated especially within the large scale industry, but a large part still needs to be further activated by different means especially in the form of bidding in the spot market. This is the only way demand response can affect the spot price when it comes to large customers. The household consumer side includes much untapped in demand flexibility which should be harnessed in the future. This is especially true for households with electricity heating. Creating flexibility in large industrial consumers', SMEs' and private consumers' demand, needs to be based on different methods. The potential methods will be discussed and analyzed in section 4.

Analysis, which has been made in previous studies and by Nord Pool, has shown that activating demand flexibility is essential in peak price situations. Demand has been relatively insensitive to the spot-price before the price peaks in the winter 2009–2010. Only a very small volume of demand flexibility would have been enough to cut prices to a substantially lower level during the peak price situations in the winter of 2009 and 2010. It should be mentioned, though, that there is experience showing that long term high prices do lead to reduction in demand, so there is a certain demand flexibility, but very little when it comes to short responses to peak demand (one to a few hours).

[12] See Chapter 5.2. for examples.

3 Barriers for offering demand flexibility to the market

3.1 Large consumers

3.1.1 Type of demand and production process

The fundamental factor influencing demand flexibility is the consumption itself. Shutdown or adjustment of the production process can create undue implications for the end customers or technical risks for the process and for the start-up phase. Demand flexibility is primarily suitable for industries and sectors where the processes allow demand flexibility. This means that there is a possibility and room for demand flexibility, which can for instance mean the existence of buffer capacity or tolerance for heating or cooling variation. Demand flexibility mechanisms that cause loss of production or major re-planning of the production process will require higher and more frequent price peaks to justify investment into them.

Industrial producers or service providers can't in most cases risk the customer relationship by default of a delivery or in deciding to periodically not offer to customers because of production standstills for price optimization reasons. Industrial mass/bulk end products or intermediate products are easier to store in an intermediate storage which can act as a buffer. However, many producers, more today than before, manufacture to order and the customer expects products to be delivered as planned. There are fewer possibilities for intermediate storage, which could buffer production and give some flexibility.

Some industrial consumers also have production processes with little short term flexibility. As one example can be mentioned the metal industry with furnace types which can't be shut down for less than several weeks. Reacting to price peaks which last for only a few hours may thus be out of the question for some industrial consumers. This naturally varies according to industry sector. Very good potential exists, however, especially within the paper industry.

In the process industry the consumed electricity volumes are large. The effect of their demand reduction on the electricity market and peak prices could thus be substantial. The involved implementation costs are relatively small compared with many other sectors with lower potential for demand flexible consumption and with more heterogeneous consumers for which standardized solutions can be difficult to find or may be more costly.

Other sectors of the economy can also have potential for demand flexibility. The most interesting ones identified are the retail and real estate sectors. As an example cold storages within retail could be steered to promote demand flexibility, which could hold good potential given the size of the retail sector. In these cases an external service provider such as a portfolio manager or aggregator could take care of the practical implementation of demand flexibility measures.

3.1.2 Motivation, internal processes

Industrial consumers and service providers focus on their own production process. The role of energy in general, and electricity in particular, in their decision making depends primarily on how much energy costs affect their competitive position.

Extremely high prices came as a surprise to most market parties in the winter of 2009–2010. Even many of the large consumers were not prepared to act or had not taken this possibility into account in the design of their internal processes and practices or in the contracts with their electricity suppliers. Interviews performed in this study have also pointed out that the fact that price peaks occur infrequently, has an impact on the behaviour of industry and has led to the relative lack of activity seen.

There had also been lack of general awareness and in some cases also interest for steering production processes based on the price of electricity. This can in part be because of either the fact that many industrial consumers buy directly from suppliers or because they have hedged most or all of their risks and are thus not exposed to the spot market price variations. Thus some have not seen them as relevant for their day to day activities.

The fact that electricity price is not necessarily a significant part of the production cost in many processes also has an influence on motivation and interest. Many companies are not at all focused on the operation of the electricity markets. They purchase their electricity through a supplier, often with long-term fixed price contracts. A stable price is often seen as the most important thing.

Awareness of the fact that adjusting consumption with the function of price could entail considerable financial gains has also in some cases been lacking. Some of the reasons behind this lack of awareness may have its base in the fact that electricity supply has not been seen as part of the core process of the company and the business opportunities have thus not been identified. Management has also not in all cases been well educated in the market mechanisms of the energy market and buy-in has been lacking or difficult to get.

It was also felt that it required a lot of knowledge of market rules and practices to become independently active in the spot market. Transaction costs were as such not seen as a barrier where large consumers were concerned.

3.1.3 Contract structures, hedging strategies and economic incentives

One reason for the relatively passive way in which consumers have acted may also lie in the fact that few large industrial consumers are direct Nord Pool members. Many do not have in practice direct or indirect access to the spot market.

Many industrial consumers have long-term fixed price agreements with suppliers. The contracts don’t in many cases include the possibility to reduce consumption and the possibility instead to sell to the spot-market. There may have been the theoretical possibility and the practice may not have been specifically forbidden by the contract terms, but the possibility may not have been seen as normal practice or has not been “on the table”. In any case normal practices and processes for this have not been in place in many cases.

Some types of supply contracts have also eliminated incentives for demand reductions as the cost for balancing has been included in the contract price. Industrial consumers buying with these contracts have not necessarily seen clear incentives for demand reduction at high spot prices.

On the basis of company interviews it seems that after the winter of 2009/2010 some changes in thinking and awareness have occurred. Many supplier contracts have been renegotiated to include the possibility to reduce consumption or to sell back volumes to the spot market in cases where production can be halted. The balancing costs have in the renegotiations in many cases been made transparent, giving some incentives for demand reductions. Some market parties have also made new independent arrangements.

Buying directly from suppliers with long term contracts has in many cases been regarded as beneficial by industrial consumers. The arrangements are often seen to be simpler. There is a need for less administration. There is less need for developing internal processes or investment into personnel resources. Additional personnel resources are often needed in house if a more active and independent approach is taken. In addition suppliers often offer one month credit in paying and do not in general demand securities, which are required by Nord Pool Spot. This is seen as an additional benefit by many buyers. The simpler arrangements may be an especially weighty argument for medium sized industry, which usually doesn't want to build an organization around energy procurement which would entail daily activity and administration.

Also, as previously mentioned, those active large consumers who have identified the need to have access to the spot market through their suppliers have apparently been able to negotiate terms and been able to plan processes to be able to do this. There seems to be some variation in how different players have acted or how active they have been in finding solutions with their suppliers or third parties.

One question, which also came up in the interviews, was that some industrial consumers own internal distribution networks. Membership as a direct trading party at Nord Pool also requires being a balance responsible party. To become a balance responsible party in some Nordic countries distribution and sales needs to be split in different companies even if the industrial consumer only distributes or sells to itself/internally. This was seen as unnecessary bureaucracy and an unnecessary barrier for direct membership.

Some interviewees expressed views that there can be a downside to buying from large suppliers as this gives suppliers who often are also large producers much insight into the behaviour of the industry and the consumption price curve. This insight can make it easier for the producer to optimize their production curve. Views were expressed by some that the process industry, which has large consumption should preferably be active directly at Nord Pool or active at Nord Pool spot through an intermediary. It was by some believed that it would be better for the market as a whole to decrease the direct connection of large industrial consumers to large suppliers.

3.1.4 Rules and regulations

Industry exercised some demand flexibility during the price peaks of 2009–2010. A part was included in the spot price curves, and a part of the demand response was seen after the price was known in the regulation/balancing market. Also, a part of the volume which could have taken part in the price formation in the spot market was reserved for the Svenska Kraftnät effect reserves and only came

into the spot market after normal spot market mechanism failed to form a spot price. This volume didn't, in accordance with the then prevailing market rules, participate in the price formation of the spot market. This available flexible volume in itself would most likely have reduced prices, if bid into the market as part of the normal market mechanism.

This fact has been quite extensively discussed and is being taken in to account in the new rules on the utilization of the reserves by Svenska Kraftnät. They will encourage that the demand capacity in the reserve is bid into the market on normal market terms.[13] It will most likely also be taken into account when future rules for effect reserves are designed.

The Nord Pool rules stipulate that the participants shall use trading in the spot market to achieve balance between energy inflow and energy demand in each bidding area. This may lead market participants to be quite risk averse and not be willing to take the risk of being off balance after spot even in peak situations, when there is a potential for end users reducing their consumption once the high spot prices are known. For instance Svenska Kraftnät agreements with the balance responsible do not specify in what market the balance should be achieved as long as it is achieved before the delivery hour. It may not be completely unambiguous to market participants what the market rules are for using Elbas for electricity supply and how these are enforced.

3.2 Households and small companies

3.2.1 Hourly metering and hourly settlement

The most significant barrier to increasing demand flexibility for households and small businesses is the lack of accurate follow-up of consumption and the lack of actual consumption data in billing. This means hourly measurement of consumption and hourly measurement based settlement. Old electricity meters follow only the cumulative electricity use over time, and with them it does not matter how the consumption fluctuates over time. New technology is required to enable the accurate time specific measurement of consumption. In addition to remote real time meters, metering and billing IT systems need to be updated.

Currently in Finland, a large share of meters has been installed, but only a small share of the metering data is used for balance settlement purposes. Meters must be installed by the end of 2013 and most likely the share of balance settlement based on hourly data will increase significantly already in 2012[14]. In Finland, the minimum level is reading the meter hourly and the data is to be in use for the retailer and also for the customer after 24 hours.

In Sweden, remote meters were installed by the end of 2009. Legislation requires in Sweden that the meters must deliver data concerning the total consumption during a month, but most of the meters can in fact deliver hour-based consumption data[15]. Some interviewed retailers considered that they don't receive all consumption data close enough to the time of consumption or a sufficient quality of

[13] Svenska Kraftnät

[14] Change is supported by the new electricity distribution regulation.

[15] Source: Elforsk, Timmätning för alla - Nytta, regelverk och ekonomi, Elforsk rapport 07:62

data so that it could be used for improving the sales forecast for the following day[16]. In Sweden, grid owners should deliver preliminary measurement data by 10 am the day after the delivery and final corrected numbers at the latest five days after delivery. However, there are no consequences for not delivering the data in time.

In Norway, according to new secondary legislation from the Norwegian Regulator 80% of remote meters should be installed by 1.1.2016. All meters must be installed by 1.1.2017.[17] The specific requirements for AMS including load management have been specified in the secondary legislation for metering. The exception is consumption which is very low and predictable.

In Denmark, several large utilities have installed remote meters to their customers. Some utilities report the consumption per hour and some report it as a total for a day. According to EU directives, remote metering must cover at least 80 % of consumption points in all countries by 2020.

For larger SMEs this is not a barrier as normally there is hourly measurement and billing already in place. Small companies most likely have the same barriers as households.

There is a project going on in NordREG for creating a Nordic Retail Market. Billing and metering issues as well as common balance settlement is going to be dealt with within this project.

3.2.2 Contract types and economic incentives

A second barrier to demand flexibility is the lack of incentives for demand flexibility in contracts. Fixed price contracts create no incentive for demand flexibility. The same applies for contracts which are valid until further notice (default tariffs). In Norway and in Sweden spot-priced contracts are fairly common, but most of the contracts are based on average monthly spot prices. This does not create an incentive to reduce consumption during peak hours. In Norway spot priced contracts make up over 55 % of electricity contracts.[18] In Finland, even contracts based on monthly average spot prices are rare.

As hourly consumption data is generally not available, the billing of spot priced contracts is based on general load curves and thus consumers' efforts to reduce demand during peak-price hours does not affect their electricity bill. Therefore, current spot priced contracts give little real incentive for customers to reduce their consumption during peak price hours. Implementing hour-based metering creates an opportunity to have hour-based contracts where the actual consumption profile of the customer will influence the price paid. This combination creates an incentive for customers to influence their consumption during peak hours.

3.2.3 Lack of load management capabilities

Another barrier to demand flexibility is the lack of load management capabilities for especially households. To get customers to share the market risks, which is in essence what happens when a

[16] This has been identified in Elforsk, Framtagande av effektprofiler samt uppbyggnad av databas över elanvändningen vid kall väderlek, Elforsk rapport 11:12

[17] Source: http://www.lovdata.no/cgi-wift/ldles?doc=/sf/sf/sf-19990311-0301.html

[18] NVE

consumer buys with a spot priced contracts, a customer needs to have the possibility to influence his consumption pattern if he wishes to limit his price risks in this way. This means in practice that possibilities for influencing load or load control are needed.

Technically, load control should be possible through some existing meters in Finland. Currently, active load management is not used in any of the Nordic countries for household customers. No retailers were recognized during the study that would have contracts with their customers that include load management except those mentioned in different experimental projects. Day and night time tariffs are common, but as said these don't create an incentive for demand flexibility that would be based on spot price. In general, retailers who answered the survey considered there to be little or no incentive for their customers to exercise demand flexibility.

3.2.4 Motivation of consumers

Load control solutions could technically be developed in 1-2 years and hour-based contracts combined with for instance SMS warnings of high power prices could be offered widely in the near future. However, a large barrier is customer attitude towards purchasing electricity. Customers are used to having power available at any time and many customers prefer a flat rate so that their power costs are predictable. Household customers don't want to be fully exposed to the electricity market price and hence they see real-time pricing as a great risk instead of seeing it as an opportunity to influence their own electricity costs. Consumers are not aware of peak demand/ peak price situations in the market and seem not to be ready to accept products that would restrict their consumption in some way. It is a significant hurdle for retailers to create interest among customers towards hourly priced contracts.

3.2.5 Cost of load management capabilities

An additional barrier to household demand flexibility is that if load management services are built, remote load management capability needs to be installed. This means in most cases that an installer needs to make this possible at the site. In many cases the initial fixed costs from this may exceed the benefits received by the consumer exercising demand flexibility. It would be practical to build the capabilities in the initial installation phase of the meters – lower installation costs for enabling this capability would be the end result. This should especially be considered in those countries where the installation of the new meters is still under way.

3.2.6 Insufficient available data, challenges in making prognosis and other retailer barriers

Currently for instance in Finland, retail companies base their consumption forecasts mainly on general load curves for different customer types. Billing is based on the load curve even if a household customer has an hour-based contract. During 2012, several Finnish utilities are likely to shift to hour-based balance settlement and thus they can use the hourly data also for billing and forecasting purposes. The regulatory framework encourages a quick shift to balance settlement based on hourly data. This will improve the accuracy of forecasts especially during cold winter days. To fully benefit from having more accurate data on consumers' consumption, retailers will need to develop data systems to do more accurate bids based on the additional information.

According to the interviewees, some SME customers with spot priced contracts already exercise demand flexibility, after the spot price has been set. As retailers don't currently have any possibilities for load control and they don't get any estimates of customers' demand flexibility, it is difficult for them to forecast the actual demand of customers that have an hour-based contract or other incentives for demand flexibility. Hence, the retailers (or the balance responsible) cannot make accurate bids to the market. As hour-based contracts become more common and retailers get more experience about consumer behaviour, the forecasting will become more accurate. Promoting some predictability could make it easier for retailers/balance responsible parties to make more accurate bids and reduce their risks. Practical measures could include for example increased information exchange between larger customers and retailers.

In addition, increasing distributed energy resources make it more difficult for retailers or balance responsible parties to forecast consumer demand.[19] Heat pumps, solar panels and wind generators would need to be taken into account in retailers' consumption bid.

In Finland, there is a large share of retailers who have their own production capacity. These retailers are not hit hard by the price peaks and thus they don't have high motivation to increase consumers' demand flexibility. However, during price peaks these companies could benefit from selling the excess generation capacity to the market, if their customers reduce their consumption.

4 Demand flexibility actions

4.1 Actions by large consumers

4.1.1 Type of consumption and production process

Industrial producers, manufacturing companies, and service providers typically plan and run their operations from the point of view of the core process. Even though energy costs are included in the process planning and operative decisions, the ability to regulate energy use is not necessary included in the process plans.

For the large consumers the first step in planning demand reduction strategies is getting to know the electricity consumption and technical possibilities to regulate it in detail. A prerequisite is that the electricity consumption of the different parts of the process is measured. Secondly the effects of demand reduction to other parts of the process should be identified to find out which demand flexibility measures are technically feasible.

In addition to the technical potential, the economic impact of demand flexibility needs to be understood. Exercise of demand flexibility means that some production is lost, and the process is interrupted. The cost of lost production, and the cost and the risks of interruptions need to be

[19] http://www.addressfp7.org/ws2010/WS2010_Report.pdf

compared to the cost of electricity. If the electricity price is high enough, then it makes economic sense to stop the production, but these price levels need to be identified.

4.1.2 Internal processes and motivation

If a large consumer has found out it has both technically and economically feasible demand flexibility options, then internal processes still need to be revised to take the demand flexibility in to account. In practice, when large industrial consumers plan demand reductions, the solutions are always tailored for the company concerned. In the interviews of this study, some large consumers noted that once practices were put in place that this was not at all difficult to do and practices became routine.

A decision to interrupt the core production process to save on electricity cost is not easily made by any large consumer. Management buy-in requires that the proposed investments can be made understandable and that the benefits can be quantified. Quantification of the benefits on the short term has been made easier as extreme prices have occurred.

4.1.3 Electricity supply contracts

Once a consumer has decided to exercise demand flexibility, and has acquired the means to do so, demand flexibility needs to be included in the electricity supply contracts. Depending on the size of operations, company resources and ambition level, the key options for a consumer are 1) to become a direct member at Nord Pool Spot and take total responsibility of all market operations, 2) acquire similar services from a third-party service provider, or 3) ensure that the supply contract includes the possibility for demand flexibility.

According to some interviews this process has been for some going on since the price peaks occurred. More awareness of these questions has been raised. If no incentives for demand response exist in contracts it should be evaluated by the consumers if they need to renegotiate these to be included in their contract.

4.1.4 Additional suggestions made by industrial consumers

Demand flexibility is not limited to only the day ahead market. Demand flexibility can also be exercised within the hour. Especially large consumers can have some continuous possibilities for adjusting their demand. The possibility to contribute to the balancing on a Nordic level was seen as something interesting. Several industrial consumers mentioned the interest for public price information for up and down regulation prices within the hour. They stated that it would be possible to adjust consumption according to the status of the Nordic balance.

This would decrease the necessity for up or down regulation of the TSOs by adjusting energy production and could even out the balance market price. This was seen by some consumers as being beneficial for the market as a whole or at least for the consumers. This type of demand adjustment already happens today but is so far based on educated guesses of the direction of down and up-regulation and the up- and down regulation price. The risk for uncontrolled mass regulation was recognized. It was seen by industry to be small as the economic impact of overregulation would

prevent this type of action and the number of players who possess the possibility for this was seen as limited.

This type of demand flexibility does not impact on the spot price, but is a type of demand flexibility which seems to exist.

4.1.5 Other large electricity consumers – retail companies, real-estate companies etc.

On aspect which needs to be taken into account is that the balance responsible parties/retailers don't necessarily have enough information about the consumption level of especially the medium sized end users. They may exercise demand flexibility after the price in the spot market is known the following day. Their processes for information exchange and contracts are not usually tailored in the same way as the processes and contracts of large industrial consumers are.

Some customers, who have spot priced contracts, may routinely reduce their consumption when the price is high if this is possible. The volume bought in the market by the balance responsible party/retailer can as a result be too high. However, it is also risky for the balance responsible party/retailer to buy too low a volume. It would be useful for balance responsible parties/retailers to have some indication of possible future price peaks to be able to take them into account in demand bids. However, the balance responsible parties/retailers would in addition require further information from their customers on how much consumption they are willing to reduce at different price levels. Experience will provide the possibility for making better prognosis, but other ways of solving this may also be useful.

In cases where the balance responsible party and retailer are separate players the balance responsible party cannot control how retailers make contracts with customers. For balance responsible parties/retailers it would be important to have information about estimated consumption volumes at different price levels or even a possibility for load control. This would require a retailer to make an agreement with the customer that data of consumption patterns would be sent to the balance responsible party/retailer and the possibility of load control by the end user or by the retailer/balance responsible party would be taken into account.

The regulators should evaluate if it could be possible to obligate customers whose consumption is above a certain level to be more active. This could mean a requirement to send information for retailers and balance responsible parties on the consumption levels at different price levels or increased information exchange on planned consumption. This could be beneficial for both parties as customers' energy costs would be reduced and balance responsible parties could reduce their risks. Contracts between companies may, however, be off limits to regulators.

Regulators should consider if it would be possible to develop an agreement with all three parties (consumer, retailer, balance responsible) that takes into account delivering required data of estimated consumption to the balance responsible party, actual consumption from grid owner to balance responsible party and possibly new methods for load management controlled by the balance responsible party.

Some large or medium sized consumers also have reserve capacity in the form of generators. Possibilities for customers that have reserve capacity (hospitals etc.) to participate in the market

with the spare generators should also be looked into. Load aggregators could also be useful in performing this service. Some already exist who do this.

4.2 Actions for households and small companies

4.2.1 Hourly metering and hourly settlement

To promote demand flexibility of household customers and small companies, the most important measure is to install remote meters that produce consumption data at a minimum on a per hour basis. In 2011, instalment of these smart meters is ongoing in all Nordic countries. Smart meters are installed by distribution companies, either on a voluntary basis or forced by the national regulation. Regulation is supported by current and upcoming EU directives that stipulate the need for timely measurement data. The time-tables for installations varies in the Nordic countries, but the majority of the meters will be smart meters in 4–5 years time.

Once hourly meters are in place, then balance settlement and billing of the customers should be changed to use actual measurement data, not the current load profiles. The hourly metering and billing creates the base for all other solutions.

In addition, measurement data should be made available for consumers, retailers, or other third parties acting on the behalf of the consumer. This enables firstly the end users to see and react to their electricity consumption more rapidly, and to all parties to innovate on new demand flexibility solutions.

It is important to feed in this aspect in the project for Nordic Balance Settlement.

4.2.2 Contract types with economic incentives

Contract types which include incentives for demand flexibility are one prerequisite. Retailers and balance responsible parties should develop contract types that create incentives for demand flexibility. Retailers should develop contracts that promote demand flexibility and are interesting for consumers. These could be for instance hour-based contracts that include some solutions for load management. At the moment, customers consider it a risk to switch to hour-based pricing. It is important that contracts offered for consumers are clear and transparent.

The share of contracts with incentives for demand flexibility is strongly affected by the marketing actions and pricing decisions of the retailers. Increasing the share of real time priced contracts will create more demand flexibility in the market. This is also in the interest of retailers, because this reduces their exposure to market risk.

Possibilities for contracts to increase consumer demand flexibility could be for example the following:

- Automated load control with the possibility for the customer to bypass steering. The contract could be based on reducing the demand of direct electricity heating or the water heating boiler when the price is above a set threshold. If a consumer would be allowed to bypass steering, the price of electricity would be higher. The incentive for the consumer may

be based on hourly electricity prices or the consumer may receive a capacity reservation fee.[20]

- Fixed price with the right to return. Customers are offered a contract with fixed price and fixed volume. Volumes are set for each hour and they may vary monthly or quarterly. Any deviation up or down from the fixed volume would be compensated with the spot price.[21]
- Dynamic time of use tariff. Customers have a fixed price for all consumption except for a few hours, when the consumption is high. A customer would be notified one day in advance of high prices during certain hours and customer could then choose to reduce demand during this period.[22]
- Time of use rates could be kept in use if they exist and be promoted if direct spot priced contracts are not offered or are not accepted by consumers. These do not however directly reflect the market price and will not give the completely correct price signals for market based demand flexibility. But they do steer consumption in the right direction to off peak hours and thus promotes demand flexibility.
- Hour-based pricing. Customers would pay hourly spot price for the electricity used per hour. This would give an incentive for the customer to reduce demand on peak price hours or take advantage of the variation of price on every hour. Customer may choose to manage consumption manually or to install an electricity management system that manages specified loads automatically based on specified rules. The electricity management system may be provided by a retailer or by a third party.

The possibility to exercise load management enables a consumer to accept the exposure to spot prices. Consumers can eliminate the impact of high prices by acting proactively. This will lead to on average lower prices compared with fixed price contracts, which include an insurance premium. Concurrently, retail companies can reduce their financial risks, if they offer such contracts to their customers.

4.2.3 Load management capabilities

For consumers to accept more widely the exposure to spot prices, some type of load management capability is needed. Load management can be based on distribution network services or home automation solutions. Retailers or other service companies should develop service products for households to lower the barrier for being more responsive with their consumption. Any solution developed for consumers should be simple and easy to use and its impacts on electricity costs should be easy to understand. Load management should be automated as customers' response by manual adjustment is likely to decrease over time. Services should be beneficial for the customer and the retail company and the possible service provider. In Sweden, benefits for the balance responsible party should also be achieved.

[20] Source: Elforsk, Market Design Project, Demand Response Resources in Sweden – a summary, Elforsk rapport 06:41

[21] Source: Elforsk, Market Design Project, Demand Response Resources in Sweden – a summary, Elforsk rapport 06:41

[22] Source: Elforsk, Market Design Project, Demand Response Resources in Sweden – a summary, Elforsk rapport 06:41

It is recognized that when load management solutions are developed consumers want some flexibility. Consumers would most likely want to sometimes bypass any automated controls. However, the consumer should then pay a higher price for the electricity used because of the increased flexibility and comfort.

In existing buildings, it would be more difficult to connect other loads to demand flexibility solutions. In new buildings, the possibility for load control could be taken into account already during construction. Even though the heating capacity is smaller in new buildings, the time frame during which a heating system can be turned off is much longer because of better insulation.

Regulators or other relevant authorities should consider setting technological requirements of remote meters that enable load management. To enhance the development of load management services, retailers, balance responsible parties and distribution companies should promote development of co-operation interface standards and standardized methods for load control. Defining the interfaces and methods allows the consumer to switch the retailer or other party providing load management services. Retailers or other parties providing services for demand flexibility could for instance start with developing a technological solution to manage water boilers and electrical heating systems that can currently be run according to a day and night tariff schedule. It should be researched how many do so, what effects they have today and could this have good potential in the future.

In Finland, all new hour-based meters can be controlled remotely and thus new software can be installed if necessary. Legislation however, does not demand that load management should be possible through meters, but most meters contain a relay that allows load control. In Finland, day and night time tariffs have been traditionally used for electric water boilers and electrical heating. These loads could be connected to remote meters and controlled for demand flexibility purposes. Technically using electrical heating and water boilers in load control should be relatively simple, but there may be some challenges in configuring control systems and interfaces.

To promote more wide use of load management solutions, the regulators and other relevant authorities such as ministries in the respective Nordic countries should evaluate the benefits of giving investment support for private consumers or SMEs who invest in load management technology. The benefits of demand flexibility are shared by the whole society and thus investment support to a few customers may be a cost-efficient solution for all electricity consumers.

4.2.4 Setting standards which promote load control

On the longer term other solutions should also be considered. Some of these are described below:

In addition to direct electric heating systems and water boilers, heat pumps, saunas and household electrical equipment, especially “white goods” as well as electrical vehicles could be used to create demand response.

Currently, heat pumps can usually not be remotely controlled and additionally heat pumps may suffer damage when turned off during cold weather. Heat pump manufacturers should be aware of a requirement for demand response and heat pumps should be built in a way that allows flexible use even during cold periods.

An increasing number of electrical vehicles may cause challenges for the electricity system, if all vehicles are charged during a short time frame. Regulators, TSOs and utilities should cooperate in developing a technological solution and also contract terms for charging electrical vehicles in order to avoid that these lead to consumption peaks.

To promote better possibilities for load management, relevant authorities such as ministries should set a standard for new buildings (or when doing a thorough renovation) for how the electricity system should be constructed. The electricity connections should be built in a way that allows combining the loads that can be used for load management purposes. For example direct electricity heating, water boilers, electrical vehicles or other loads could be connected so that they are easily available for load management.

Equipment manufacturers should improve the possibility to vary the consumption level of white goods and heat pumps according to the price level of the market. The simplest solution for white goods could be a timer that allows setting e.g. a dish washer to run during cheaper night-hours. In the long run manufacturers could include sensors and computer systems in equipment that allows remote control of equipment and running them at the cheapest price available on a given time-frame. Equipping refrigerators, washing machines, dish washers etc. with timers or computer systems that allow remote control at the time of production would further increase the flexibility of households' electricity demand.

4.2.5 Consumer motivation

General awareness of consumers should be raised about the constraints in the Nordic electricity market. If consumers would be aware of the general need for demand flexibility and the benefits for themselves and for consumers in general, they would be more willing to take actions to increase demand flexibility. Environmental benefits could also be lifted to the forefront in order to increase motivation.

4.2.6 Roles of distribution and retail company and balance responsible party[23]

As electricity meters are owned by distribution companies, co-operation between retailers and distribution companies is required. It is in the interest of distribution companies and TSOs to develop demand response in order to optimize grid investments or to improve balancing in areas where significant volumes of intermittent power production is connected to the grid, such as wind power, micro turbines etc. The strength of the incentive depends on the regulation method used. In the Finnish regulation method, the incentive to reduce outage costs creates an incentive to develop demand flexibility.

To avoid peak-hours in the overall market, retailers should be closely involved in developing demand response solutions as they operate on the customers' behalf in the wholesale market.

[23] Three levels of balance responsibility exist in Sweden. By signing a Balance Obligation Agreement with SvK, a company becomes a balance provider (BRP) and by that takes the economical responsibility for the physical balance in their trade. On the next level there are other players with agreements with the BRPs. With these agreements the BRP takes responsibility for the other actor's economical balance

Load control would entail the need for some cooperation between the distribution company which owns the meters and the retail company, who would be a natural partner for the consumers in load control solutions. The rules for co-operation between distribution companies and retail companies are not clear. At least in Finland, creating a common business would not be allowed. Regulation has restricted the co-operation of distribution and retail companies to exchange of information for billing purposes and other defined data.

Even if load control would be possible by the installed meter, the interfaces between a distribution company and a retail company or a possible third party, would need to be defined in both legal and technical terms. Some standards may need to be defined for communication. There is an on-going discussion on harmonizing the Nordic electricity retail market so that customers could purchase their electricity from a provider in any Nordic country. This would set further requirements for harmonizing the measures for load control as well. On the other hand, having a harmonized infrastructure for load control in all Nordic countries would create good opportunities for demand flexibility.

The legal framework in Sweden may require some changes to improve possibilities for demand flexibility. The Balance responsible party would have a high interest for developing demand flexibility, but currently they may not have a possibility to impact on end customers' contract terms in those cases where they are not the party selling to the end customer. Business models should be developed where all parties; retailer, customer and balance responsible party would benefit.

The regulator or ministries should define roles and interfaces for the co-operation between a distribution company and a retail company or other service providers. In Sweden, the definition should include the role of the balance responsible party. The regulator should take care of any changes required in the legislative framework.

In addition, the regulator or relevant ministry should consider what could be the best way to ensure co-operation between distribution companies and retailers or other service companies. To optimize overall investment, it may be necessary to give an incentive for distribution companies to invest in meters that enable load management required by the retailer. Another possibility is that distribution companies are obligated to offer a possibility for retailers to manage customer's consumption, if the retailer has a contract including load management with the customer. However, it should also be taken into consideration that the load management system must take into account technical requirements that ensure security of supply.

Distribution companies and retail companies have different interests for demand flexibility. A distribution company could use load control to ease restrictions in the distribution network and optimize grid investments whereas a retail company could use load control to reduce power purchase costs. The cost savings could be shared with the customer. The best case would be that the interests of both parties could be taken into account in a demand flexibility solution.

As the distribution companies have control over the electricity meters, it is important to guarantee that management of loads would be possible for retail companies or third parties even if it is not in the interest of a distribution company to develop such solutions. It may be necessary to include a possibility for load management in the basic services offered by a distribution company. These factors are also included in the new energy efficiency directive draft described in Appendix 1.

4.2.7 Data available for retailers

Distribution companies should deliver consumers' hour-based consumption data to retailers. The data should have sufficient quality and be delivered for example one or at the latest two days after the day of consumption. Regulators should set some consequences for not delivering the data to retailers and balance responsible parties. Some minimum required service levels should be set.

Retailers should have the proper tools to analyze the data and to use it in making consumption bids. Retailers should analyze the impacts of weather and price levels on consumers who have hour-based contracts to be able to produce more accurate bids.

5 Effects of demand flexibility

5.1 Potential for demand flexibility

The practical potential for demand flexibility in the Nordic area on the medium term has been estimated to be about 12 000 MW.[24] The potential is dependent on the price levels on the spot market as well as many other factors. Table 5.1 presents a conservative estimate by country.[25] The demand flexibility is generally assumed to consist of mainly large scale industry and electricity heated homes. These are seen to hold the most easily achievable potential.

Electricity heating can be steered quite quickly and without loss of comfort or major momentary costs to the consumer. In this way it differs from industrial loads where costs for lost production have to be weighed in. On the other hand, it is possible that greater investments are needed to realize the full potential for electricity heated households. The costs compared to benefits need to be kept in mind. However, the costliest investment, which is the hourly electricity meter and its installation, has already been decided.

Table 5.1. *Estimate of the potential for demand flexibility in the Nordic area.*[26]

	Denmark	Finland	Norway	Sweden
Demand flexibility	500 MW	2 500 MW	5 000 MW	4 000 MW

According to estimates made by Nordel, Elforsk och EME Analys the total Swedish demand flexibility potential could be between 3 300 MW and 5 500 MW, which is about 10-20 % of the maximum effect.

[24] Nordic TSOs' Action Plans in enhancing and monitoring Demand Response, Nordel Market Committee and Nordel Planning Committee, 28 February 2005

[25] DSM experiences in Nordic countries, Presentation by Seppo Kärkkäinen, VTT, 2007

[26] DSM experiences in Nordic countries, Presentation by Seppo Kärkkäinen, VTT, 2007

The following sections quantify to some extent the effects of the actions described in section 4. Separate actions can't usually be quantified in a useful way. To get tangible impacts a combination of actions described in section 4 are generally needed especially when households are concerned. No one action will solve the demand flexibility issue.

5.1.1 Industry

Few reliable and current studies exist on the potential for demand flexibility. In addition it is not possible to know how much of the technically possible potential is already activated. This would require asking the largest industrial consumers in the Nordic area details of their flexibility potential and its use for different purposes and at different price levels. Detailed data on demand flexibility potential and the characteristics of the production process also fall within the business confidentiality of the companies. A detailed analysis could be the subject of its own study and is not within the scope of this study.

Bids to the spot market, however, seem to show more price sensitivity, which is apparent from the analysis of the spot price curves, which are analyzed in section 5.2. It may also be apparent in the fact that extreme price situations have been fewer in the last year. This may indicate an increased use of demand flexibility by industry.

According to a VTT report [27] the Finnish process industry has the following demand flexibility potential:

Paper industry	790 MW
Metal industry	330 MW
Chemical industry	160 MW
Total	1280 MW

A part of the potential is already activated, but how much is uncertain at this time.

According to evaluations made by a working group for The Finnish Ministry of Employment[28] and the Economy the demand response potential of the Finnish industry has been estimated to be about 500 MW. The potential is seen to be dependent on many different factors and a great deal of insecurity is inherent in the estimate.

For the demand flexibility potential of Swedish industry different estimates have been made in different studies. The potential has been estimated in a report by Elforsk[29] (2007) to be 700 MW for base industry[30] with price peaks of about 10 000 SEK/MWh. EME Analys has estimated the potential to be about 1 300 MW. For the whole potential to be realized peaks of 90 000 SEK/MWh would be

[27] DSM experiences in Nordic countries, Presentation by Seppo Kärkkäinen, VTT, 2007

[28] Sähkön kysyntäjouston edistäminen, Sähkön kysyntäjouston roolia ja tavoitteita sähkömarkkinoilla selvittäneen työryhmän mietintö, 14.3.2008

[29] Timmätning för alla, Nytta, regelverk och ekonomi, Andrea Badano, Peter Fritz, Anders Göransson, Magnus Lindén Elforsk rapport 07:62

[30] For medium sized industry the estimate is 300 MW and 300MW was included as effect reserve.

needed for about 10 hours per year. Different studies point out that several instances with high prices are needed for industrial consumers to begin to act and for the potential to be realized.

The total demand response potential in Denmark has been estimated by Nordel to be about 500 MW. There is little large scale industry in Denmark, which limits finding short term solutions for new demand flexibility.

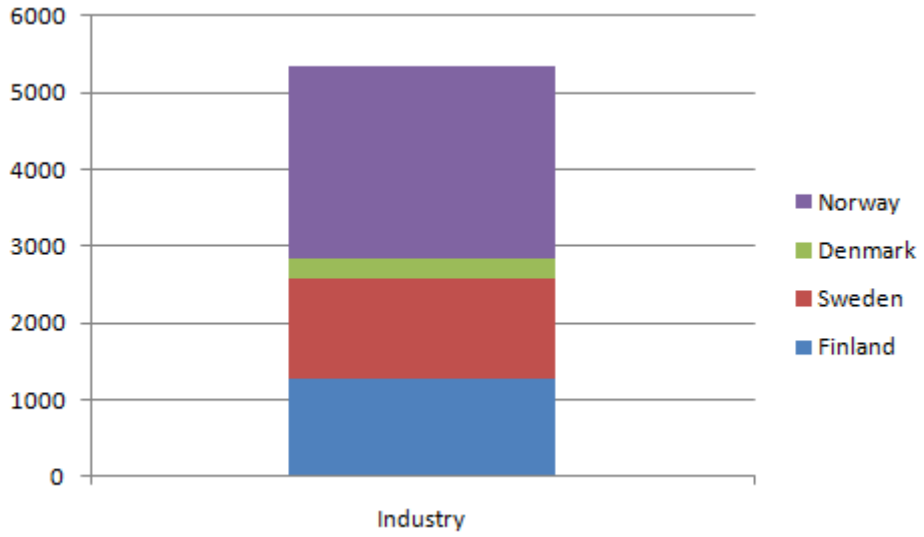

Figure 5.1. *Rough estimate of demand flexibility potential of industry in the Nordic region.*[31]

The demand response potential has been assumed to be roughly 5 000 MW in Norway. Of this an estimated 1500–3 500 could come from industry.[32]

5.1.2 Households

The household potential for demand flexibility lies especially in housing which is heated by electricity. Most of the potential can be found in space heating and in production of warm water. The potential for flexibility is greater in houses which have the possibility for heat storage and which have good isolation as well as solutions for heat capture. These are factors which make it possible to steer demand from high price hours without major loss of comfort for the consumers. The potential for demand flexibility for households not heating with electricity or for apartments is smaller. The demand flexibility potential for the households is estimated to be in between 4 000 MW and 7 000 MW as illustrated in Figure 5.2.

In Finland there are about 600 000 electricity heated homes. The potential for demand flexibility is estimated to be about 1 a 2 kW per a house, which means that the total potential could be about 600–1200 MW. In addition there are about 400 000 holiday homes, of which an increasing number

[31] Sources are VTT Kärkkäinen (Finland), EME Analys (Sweden), for Norway and Denmark estimates were made based on Nordel estimate for whole demand flexibility potential and estimate made for electricity heating demand flexibility potential. The rest is assumed to be industrial demand flexibility. Thus the numbers may not be comparable but give some indication of the size.

[32] A very rough estimate based on an estimate that 1700 – 3500 MW demand flexibility could come from electricity heated households and the rest of the Nordel estimate from large scale industry.

are heated with electricity. Finland already uses time of use (ToU) tariffs and some loads are steered to be switched on at night when the price levels are somewhat lower. This has lead to a load increase of about 1000 MW in the evenings during cold periods in the winter. This means in practice that some of the demand flexibility of the electricity heating customers is already in use although the demand reduction which is now produced is not directly connected to the actual market price or spot price.

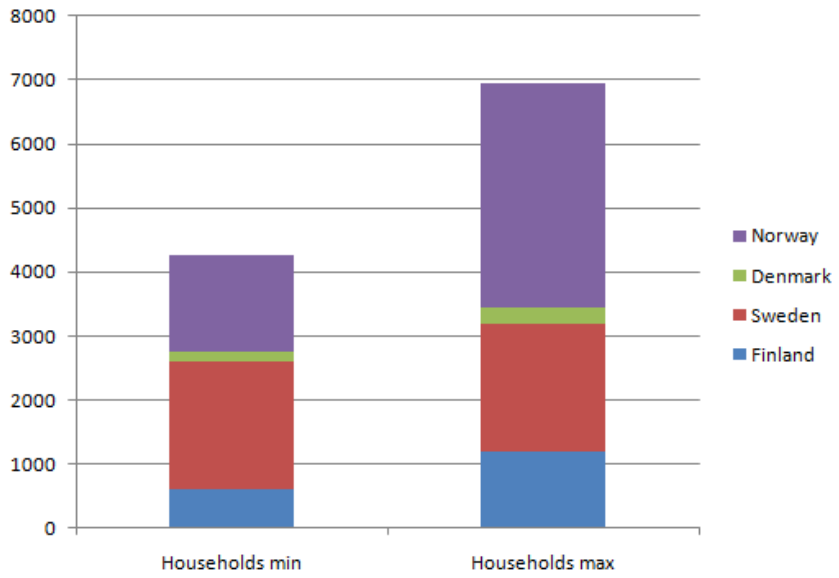

Figure 5.2. *Estimated minimum and maximum demand flexibility for electricity heated households.*[33]

In the case of Finland it has been estimated that the total electricity consumption used for heating during a so called normal winter day (temperature of -8,7°) amounts to about 1 GWh/h during daytime and peaks to over 2,5 GWh/h during the night. It is assumed that the situation is similar in the other Nordic countries. According to evaluations made by a working group for The Finnish Ministry of Employment and the Economy the demand response potential from electricity heated houses to be about 300 MW. [34]

Because of the small potential for demand flexibility of the smaller households and those without electricity heating, the practical household demand flexibility potential is in Sweden in total estimated to be 2 000 MW[35]. The number of houses in Sweden is almost 1.9 million. About half of these use electricity based heating of some form.[36]

[33] This is a very rough estimate which uses different sources and where the assumption for Finland, Norway is based on 1-2kW demand flexibility for electricity heated households. Swedish estimate of 2000 MW. In different studies 2000 MW is used as an estimate for demand flexibility for Swedish households.

[34] Sähkön kysyntäjouston edistäminen, Sähkön kysyntäjouston roolia ja tavoitteita sähkömarkkinoilla selvittäneen työryhmän mietintö, 14.3.2008

[35] Market Design Project, Demand Response Resources in Sweden– a summary, Elforsk rapport 06:41

[36] Statistics from Energimyndigheten, Sweden

A large part of homes in Norway are still using electricity heating. An estimate has been made that about 80 % of the Norwegian households use electricity heating in some form. Based on the assumption that there is a demand flexibility potential of about 1–2 kW per electricity heating customer, it can be assumed that there is at least about 1 700 – 3 500 MW demand flexibility potential.[37] These numbers are very rough estimates.

Only about 6 % of the 2,6 million households In Denmark[38] are using electricity heating, which makes approximately 150 000 households. Most use district heating. If we assume that the same applies for Denmark as for Finland. With an estimated demand flexibility of 1–2 kW per electricity heated household, we reach an estimated potential of 150–300 MW.[39]

5.2 Effect of demand flexibility on price formation

5.2.1 Brief notes on the theoretical setting

In this section demand flexibility is considered as a result of the reaction of demand to the price. The current Nord Pool spot mechanism offers in principle sufficient tools for market participants to include demand flexibility to their bids for an individual hour.

In practice the market model used by Nord Pool has more limitations. The day-ahead nature of Nord Pool spot requires market participants to make *ex ante* judgement on the appropriate price levels where they want to activate demand flexibility. For some market participants it could be beneficial to have the possibility for *ex post* decision. This means that they would be keen to react to price changes dynamically as they occur, rather than statically beforehand.

Elbas market settlement is made closer to the delivery hour. The additional time gives market participants potentially more accurate information about their likely consumption during the delivery hour. For example, the weather forecast can have changed. In theory, the potential for additional information supports purchases from Elbas, at least for the more uncertain part of the consumption. However, financial hedging is available only for the spot market, thus creating additional financial risk that can overweight the risk reduction from the physical conditions. In addition, operating on both markets can increase transaction costs of trading.

In practice also the settlement of each hour separately can be challenging for market participants that would have possibility to adjust their demand, but only over time periods over several hours. However, allowing flexible bids of several hours can create some problems for the spot price calculation.

[37] Assumption made from the Finnish calculations as no other estimates have been available. In the Finnish calculations each electricity heating object has a potential demand flexibility of 1- 2 kW.

[38] www.ens.dk

[39] Different estimates for the demand flexibility potential per object exist. Here we have used the conservative estimate of 1 – 2 kW.

For the purposes of spot price formation, the source of demand flexibility is of limited importance. All power is bid in similar units and only the total amount of demand flexibility at various price ranges is important.

It is good to note that the market model used by Nord Pool is fundamentally based on the idea of perfect competition. One interpretation of this is that no market participant should have enough market power to affect price formation for his/her own benefit. Previous studies on the price peaks during the winter 2009–2010 have shown that the existence of market power cannot be ruled out in high price situations[40].

5.2.2 Examples of the effects of trading strategies

Opportunities similar to arbitrage are possible between the various physical electricity markets in Nord Pool. This means that some market participants can have contractual arrangements with little or no risk of loss but high potential for gains in some market situations. In addition to physical Nord Pool spot and Elbas markets, the participants can have physical delivery contracts and financial hedging contracts.

The following simple example illustrates how market participants with physical consumption can use a combination of demand flexibility, Nord Pool spot trading, and financial trading to make profit in high price situations.

Industrial consumer

Example – Industrial consumer in spot and financial market

Consider an industrial market participant with a constant 1 MW physical consumption. The participant acquires electricity through Nord Pool spot and has hedged the physical consumption with a financial instrument that guarantees a purchase price of 50 €/MWh.

In normal market situation the price of electricity can be for example 60 €/MWh. The financial settlement for the market participant for one hour is as follows:

- Physical spot purchase -60 euro
- Financial hedge +10 euro
- Net gain -50 euro

During high price situations, the industrial participant may choose to use demand flexibility if spot price exceed some predetermined trigger level, for example 200 €/MWh. Consider now a situation where the spot price for the delivery hour is 300 €/MWh. Note that the participants purchase bid for spot electricity is below the spot price and is therefore not activated.

- Physical spot purchase 0 euro
- Financial hedge +250 euro
- Net gain +250 euro

[40] See e.g. Gaia EMV Peak

In this strategy, the participant may wish to set the trigger level for purchase so that the rewards from financial hedge compensate the opportunity cost set by the lost utility of the electricity.

If the market participants have access also to Elbas market, there are additional possibilities as the example below demonstrates.

Example – Industrial consumer in spot, financial, and Elbas market

Consider the market participant from the previous example with a 1 MW physical consumption and a 50 €/MWh financial hedge. The possibility to trade on Elbas market does not affect the previous trading strategies. However, additional possibilities for risk free gains are introduced.

Take a market situation, where the spot price for the delivery hour is 300 €/MWh, over the 200 €/MWh trigger level determined by the market participant. Assume in addition that the market tightness eases after the spot price is formed and Elbas price is at 100 €/MWh. It can again become lucrative for the market participant to purchase the physical electricity from Elbas and continue operation using electricity as normal. The financials in this arrangement for one hour are as follows:

- Physical spot purchase 0 euro
- Financial hedge +250 euro
- Physical Elbas purchase -100 euro
- Net gain +150 euro

The net gain for the participant is received with no risk of loss. If the Elbas market prices remain higher than the utility of the electricity for the participant, then she does not need to purchase it.

Retail company

In the market situation of 2011, very few retails companies have very few customers with demand flexible contracts. They are obliged contractually to sell electricity to their customers regardless of the market price.

Example – Retail company with no possibility for demand flexibility

Consider now a retail market participant with an estimated 1 MW physical consumption. The participant acquires electricity through Nord Pool spot and has hedged the physical consumption with a financial instrument that guarantees a purchase price of 50 €/MWh.

In normal market situation the price of electricity can be for example 60 €/MWh. Ignoring the balancing market, the financial settlement for one hour for the market participant is as with the industrial participant as follows:

- Physical spot purchase -60 euro
- Financial hedge +10 euro
- Net gain -50 euro

The customers of the retailer then receive the electricity and are charged by the retail company. In practice, a retail company is typically exposed to many additional uncertainties, including demand uncertainty.

The following example shows how a retail company can benefit from customer contracts with demand flexibility.

Example – Retail company with demand flexible contracts

In this example, it is assumed that the retail company has made demand flexible contracts with its customers for a total volume of 1 MW physical consumption. It is assumed that the trigger level for reduced consumption is set at 200 €/MWh. The participant acquires electricity through Nord Pool spot and has hedged the physical consumption with a financial instrument that guarantees a purchase price of 50 €/MWh.

Again, in normal market situation the financial settlement for the market participant remains the same. However, the retail participant continuously needs to take demand flexibility in to account in its bids to the market. The bids above the trigger level of 200 €/MWh are lowered by the agreed 1 MW of physical consumption. Now if a price peak of 300 €/MWh occurs, the settlement for the retail company for one hour is changed to:

- Physical spot purchase 0 euro
- Financial hedge +250 euro
- Net gain +250 euro

The net gain can then be shared between the retail company and its customers. This can be done for example with lower average sales price, bonuses per occurrence, or other means.

Other strategies

The simple examples above illustrate how even with standard market instruments, demand flexibility can open lucrative trading strategies for market participants with possibilities to regulate their demand. The participants can use financial hedging contracts to protect them against high spot prices and use the regulating possibilities to take advance from the potential price differences in spot and Elbas markets.

It should be noted that the examples above give a very simple illustration of the potential trading strategies of the market participants. Bilateral physical delivery contracts and balancing arrangements can offer even more possibilities for participants willing to actively regulate their electricity positions.

It is interesting to consider the incentives created by these trading strategies. High price peaks can be interesting trading opportunities for consumers with possibilities for demand flexibility. Even if the long-term prices can rise because of the price peaks, it can be economically feasible for the companies to use the existing trading possibilities to try to benefit from price peaks in the short term.

5.2.3 Demand elasticity on different price levels

The amount of demand flexibility available is dependent on the market price level. The demand curve for one day is shown in is Figure 5.3. It shows the demand at the given price levels for one relatively high priced hour in winter 2010–2011.

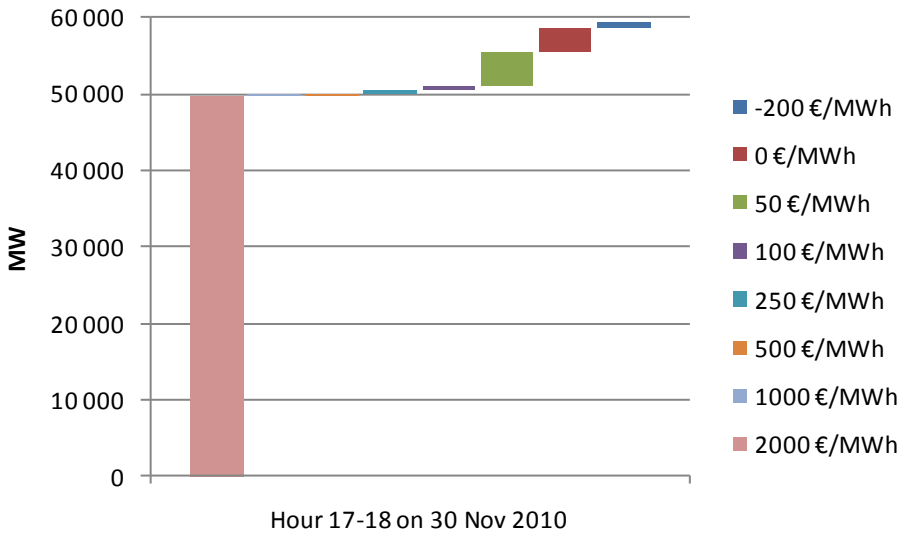

Figure 5.3. *Demand flexibility at different price levels on the hour 17–18 on 30 Nov 2010.*

The maximum technical price level in Nord Pool spot is 2 000 €/MWh. Around 50 000 MW of consumption was bid at this maximum price level on that hour. A drop of price from 2000 €/MWh to 100 €/MWh increases demand only by around 1 300 MW. The biggest demand changes occur in the price range below 100 €/MWh. Demand changes by total amount of 8 300 MW from 100 €/MWh to the minimum bid level of -200 €/MWh.

The data for other hours in different time periods is rather similar. A large proportion of the demand is bid "at any cost", i.e. at the maximum technical price level. It is questionable if the value of electricity is indeed that high for all the consumers. Some consumers can have operations that indeed are more valuable, for example an interruption in an industrial process. Also, for retail companies the delivery obligations to customers force them to purchase at any price level. Another interpretation is that a large part of the volume is hedged with financial contracts, thereby eliminating the direct interest of the bidders in the price levels.

Another part of the demand curve demonstrates relatively stronger price elasticity near the normal spot price levels than the elasticity seen on higher price levels. At least partially the high price elasticity near spot price level results from the use of pump storages. A pump storage can pump water up with low spot prices and to discharge it when the prices are higher. The pump storages are not the focus of this study and the focus should be put on the changes in the curves on higher price levels which show the price elasticity of demand. Further it needs to be noted that a part of the demand flexibility is integrated in the sales curve. This means that the analysis of the buy curve will not give a completely correct picture. What part of the demand flexibility is included in the sales curve is not possible to know without gaining insight into the actions of individual market parties.

A market participant can for example leave a demand bid of 100 MW at 2 000 €/MWh and a supply bid of 10 MW at 1 000 €/MWh. If the price is below 1 000 €/MWh, the net demand is 100 MW, but if price exceeds 1 000 €/MWh, the net demand is 90 MW. It is not possible to differentiate these bids from other supply side bids without a very detailed study on the behaviour of individual companies.

5.2.4 Dynamics of price changes

Electricity market is influenced by a multitude of continuously changing factors. Electricity is needed on continuous basis and possibilities for storage are limited. Supply and demand show variations that are dependent on the time of the day, week and year, weather conditions, technical availabilities, interconnections to other market areas and the state of the economical activity, among other things. In addition the price formation is affected by the generation costs, profit margin requirements, and purchase power of the demand side.

The changes are evident even during a one single day, as is shown in Figure 5.4. below. It can be noted that the variation in demand during the day occurs mostly on the maximum price level.

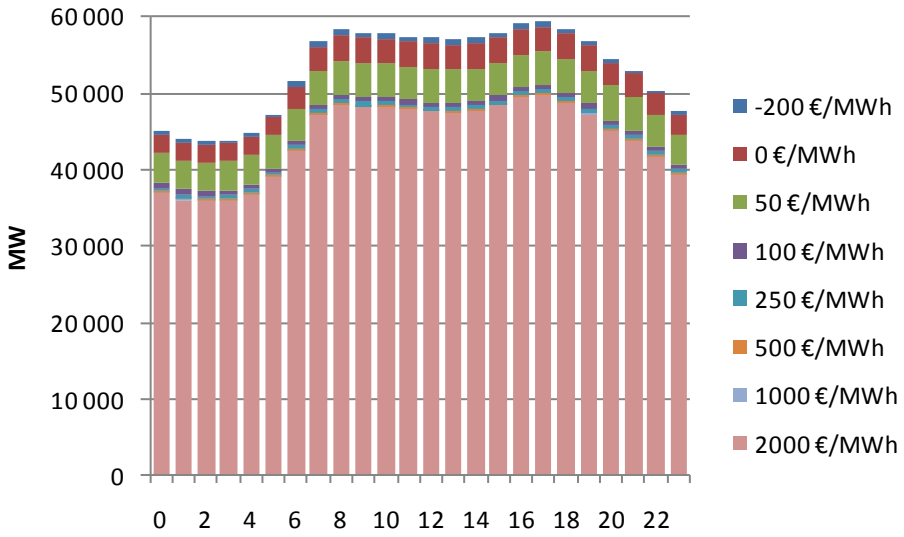

Figure 5.4. *Demand flexibility at different price levels on all hours of 30 Nov 2010.*

On top of the continuously changing underlying physical conditions, the Nord Pool spot market can be seen as a dynamic game between the market participants. The profit margins available to the participants are in principle set in a competitive manner, but in practice the ever changing nature of the market makes the selection of optimal bidding decisions challenging.

Given the complexity of the Nord Pool market, the full analysis and quantification of demand flexibility in the market is beyond the scope of this project. A full analysis would require a thorough understanding of not only historical, but also planned trading strategies of all market participants. Assume for example that the market is in a relatively stable condition. There is no need for new demand flexibility measures, as peak prices do not occur in any case. However, a change in market conditions, for example an increase of demand or a decommissioning of a physical generation unit, can change the price formation so that demand flexibility becomes necessary. Prediction of such events is not possible from the historical trading behaviour of market participants.

The change in demand as a function of price can be described by the price elasticity of demand. The price elasticity of demand is relative change in demand divided by the relative change in price. A larger elasticity means a larger demand response to price changes and a value of 0 means that the price does not affect demand at all. The price elasticity of demand is measured at a certain level of demand or price.

Figure 5.5 shows the price elasticity of demand as a function of price levels for one relatively high priced hour in winter 2010–2011. Elasticity is highest in the price range below 100 €/MWh. There are a very few and very small price changes over the price of 1 000 €/MWh.

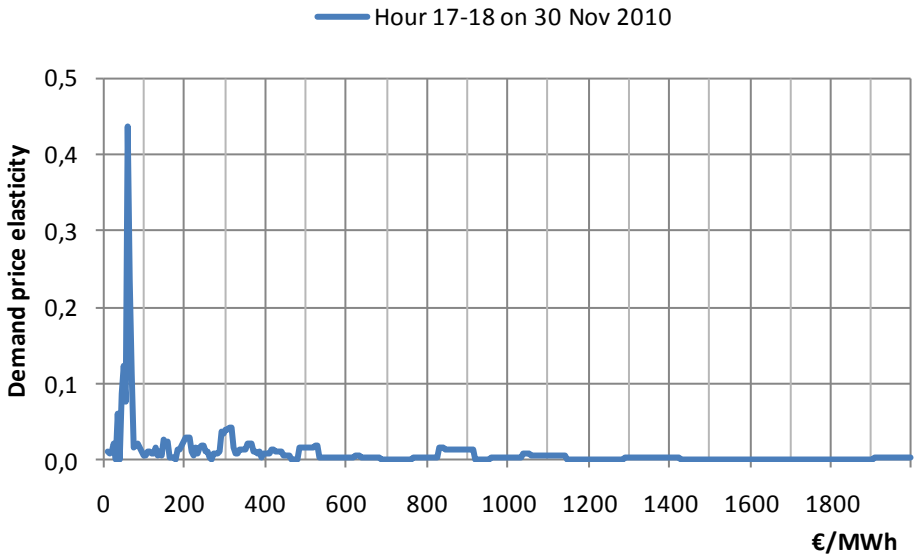

Figure 5.5. *Illustration of the changes in the price elasticity of demand on the hour 17–18 on 30 November 2010.*

The price elasticity of demand changes over time. An example from the difference in price elasticity between November 2010 and July is depicted in Figure 5.6. Although the shape of the curves is similar, there are notable variations between the demand price elasticity. A systematic tracking of demand price elasticity would be needed in order to keep track on how much demand flexibility is bid on the market through spot prices.

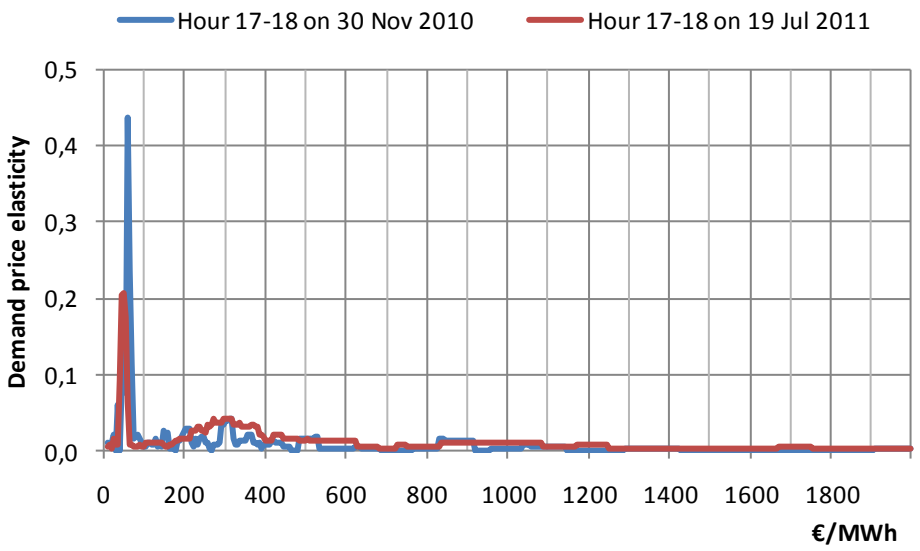

Figure 5.6. *Illustration of the changes in demand price elasticity from 30 November 2010 to 19 July 2011.*

Another example of the changes in demand flexibility is seen in Figure 5.7. Demand elasticity seems to have increased slightly on the high end of the price curve from 19 July 2010 to 20 July 2011.

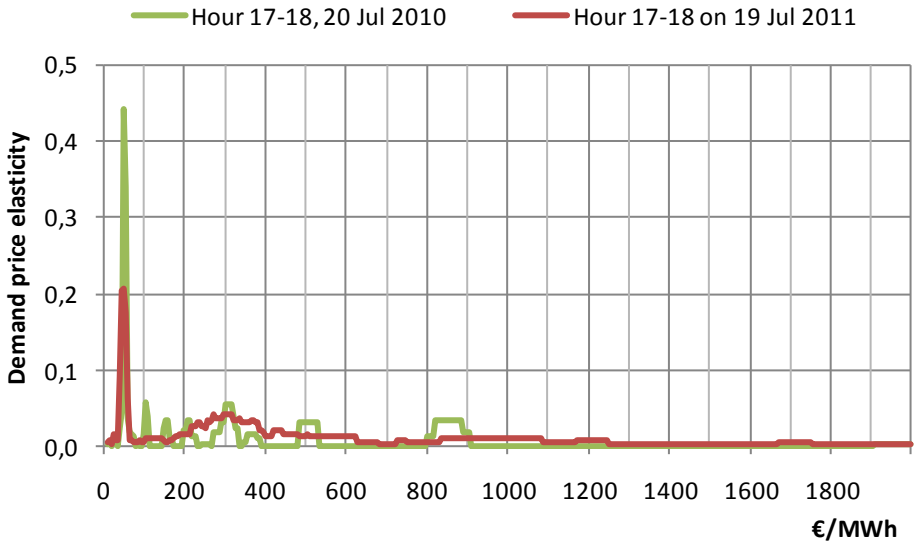

Figure 5.7. *Illustration of the changes in demand price elasticity from 20 July 2011 to 19 July 2011 (both summer Tuesdays).*

5.2.5 Indicator for demand flexibility

The dynamic price formation cannot be accurate followed without a continuous follow-up system. With current public data, it is already possible to create indicative system to follow the likely price formation for the coming day. Such follow-up gives information for the market participants on the potential price levels and it can give a tool to monitor market bidding.

Figure 5.8 illustrates prices from the summer 2011, the realized spot price for 18 and 19 July 2011 and a model estimate for 19 July 2011. The price level on 18 July, a Monday, was somewhat below the price level of 19 July, especially during the early morning hours. This somewhat typical situation is most likely due to a load increase from the weekend.

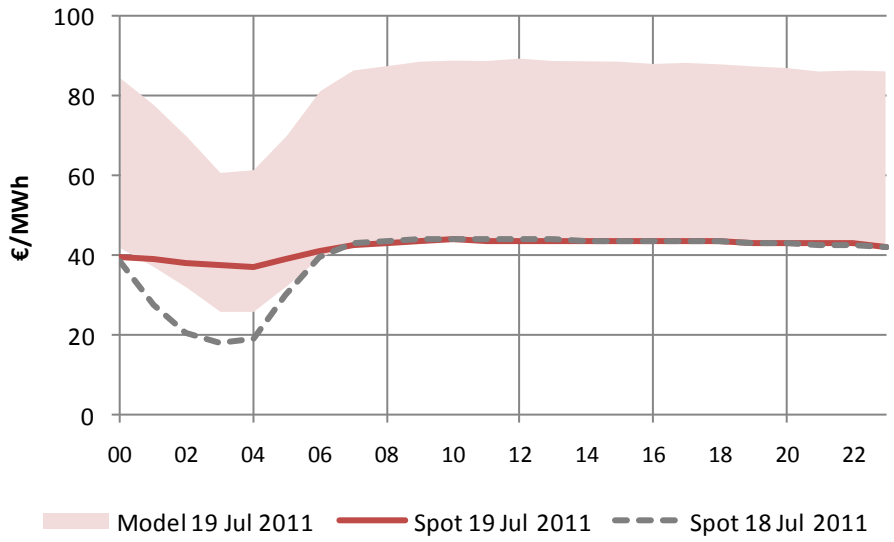

Figure 5.8. *The realized spot price for 18 and 19 July 2011 and a model estimate for 19 July 2011.*

The model estimate is calculated by using the publicly available consumption forecast for 19 July 2011 and the supply curve of 18 July 2011[41]. The upper and lower boundaries for consumption are calculated by using an illustrative 2 % margin[42]. As a result, the model estimates what the spot price of tomorrow is, if no demand flexible mechanisms are activated. The model thus totally ignores the possible demand flexibility. This reflects the current market conditions, where the physical changes in demand are mostly reflected in the "at any cost" bids. It is however important to notice that the intention here is not to predict spot price exactly, but rather to indicate where there is a risk for low demand flexibility and high prices.

The realized price of 19 July 2011 is mostly within the model price range. The spot price at the upper range stays below 100 €/MWh, indicating that a deviation of over 2 % from the consumption forecast, or some other unexpected change, would be required to get to higher price levels.

One of the largest daily upward movements in peak time spot prices during the winter 2010–2011 was seen from 29 November 2010 to 30 November 2010. Figure 5.9 demonstrates the data from those dates.

[41] Demand on the spot market is not the same as the consumption on the whole market area. The forecast is therefore used to adjust spot bids directly. Trading to other regions and other factors are ignored here.

[42] The margin here reflects the possible error between the change in consumption forecast provided by the TSOs and the change in the bids made by the market participants.

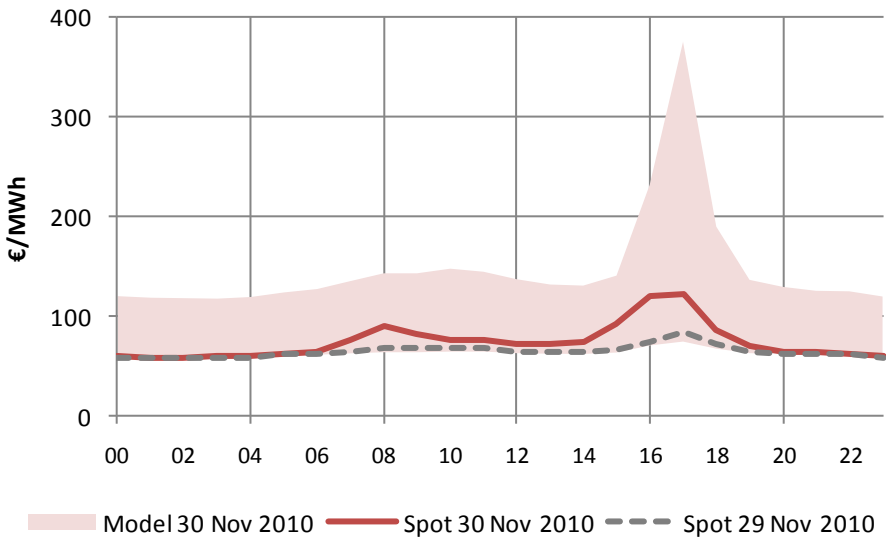

Figure 5.9. *The realized spot price for 29 and 30 July 2011 and a model estimate for 30 July 2011.*

The prices on 29 November 2011 were quite stable and below 100 €/MWh throughout the day. However, on the following day, there were two relatively small price spikes. During the higher one in the late afternoon, system price was over 120 €/MWh for two hours. The model indicates that the prices can reach almost 400 €/MWh in the late afternoon, if no demand flexible mechanisms are taken in use. This information could be used to inform all market participants about the need for demand flexibility measures.[43]

Figure 5.10 illustrates further the time points that are most vulnerable for price peaks. For each hour, the price elasticity of demand is calculated around the best estimate for the spot price[44]. Expected price elasticity is lower during the morning and later afternoon hours, which turn out to have the highest spot prices.

[43] Svenska Kraftnät has an indicator (green, yellow or red) on their webb site, which indicates the capacity situation in the system. In the peak price situations of 2009/2010 this indicator did not indicate a problem for the system, as it was considered that the availability of effect reserves eliminated the potential problems. This could have been faultily interpreted by market participants. Another type of market/price indicator could possibly have promoted demand response. If signals are given to the market they should be transparent as to their purpose. As an example of the use of indicators also see Texas: http://www.puc.state.tx.us/agency/conserve/KeyCold.aspx

[44] The spot price estimate is calculated as previously for the model price range, but now taking the mid-point estimate and adjusting for demand flexibility in the demand curve of the previous day.

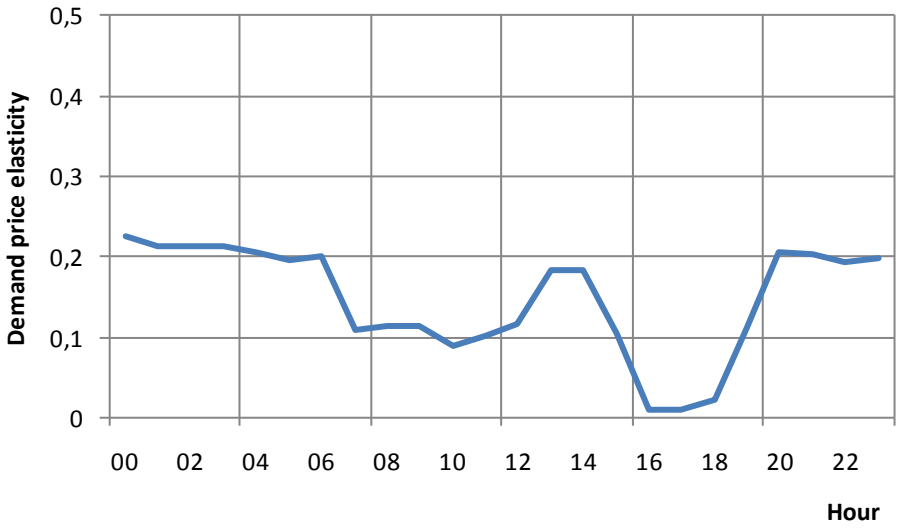

Figure 5.10. *Estimated price elasticity of demand for 30 November 2011.*

Note that the model assumption here is that the consumption forecast does not take demand flexibility in to account. One interesting assignment for the TSOs providing consumption forecasts, and indeed for all consumption forecasting, is how to separate consumption changes due to the physical conditions from the consumption changes due to demand flexibility.

5.2.6 Role of regulation in market follow-up

Studies on the Nordic electricity market have indicated that the market is imperfectly competitive in the higher price region[45]. According to the public interest theory of regulation, regulators should take measures to ensure that abuse of market power does not take place. As the market is in continuous change, follow-up of the market would also need to be continuous.

A follow-up model developed on the basis of the above notes could offer a potent tool for the regulator to monitor market behaviour, especially during high price periods. In a competitive market setting, the supply bids of producers should converge to the level of production cost plus a company specific margin requirement. The production costs can vary to some extent from hour to hour or day to day, for example because of planned availability in condensing plants and weather conditions in hydro and wind power plants, but the changes should be relatively easy to separate from the changes in market behaviour.

5.3 Influence on market positions

Nordic spot market model assumes that consumers are price sensitive. Bids made by consumers should in some way reflect the willingness to pay. Increasing demand flexibility of consumers will influence how the market and market dynamics work.

[45] See e.g. Gaia, Nordic electricity peak prices during the winter 2009–2010, 2010.

Exercise of demand flexibility gives the consumers more influence on the price formation. Today mostly producers and large consumers are actively involved in the market. If consumers are increasingly active and price sensitive, it will transfer some of the power of the producers to the consumers.

The position of independent retailers will probably be better assuming that active load management will make it possible to manage risks in a better fashion than previously. The distribution of risks between retailer and consumer will change, but assuming that active demand management is possible for consumers, the consumer position will not be affected negatively. Consumers will in general benefit from these arrangements if they can be implemented in a cost efficient way.

Increased demand flexibility and the adoption of new solutions will offer new opportunities for traders, portfolio managers and aggregators for providing new services and for developing new business models.

Increased demand flexibility may also be a tool for improving the handling of area risks. It may be beneficial as Sweden is split into different price areas. This will ultimately benefit consumers.

6 Policy measures to capture potential

6.1 Legislation, regulation, and market rules

Guarantee that short-term industrial potential is captured

Some industrial consumers already offer part of their demand to the national peak power reserves as disconnectable capacity. The same disconnectable capacity could benefit also the demand flexibility in the spot market. Regulators and legislators should take care that the peak power capacity can also be bid to the spot market to promote demand flexibility[46]. Together with the TSOs they should also ensure the practical inclusion of current industrial demand flexibility that is willing to participate in the spot market.

Ensure that companies can prepare for medium-term developments

Without additional measures, distribution companies may lack real incentives for promoting demand flexibility. In fact, current distribution regulation can restrict profitable possibilities for distribution companies to offer demand flexibility services.

Regulators should define roles and interfaces for the co-operation of a distribution company and a retail company or other service providers. In Sweden, the definition should include the role of the balance responsible party. If needed, legislators should accommodate the necessary changes in legislation. Action is also motivated by the upcoming EU directive that can introduce requirements

[46] For example, the rules have been already changed in Sweden so that more demand flexibility can participate the spot market already in winter 2011–2012.

to clarify the roles[47]. In addition, it should be considered, how the distribution company would best be regulated to provide possibilities for load management. One possibility is that distribution companies should offer a possibility for retailers to manage customer's consumption. A prerequisite for this would be that the retailer has a contract including load management with the customer. However, it should also be taken into account that the load management system must take into account distributor's technical requirements that ensure supply security.

Nord REG will soon be publishing a report on the rights and obligations of distribution companies and suppliers in the customer interface.

Change to hourly measurements and billing in the medium-term

Hourly measurement instalments for most electricity users are underway or planned in all Nordic countries. A faster schedule would benefit demand flexibility, as hourly measurement creates the base for other demand flexibility incentives for the households and other small end users. Legislators should consider speeding up the transition from old meters to smart meters. However, metering investments include other considerations, such as the cost of meters and upcoming changes in technology and standards of the meters. Priority should be put on solutions for electricity heated households especially.

Similarly to the hourly measurements, hourly balancing and settlement is also required for the other household demand flexibility measures to become feasible. To promote demand flexibility, regulators and if needed legislators, should ensure that hourly measurements are complemented with hourly billing.

Regulators and relevant authorities should also ensure that measurement data is accessible to balance responsible parties, the consumer and third parties designated by the consumer to facilitate demand management as close to the consumption period as possible. The quality of data delivered, schedule and format of delivery should be defined. It could also be evaluated if there should be some consequences set for not delivering the data as agreed. These conditions are also likely to be required by the EU directives later on[48].

Investigate the feasibility of current market structures to long-term challenges

Current market structures are based in the development done in the early 1990's. The market has since been in continuous development. Although the market rules have been adjusted several times to accommodate the changes in the market, now is perhaps a good point in time to consider the suitability of the current market structures to the future market changes.

Planned increase in wind and nuclear production will reduce the flexibility, at least in relative terms, on the supply side. This needs to be compensated with additional flexibility. Also, distributed generation and two-way metering create pressure to the market system that has been based on the idea a relatively small number of generators.

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[47] EU Commission, Proposal for a Directive on energy efficiency, 22 Jun 2011.

[48] EU Commission, Proposal for a Directive on energy efficiency, 22 Jun 2011.

6.2 Financial measures

Aid industry to capture short-term demand flexibility

At the moment, many Nordic public bodies give direct investment subsidies to renewable energy and energy efficiency. In addition, R&D&I activity is supported. Legislators should consider similar subsidies to promote demand flexibility for industrial and other large consumers.

Although demand flexibility investments are often already economically feasible, many companies have very strict investment guidelines. Public support can to some extent be motivated by the improved functioning of the market and by the benefit to all consumers. Subsidies are also effective as a tool to increase awareness of demand flexibility.

Support rapid voluntary transition to hourly metering and hourly billing

Hourly metering and hourly billing are becoming mandatory and common in all Nordic countries within the coming 4–5 years. There is a possibility for earlier voluntary adaptation, if monetary incentives can be created for the distribution companies. Such changes need to be taken into account in the distribution regulation models[49].

In addition, regulators should consider overseeing how the cost allocation is handled if a distributor voluntarily adopts smart metering solutions which exceed the minimum requirement. Now there may not be incentives to invest in better than minimum standard solutions.

6.3 Standards

Ensure that the short-term installation of smart meters fulfil future needs

Energy regulators, or if needed other relevant authorities, should take care of setting a high enough standard for remote meters if the voluntary installations made by the companies seem to be inadequate. These standards should be set on a long-term basis, however taking into account the possible evolvement of technology and requirements over time. At the moment, the data provided by meters should be at a minimum hour based and it should be delivered to specified parties as close to the time of consumption as feasible. For example, the data could be delivered at a minimum one or two days after the time of consumption.

Regulators or relevant authorities should also consider setting the technological requirements of remote meters that enable load management. The consideration should take in to account the voluntary developments by the industry and also the other possibilities for load management.

Ensure that households and appliances become smarter on the long-term

Besides electric heating, a large portion of household electricity use comprises of refrigerators, freezers, and other large appliances. The use of heat pumps is becoming more widespread. Over a

[49] Third regulation period 2012-2015 for Finland includes incentives for adopting hourly settlement. This could be a good recommendation for other regulators as well.

longer period, electricity vehicles will in the future set demands on the distribution network and can cause consumption peaks which can be substantial if these are charged simultaneously.

In addition to the electric appliances and vehicles, electricity systems within buildings need to be able to transmit load management instructions from service providers to smart household appliances. One possibility could be to include requirements for load management to building regulation. This would facilitate long-term development of smart energy solutions.

Several initiatives are on the way to develop more intelligent energy systems, on national level, Nordic and on EU-level. The role of regulators is to ensure that feasible requirements for demand flexibility are included in these developments.

6.4 Complementary actions

Increase demand flexibility awareness

Active public discussion ensued after the electricity price spikes of the winter 2009–2010. Additional public awareness is conditional to more price spikes occurring.

Nordic energy regulators have actively studied the effects of the price spikes and are following up on the possible actions to improve the functioning of the market. This work should be continued to educate and inform stakeholders about the need for demand flexibility measures and the opportunities and positive aspects of implementing measures to activate demand flexibility.

Reduce information asymmetry and increase transparency

Exercise of demand flexibility can imply an interruption or reduction in the production process. Such activities can benefit from more time to plan the actions. As the market conditions are in continuous dynamic change, there is a need for continuous tools to enable planning of early actions.

Nord Pool Spot has increased its transparency and currently publishes a lot of raw data about the market conditions. The data benefits especially those market participants that have the resources to analyze it. For smaller market participants, cost of such resources can be prohibitive.

There is an ongoing debate between the larger market participants and the smaller on if it is possible for the larger market participants to use market power for their benefit. According to the earlier studies, such possibilities are not ruled out when there are price spikers. To reduce such concerns and to proactively prevent such behaviour, regulators should increase the monitoring of market conditions and price formation to continuous basis. As there is a lot of market data to be analyzed, a simpler indicator could be beneficial for the continuous follow-up of market conditions.

Regulators should also study the possibility of publishing some type of day-ahead indicator to highlight the need for additional demand flexibility. Such indicator could activate preparation of demand flexibility measures of industry and retailers.

Develop demand flexibility model contracts for retailers

Arrangements for demand flexibility can be contractually difficult to implement. There are several additional technical and legal considerations that can become prohibitive especially for smaller retailers. Providing some ready templates would eliminate the investment into development work

otherwise required by retailers, possibly lowering the threshold for adopting new types of agreements.

Typically industry organisations are in a position to issue instructions for their members on issues such as how demand flexibility could contractually be implemented. If needed, regulators can consider promoting demand flexibility by initiating the developing of model contracts with the industry. Creating templates could in addition to providing a model for the retailers also promote the acceptance of these contracts by households.

7 Conclusions

Demand for demand flexibility

The peak price situations during the winter 2009–2010 highlighted the importance of activating demand flexibility. Analyses have shown that only a modest reduction in demand could have resulted in significant drop in market prices. The monetary value of savings for consumers could have reached tens of millions of euro over one single hour.

High prices result when more expensive supply is needed to cover the demand. If demand is not adjusted in high price situations, then high prices are needed to provide incentives for supply side investments. Demand flexibility reduces the need for generation capacity investments and reduces the prices of electricity.

Potential for demand flexibility

The practical possibilities for demand flexibility have been estimated to be about 12 000 MW in total for the Nordic countries on the medium term. The potential and ways in which it can be activated is very different for large scale consumers, and for households and other small consumers.

A large potential, which could most easily be realised on a short term, exists within the large scale industry. A very rough estimate on a Nordic level is over 5 000 MW. How much of this potential is already in use and in what price range is not known.

Viewed over a longer term there is great potential in the activation of demand flexibility within the household sector, especially in electricity heated households. A very tentative estimate of the potential for the households is 4 000 – 7 000 MW.

The actions should be focused on promoting demand flexibility in especially large scale industry for achieving short term impacts and for electricity heated housing for impacts on the longer term.

The solutions for other sectors such as retailers or real estate sector are more heterogenous than for households and volumes smaller than those which could be achieved from large scale industry on the short term.

Actions by large scale industry

Demand flexibility in large scale industry requires that the companies themselves have high enough incentives for action, have the knowledge and resources necessary to implement the required

internal process changes, and have the contractual possibilities to benefit from the use of demand flexibility.

Some large industrial electricity consumers already use demand flexibility actively, and the peak price situations of the winter 2009–2010 increased the awareness about the economic possibilities for demand flexibility for others. Some large companies have recently renegotiated their supplier contracts to include the possibility for demand flexibility. Some have also developed processes to enable demand flexibility in cooperation with their suppliers. The reduced price spikes seem to indicate that demand flexibility has increased at least to some extent.

Actions for households and small companies

At the moment most households and some smaller companies in the Nordic area do not have the possibility to benefit from the use of demand flexibility. The two key requirements are that consumption is measured on an hourly basis and that billing is based on the hourly measurements. These requirements are going to be partly met with the ongoing instalment of smart meters in all Nordic countries. However, the deployment of smart meters and the development of related IT systems necessary to handle vastly increasing data will take some years.

To be able to motivate households and smaller companies to take a part of the price risk there needs to be some realistic, cost efficient and convenient way for the consumer to influence his own consumption at high price situations. Today load management capabilities, where load management would be done as a function of spot price, do not exist for the normal household consumer or small business.

Policy measures to support demand flexibility

Legislation and regulation are needed to support the development of demand flexibility in the market. A lot of the relevant legislation and regulation is already prepared by the Nordic countries, and the required development will likely be affected also by the EU to an increasing degree.

On the short-term, regulators should continue to support the market with additional information that can promote demand flexibility awareness. More concretely, regulators should take measures to further increase transparency and reduce information asymmetry in the market. Although data transparency has increased during the recent years, market participants have varying capacity to extract useful information from the data.

Also on the short-term, regulators need to secure the access of current industrial demand flexibility to the market. Further demand flexibility could be activated by investment subsidies to demand flexibility measures.

Regulators should also make sure that legal conditions exist for retailers and distributors to offer demand flexibility to smaller electricity end users. Regulation of the short-term instalments of smart meters needs to take in to account future needs also for demand flexibility. Financial incentives for a more speedy transition to hourly metering and hourly billing could also be given e.g. through distribution regulation. In addition, regulators could consider providing demand flexibility model contracts for the companies to speed the voluntary introduction of demand flexibility.

On the medium term, EU directives and already implemented national legislation will force changes in the way distribution and retail companies can offer demand flexibility to the end users. The most

important change is to hourly measurements and hourly billing that is the basis for the activation of household demand flexibility.

Long-term developments include further possibilities for demand flexibility in households and other more heterogeneous sectors. Regulators and legislators should consider to which extent the households, buildings, and electric vehicles are in need for regulation to promote additional long-term demand flexibility.

Influence of demand flexibility on the market

Demand flexibility of consumers is today an underutilized resource. The spot market model implicitly assumes that consumers' bids are price sensitive. Bids made by consumers should in some way reflect the willingness to pay. Increasing demand flexibility of consumers will influence how the market works and market dynamics.

Exercise of demand flexibility gives the consumers more influence on the price formation. Today mostly producers and large consumers are actively involved in the market. If consumers are increasingly active and price sensitive, it will transfer some of the power of the producers to the consumers.

The position of independent retailers will probably be better assuming that active load management will make it possible to manage risks in a better fashion than previously. The distribution of risks between retailer and consumer will change, but assuming that active demand management is possible for consumers, the consumer position will not be affected negatively. Consumers will in general benefit from these arrangements if they can be implemented in a cost efficient way.

Appendix 1: The new energy efficiency directive draft includes regulatory requirements about demand flexibility

The new EU regulations for Energy efficiency include requirements[50] for the distributors which relate to demand response and the supporting of demand response solutions[51]

1. Network tariffs shall accurately reflect electricity and cost savings in networks achieved from demand side and demand response measures and distributed generation, including savings from lowering the cost of delivery or of network investment and a more optimal operation of the network.

2. Network regulation and tariffs shall allow network operators to offer system services and system tariffs for demand response measures, demand management and distributed generation on organised electricity markets, in particular:

a) the shifting of the load from peak to off-peak times by final customers taking into account the availability of renewable energy, energy from cogeneration and distributed generation;

b) energy savings from demand response of distributed consumers by energy aggregators ;

c) demand reduction from energy efficiency measures undertaken by energy service providers, including energy service companies ;

For the purposes of this provision the term "organized electricity markets" shall include over-the-counter markets and electricity exchanges for trading energy, capacity, balancing and ancillary services in all timeframes, including forward, day-ahead and intra-day markets.

3. Network tariffs shall be available that support dynamic pricing for demand response measures by final customers, including:

a) time-of-use tariffs;

b) critical peak pricing;

c) real time pricing; and

d) peak time rebates.

[50] Only those with relevance to this report are summarized here.

[51] Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on energy efficiency and repealing Directives 2004/8/EC and 2006/32/EC ,{SEC(2011) 779 final}, {SEC(2011) 780 final}