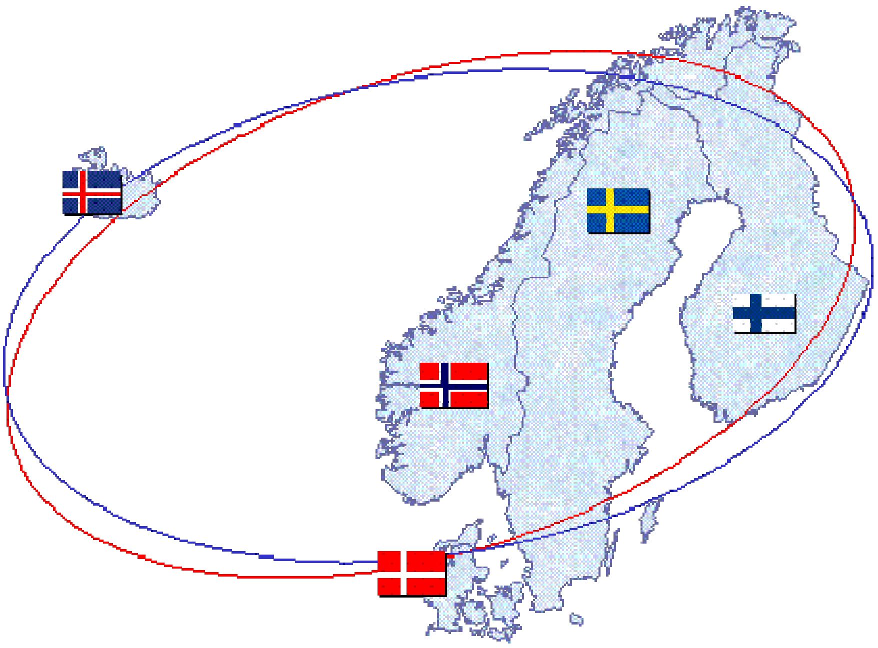
Enhancement of Demand Response



FINAL STATUS REPORT
by
Nordel Demand Response Group
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Contents

1. INTRODUCTION

Studies within Nordel have shown that the price elasticity of demand should be increased to improve market functioning. Higher elasticity in the day-ahead market would reduce the risk that day-ahead market fails to clear, as well as the financial risks of market participants and the possibilities to abuse market power. An increased demand elasticity would reduce the possibilities of market players to get through the price increases. Increased demand side competition in the day-ahead market would reduce price peaks and lead to enhanced market credibility.

The TSOs may benefit from demand-side participation in operating reserves in two ways: they can maintain the security of supply in tight situations by getting access to additional resources and through a more intense competition by the reserve providers the TSOs can reduce reserve procurement costs.

The TSOs have actively contributed to the enhancement of demand response (DR) by acquiring demand resources to be used as operational reserves, by supporting R&D projects and by playing a role of a catalyst in the development.

The Nordic TSOs made their programmes to enhance demand side flexibility on a national basis. To follow up the process and to promote important demand response initiatives the Nordic TSOs created an ad hoc Nordel Demand Response group under the auspices of Nordel Market Committee for enhancing demand response. The members of the group are Søren Dupont Kristensen from Energinet.dk, Risto Lindroos and Jarno Sederlund from Fingrid, Inge Vognild from Statnett and Marcus Melkersson from Svenska Kraftnät.

The mandate of the group asks the Nordel Demand Response group to follow the development regarding DR, to take the necessary steps to initiate projects and to coordinate the TSO inputs in national and international projects.

In the initial phase, the work of the group has focussed on analysing the various products available for demand participation in the electricity market and how appropriate these products are from a demand point of view. The report concentrates on analysing the spot and regulating power market, the purchase of operational reserves and the industrial customers. The small and medium sized customers are not largely discussed, since the end-user market is developed by the Nordic authorities. There is a separate monitoring group under the auspices of Nordel Planning Committee analysing actually realised demand response.

This status report summarises the findings of this work, gives an overview of DR in the market, tries to depict some of the barriers associated with the demand response and gives some recommendations to enhance DR. Many of the DR issues are closely linked with the market issues, but this report does not address them, if they don't have relevance from the DR point of view.

2. DEFINITION OF DEMAND RESPONSE AND DEMAND RESOURCES

Nordel has chosen to define demand response (DR) as a voluntary temporary adjustment of electricity demand as a response to a price signal or a reliability-based action.

- DR may be short-term (capacity) or medium term (energy).
- The price signal may come from the power market, intraday market, regulating power market after a TSO call, balancing markets, ancillary services markets or from tariffs.
- Reliability-based actions may come from TSOs or distribution companies and can be activated manually or automatically.
- Distributed generation in consumption areas can be considered as DR.

TSOs may acquire demand resources to be used as ancillary services in the power system operation in case of disturbances or in order to maintain the power system balance.

3. SHORT SUMMARY OF DR PROGRAMMES OF TSOS

3.1 Denmark

Energinet.dk grants annually 130 million DKr to R&D to pilot scale and demonstration activities. Within the area of demand response Energinet.dk supports a single ongoing project. Furthermore, three projects are approved to start within six months. The total budget for all four projects is 18.1 million DKr, where 11.0 million DKr come from PSO funding.

The ongoing project is to demonstrate the use of interactive electricity meters responding on price signal. The demonstration project is carried out in office buildings and will also be used to improve the future design of electrical demand response installations.

In another project, which will start in 2006, companies in the horticulture business will map the potential for demand response (incl. ancillary services and regulating reserves). Technical possibilities and economical stimulus necessary for horticulture companies will be analysed. Appropriate consideration of the demands that the plants have will be taken.

The possibilities of using demand response in the mass market - that of small electricity consumers like households and small companies - is the focus of another project to start in 2006. The project will focus on consumers preferences regarding economics, comfort, and self-determination; standardisation of competitive electrical installations; and the possibilities of electricity suppliers to offer attractive products within the evolving area of demand response equipment.

Finally, one of the projects will focus on the use of demand response in selected industrial companies. An overview of technical, economical, and practical possibilities for a selected number of - for Denmark - large electricity consumers to act on price signals will be investigated and described.

Energinet.dk supports furthermore the demand response projects of IEA.

3.2 Finland

The DR potential in Finnish large scale industry was assessed in 2005. The objective was to get an overview of DR potential available in the large-scale forest, chemical and metal industry and to find out the most important factors affecting the potential. These sectors use 33 TWh of electricity or 73 % of total industry use. Fingrid was a co-financer of the project.

A project studying the consumer reactions on market price signals was supported by Fingrid among others. Field tests on market price signals show that automation is necessary to guarantee the small end-users' response. If the end-user demands are to be traded, intermediaries (aggregators) are necessary to facilitate the transactions.

Fingrid have also supported the demand response project of IEA.

The Finnish electrical industry wide discussion forum for Demand Response is promoting DR in the electricity market by topical discussions related to the issue. Fingrid has had an active role in the discussions of the forum.

3.3 Norway

Since Statnett introduced the market for fast active operating reserves (RKOM) in 2000, large industries have bid DR into this market. RKOM (Regulating Capacity Options Market) is an arrangement for procuring both fast operating reserves and regulating reserves. RKOM is a catalyst for securing the availability of sufficient regulating power.

Statnett purchases the option to dispose of regulating resources in both generation and demand. The contracted volume depends on expectations about temperature and load flow patterns for next week. The RKOM contractors receive an option premium and are obliged to bid the contracted volume in the regulating power market. Maximum weekly TSO-purchase from the demand-side has been 1481 MW (week 4/2006).

Statnett has initiated 5 pilots to facilitate participation from medium-sized resources in RKOM. Two of the RKOM-pilot contractors are retail companies, who are now bidding ca 25 MW in the regulating power market. They have been given predictable revenues that cover the costs of marketing interruptible contracts to their customers, demand control technology and administrative routines. When necessary initial investments have been undertaken, weekly revenues from RKOM may cover the operating costs of being active participants in RKOM/the regulating power market.

In co-operation with several participants in the Norwegian electricity industry, Statnett is engaged in a R&D project “Market-based demand response”. The project goal is to increase price elasticity of demand. The project details are available at http://www.energy.sintef.no/prosjekt/mabfot/. Statnett has also supported the demand response project of IEA.

3.4 Sweden

In November year 2005 Svenska Kraftnät together with Swedenergy and STEM initiated the evaluation of how the market participants have used their respite, given by the temporary law for peak power reserves, to pave the way for a market-based solution. The start-up seminar showed that the main problem was to still to establish a common viewpoint of the market responsibilities.

The evaluation process also resulted in a recently initiated study to map the possibilities of increased DR due to new metering technology.

R&D projects for DR has been initiated to cover participant analysis and business models as well as the mapping of the DR potential in the industrial segment. Recently completed studies of the household sector show that a significant potential can be activated even with a simple SMS-message.

Since Sweden started purchasing peak power reserves due to the temporary law, the amount of DR offered in the tender procedure has increased annually and for 2005/2006 comprised of slightly more than 870 MW of demand resources, which is about 23% of the total amount of reserves offered.

4. DR POTENTIAL OF INDUSTRIAL CUSTOMERS

4.1 Denmark

In Denmark there was last year made an investigation into the DR potential of Danish industry based on a survey among 25 of the most electricity consuming companies. The interviewed companies are covering 11 % of the total electricity demand of Danish industry and public sector. The DR potential was identified and hereafter extrapolated to the entire industry and public sector based on characteristics of subsegments and was found to be 380 MWh/h, which is equal to about 7 % of the maximum demand in Denmark. The Danish summary report is available on http://www.energinet.dk/composite-87.htm

4.2 Finland

DR potential assessment in Finnish large scale industry showed that the available technical DR potential in the forest, chemical and metal industry is about 1280 MW, which is equal to about 9 % of the maximum demand in Finland. The volume to be activated is dependent on the DR duration and the anticipated income from the activation. The potential has its maximum for a utilisation time of 1-3 hours. A price level of 300€/MWh would usually be sufficient to activate the most of the potential during 3 hours according to the survey. The potential and the related barriers have been described in the study of Hannu Pihala/VTT Processes: Demand Response Potential Assessment in Finnish Large-Scale Industry, 2005.

4.3 Norway

As mentioned in Section 3.3, Statnett has purchased almost 1500 MW from demand side RKOM contractors, mainly from large industrials. The offered volume is even higher. In addition, up to 1000 MW of electric boilers could be made available. This potential is depending on temperature and the price ratio between oil (or other fuels) and average daily or weekly electricity prices. A technical potential of at least 500 MW could also be made available from the back-up generation. Other resources, whose potential is not yet quantified with accuracy, are also available.

Generally speaking, the potential is large. To release more of this potential, revenues from the market and TSO purchase of reserves must be large and predictable enough to cover initial investments and operating costs.

4.4 Sweden

The potential for DR seems to vary from study to study. The better the industry is informed about DR, the higher the potential seems to have become.

Svenska Kraftnät organises tenders to cover the requirements for temporary peak power reserve, where demand resources also participate. The observed flexible demand in the tender procedures has increased yearly and is now even greater than what the most optimistic initial studies showed.

Earlier studies have shown that the industry need an activation time of 3 to 24 hours. The reality, from the tenders due to the temporary peak power law, has shown that 15 minutes of activation time is sufficient. The industries may have been able to adapt or the benefits of being able to plan maintenance was initially overestimated. Neither the price of activation nor the fixed price demanded has increased significantly with shorter activation time in the tenders for temporary peak power reserve.

The studies of DR have shown that most industries would be able to do reductions between 30 minutes and 3 hours. This interval has not improved as much as the other limitations, but eventually there should be resources available for longer durations than 3 hours, if the market only chooses to pay enough.

4.5 Barriers for demand participation

The studies have shown that there are some barriers related to production processes and some barriers related to human or organisational factors.

The production process related barriers for DR:

- To stop and to restart a process equipment (DR action) can increase production costs and lead to faults in equipment.
- Equipment restarting after DR action is not always certain, in the case of failure a whole production line can come to a standstill.
- During winter time there is a risk of freezing because of cold weather and decrease of heat produced from the production equipment.
- Production processes are integrated (e.g. DR action in a production process can also stop heat production or fuel production to a power plant).
- There is no or too little intermediate storage in production lines in order to carry out DR actions.
- Unbundling of processes and electricity management

Barriers related to human or organisational factors:

- Difficult to motivate persons responsible for production to participate on DR (DR actions can result to equipment faults).
- Things like DR actions that happen seldom are not very comfortable.
- If DR action means reduction in production, usually fixed cost remain (labour etc.); persons in production should be able to do something else like maintenance work.
- Decisions concerning production timing and the amount of production can be done far away from the production site e.g. abroad.
- Disappearing of incentives related to the old wholesale tariff structure

5. DR IN THE ELECTRICITY MARKET

5.1 Financial market

Financial trading products create a link between economic risk management and physical resources. Existing standard financial instruments at Nord Pool ASA are based on a flat profile reflecting equal capacity exposure during every hour of the day in the delivery period. The market players who need more power during parts of the day will face the risk that they will have to buy the extra energy at a price that is much higher than the price hedged by the flat profile. A financial product that facilitates the hedging against such situations may be constructed e.g. in a way earlier proposed by Nordel in the report Peak Production Capability and Peak Load in the Nordic Electricity Market (2004) (www.nordel.org). Nordel proposed a product that would give the buyer the right to receive the difference between the average price during peak hours to be defined and the average area day-ahead price. The idea of the product proposed was based on the incentives created for the generators to hold a larger quantity of idle capacity or for the demand owners to keep the readiness for DR as they will be able to secure a more predictable revenue.

However, there are currently no standard financial products at Nord Pool ASA tailored to hedge the risk of price peaks. Even though this may seem as a problem to some market participants, Nord Pool ASA has not received a clear enough signal that the market participants would like Nord Pool ASA to offer this kind of a product.

This may be due to several reasons. The primary cause is probably the lack of observed price peaks. Further, the Nord Pool ASA product group is far from homogeneous, as it is tailored to represent different interests of the market participants. As regards the potential peak products some participants advocate a product tailored primarily to solve the underlying capacity problem, some have more need of a pure financial product to take care of the financial risk, whereas others don't perceive the need at all.

There are several possibilities for peak products each with their own strengths and weaknesses. The main concern with a peak power product seems to be that it will not attract enough interest and will not be traded enough to sustain a least required amount of liquidity. The liquidity would be influenced by the bilateral and intracompany DR, described in more detail in the next section, which would compete with the potential financial hedging products. When the risk to hedge against is the excess energy to be purchased during the high price hours, the alternative for market players is to agree on a sufficient amount of DR instead. The benefit of financial product, if liquid enough, over DR would, however, be that a financial product would reveal the market price of peak demand capacity or DR.

Too low liquidity will result in a lack of credible and transparent pricing. This means that several trade-offs have to be done. The most appropriate products for the hedging of price spikes may not be the most appropriate for solving the underlying capacity problems, or may not fit the trading purposes of enough market participants.

Nord Pool ASA knows from experience that it's difficult to get enough liquidity in options trading. On the other hand, given enough liquidity, options can be tailored to work great in the hedging of price spikes. With low liquidity, a compromise has to be done between how well to solve the capacity problem and how well to hedge the financial risk.

For the above reasons, it's difficult to assess the potential of both financial as well as physical capacity products. This could be worth a closer examination.

5.2 Day ahead market (Elspot market)

In the day-ahead market, Nord Pool Spot offers the flexible hourly bid and the block bid appropriate for DR usage in addition to normal hourly bids. The flexible hourly bid allows for price sensitivity per one hour, whereas the block bid is activated, if the price level exceeds a certain level for four hours or more. For many demand side participants these types of bids should be enough, though some participants have recently highlighted the need for an increased flexibility.

Based on the Finnish and Swedish surveys referred in Section 4, the DR potential in big electricity consuming industries has its maximum for a utilisation time of 1-3 hours. In that respect, a block bid of minimum 4 hours is too long. On the other hand, the revenues from a one hour flexible bid are perhaps not sufficient.

According to Nord Pool Spot, it's more complicated to allow more than one hour of flexibility for flexible bids. It would be much easier to decrease the required timeframe for the block bids from the present four to three or even two hours to reach the amount of needed flexibility. It might be also reasonable to focus on block bids rather than on the flexible bid, since in most cases the participants know with great accuracy when the peak prices will occur. The available services and products should be more customer friendly to help end-users bid for DR.

It is difficult to measure the amount of flexible bids by observing the bids on Nord Pool Spot day-ahead market. Every market participant is entitled to choose whether he submits the flexibility of his portfolio to the day-ahead market. The participant may believe he is better off by adjusting his own production or solving the trade bilaterally in situations when DR is due to be activated. Either the amount of DR is low or many market participants with an integrated portfolio seem to believe they are worse off, if they submit flexible bids to day-ahead market.

The above situation will result in an increased day-ahead price. An integrated market participant will profit from this situation, since he will acquire a higher spot price for his complete generations portfolio and only pay a small amount too much to the DR participants who is "selling back" the electricity.

Even when an end-user buys from an electricity provider/trader without own production, it may be problematic to make the flexibility transparent. This is partly caused by the nature of the contracts as well as by the difficulties to follow up the actions of the end-user.

By being a direct participant at Nord Pool Spot, the demand side would be able to increase competition by selling back electricity at high prices using an already existing appropriate Nord Pool Spot contract. This can be done, even if the end-user buys its electricity from another market participant who takes care of the balance responsibility. The balance provider would suffer no loss due to imbalances, since all the end-user needs to do is to report that it has sold the electricity further to another party. The balance provider then only needs to update it's plans and send them to the TSO.

Most end-users do not choose to become a direct participant in the day-ahead market. The reasons for that are summarised below:

- If the end-user is interested in relinquishing electricity at high day-ahead market prices, the balance provider may very well offer this opportunity himself. This will lead to lower incentives for the end-user to act in the day-ahead market at the same time. Non-advantageous contracts for end-users trying to exploit the opportunity to simultaneously act on Nord Pool Spot may be another deterrent. On the other hand, having an own balance responsibility agreement can be perceived as expensive due to the reporting required and the costs associated with it. It is also far from the end-user's core business.

- There may also be expectations within electricity intensive industry to be able to sign special agreements for longer time periods at a price lower than the market price.
- Nord Pool Spot demands financial securities. A balance provider may have economies of scale or other advantages that may allow them to offer more slack conditions.
- The situation may depend on the lack of information. Both studies and experience have shown that there is a lack of knowledge and lack of interests for DR within the industry.
- Another barrier for DR is the lack of a common view of the responsibilities of the market participants. Many participants don't perceive any problem as they see RKOM and the temporary peak power reserve as a definite solution to the peak power problem.

Although the situation described above is relevant in Sweden and Finland, it is not relevant for the large energy intensive end-users in Norway. Norwegian large industrials are direct participants at Nord Pool Spot. As demand-side RKOM contractors they are allowed to opt out to the day-ahead market. As a consequence, large industry consumption is now being bid in the day-ahead market. A shift from core business protection to utilisation of business opportunities provided by the RKOM approach has been observed within the industry. Price elastic bidding by demand side participants requires necessary preparedness measures enabling the end-user to undertake controlled load reduction procedures when price spikes occur. Provided that frequent price spikes occur, which is presently not the situation in the Nordic market, market players may have corporate incentives to bid consumption price elastic in the day-ahead market. In the present situation with unfrequent price spikes, RKOM has financed the necessary measures for preparedness in Norway.

5.3 Intraday market (Elbas market)

The Elbas market is an adjustment market for balance providers with no special DR tailored products. The main barrier for participation in this market may be that in order to be able to utilise this market really well, there is a need to put human resources in for continuous trading. The demand side usually doesn't have these resources, since the really high price that may interest this group is expected to occur very seldom. If they had the resources, it is not sure, whether the type of bids offered in this market would fit the DR.

6. DEMAND RESOURCES AS OPERATING RESERVES

6.1 General

The demand resources may participate in all kind of operating reserves, like reserves for regulating power market, frequency controlled disturbance reserves and fast active disturbance reserves. This section describes the requirements put on demand resources when they participate in the various reserves, the status of demand participation and considerations about the incentives and barriers for their participation. The reserve definitions and requirements are taken from the Nordel System Operation Agreement.

The requirements for generation and demand reserves are usually the same, since the rules are not planned for the demand separately.

6.2 Frequency controlled disturbance reserves

6.2.1 Requirements for frequency controlled disturbance reserves

The requirements for frequency controlled disturbance reserve are defined in the system operation agreement. The table below summarises the relevant requirements for DR participation.

Description	**Denmark-west**	**DK-east**	**Finland**	**Norway**	**Sweden**
Activation time (seconds)	100% in 30 sec	50% in 5 sec. 100% in 30 sec	50% in 5 sec. 100% in 30 sec.	50% in 5 sec. 100% in 30 sec.	50% in 5 sec. 100% in 30 sec.
Minimum volume (MW)	1 MW	Not defined	15	Not defined	No minimum limit See below
Aggregation allowed	Only by balance providers	Not defined	Not defined	Not defined	Yes
Min. duration (hours)	No formal requirements	Not defined	3	Not defined	1 or more hours See below
Max resting time (hours)	No formal requirements (no limitations allowed)	Not defined	No formal requirements	Not defined	Not defined
Contract period	6 months	5 months	2005 - 2015	Mandatory arrangement for generators. Payment negotiated yearly Also a twice-a-week market for extra frequency response in the summer season	Daily or weekly
Contracted testing	Not defined	Yes	Yes	Will probably be introduced	Yes
Verification	Scada	Scada	Scada	Will probably be introduced	Verification of the regulator setup

In Sweden, frequency controlled reserves are defined as a mix of frequency controlled disturbance reserves and the frequency controlled normal operation reserves used between 49,9 and 50,1 Hz. Svenska Kraftnät buys frequency controlled reserves once a week (every Thursday at 16.00 for the next week), as well as daily at 21.00 (for the next day). The weekly procurement is divided into 3 periods of an arbitrary number of hours each day (i.e. 1-22 hours). The periods for daily procurements are on an hourly basis. The seller of the daily contracts has the option to change his mind and cancel the agreement up until 2 hours prior to delivery. There is no such option in the weekly procurement.

6.2.2 Status of demand participation as frequency controlled disturbance reserve

In Denmark, there are presently no DR arrangements for frequency controlled disturbance reserves. In Sweden, as well, there are no contracts from demand side.

In Finland, during the years 2005 ... 2008 frequency controlled disturbance reserve includes 120 MW of demand side resources. Fingrid has also contracted a possibility to procure more demand resources if needed. From the year 2009 the total active amount of demand participation will be raised up to 200 MW.

In Norway, there is a mandatory arrangement for frequency response/spinning reserves, in which generators participate. Payments are negotiated each year. In addition, Statnett runs a twice-a-week market for extra frequency response in the summer season. Market rules are not designed to include demand-side participation, but a Norwegian R&D project has started looking at demand-side participation as a resource for frequency controlled disturbance reserves.

6.2.3 Ideas to improve demand participation

The more activations the resources allow, the better quality the resource has from the system operation point of view. Since demand side resources have usually more restrictions for their activation than generation, they have a lower quality than generation resources as operating reserves.
Demand side resources can contribute to enhance competition for procurement of frequency controlled reserves. To improve the possibilities of demand side participation it might be better to differentiate the products requested in the market with different qualities. Since frequency controlled reserves are always activated by a frequency change, the products should be differentiated by frequency intervals. Also from the system operation point of view a multistage activation in the Nordic countries would be preferable.

An example of the products, presented here as Q1 - Q5, would enhance demand to participate as operating reserves. The dense division of the frequency area here below is done to maximise the frequency quality and maximise the possibilities for demand resources participation.

Frequency controlled normal operating reserve	Q1: 49,9-50,1 Hz
Frequency controlled disturbance reserves	Q2: 49,8-49,9 Hz
	Q3: 49,7-49,8 Hz
	Q4: 49,6-49,7 Hz
	Q5: 49,5-49,6 Hz

Higher qualities can be taken as substitutes for lower quality resources. If there are cheaper bids from a better quality, those bids can always substitute the lower quality bids.

Having several products the demand side would be able to choose a fitting product for their bids. Since the activation of DR reserves is implemented with help of frequency sensitive relays, a frequency limit close to 50 Hz can cause too frequent DR activation. Therefore, in product category Q1 DR may not be able to compete due to excess difficulties to the core business. Hydro power generators would probably still continue to dominate this group.

In general, products and procurement routines should be designed to promote intraquality competition, meaning that a better quality product should always be preferred to a lower quality given the same or lower price, taking security constraints into consideration. That way liquidity problems will be minimised and, the liquidity problems will not be greater than in a single product market. Frequency quality would be maximised at lower cost to society.

Although the above is theoretically nice, it may not be practical enough. The present requirement of frequency controlled reserves is 1000 MW. If e.g. 1/3 thereof or 333 MW, would be subject for trade with 4 products there would be less than 100 MW in each product category.

A ultimate simplification of the 4 product model is to define a frequency limit, where demand activates immediately, e.g. in the range between 49,5 Hz and 49,9 Hz. If 100% of the demand would be activated at a certain frequency, it would compensate for the fact that generators are used more frequently when frequency drops below the frequency controlled disturbance reserves activation limit 49,9 Hz.

An important issue is the relation between the frequency controlled normal operating reserve, which is anticipated not to be relevant for large industrials, and the frequency controlled disturbance reserves.Unless generators have a possibility to limit their activation below 49,9 Hz, generators will, at least technically, deliver frequency controlled disturbance reserves, as well. This will influence competition.

Mark-up due to location: Except the specified interval, also the point of the grid connection has some importance during the 15 minutes that is needed to restore the operating reserves. If the N-1 criteria is due to a production unit, frequency reserves located close to it are of higher value and can result in acceptance of bids to higher prices than otherwise paid. Allocated market capacity can be increased, since the transmission network can be used more efficiently. E.g. frequency controlled disturbance reserves in the southern part of Sweden and in Zealand as well as in some parts of Norway may be of a higher than the average value.

6.3 Fast active disturbance reserves

6.3.1 Requirements for fast active disturbance reserves

The fast active disturbance reserve shall exist in order to restore the frequency controlled normal operating reserve and frequency controlled disturbance reserve when these reserves have been used or lost, and in order to restore transmissions within applicable limits following disturbances.

The fast active disturbance reserve shall be available within 15 minutes.

The fast active disturbance reserve shall exist and be localised to the extent that the system can be restored to normal state following faults. The table below summarises the relevant requirements for DR participation.

Description	DK-west	DK-east	Finland	Norway	Sweden
Activation time (minutes)	15	15	15	15	15
Minimum volume (MW)	Min. group of 10 MW	Min. group of 10 MW	15	25	No formal requirements
Aggregation allowed	Only by balance providers	Only by balance providers	Not yet discussed	yes	No formal requirements
Min. duration (hours)	No formal requirements (no limitations allowed)	No formal requirements	3	1	No formal requirements
Max resting time (hours)	No limitations allowed	No formal requirements	No formal requirements	8	No formal requirements
Contract period	Monthly, in addition some bilateral contracts of longer duration	On hourly basis (one day ahead) in addition some bilateral contracts of longer duration	2005 – 2015	week	No formal requirements
Contracted testing	Yes	Yes, several times a year	Yes	yes	No formal requirements
Verification	Scada	Scada	Scada	Scada	Scada

6.3.2 Status of demand participation in fast active disturbance reserve

In Denmark, operating reserves are acquired through tenders where DR is encouraged to participate. Energinet.dk has two pilot-projects on back-up generation as operating reserves, each amounting to 25 MW. In addition, 3 MW demand has so far been acquired as operating reserve in Eastern Denmark.

In Finland, during the years 2005 ... 2008 fast active disturbance reserve includes 390 MW of demand side resources. Fingrid has also contracted a possibility to procure more demand resources if needed. From the year 2009, the total amount of active demand participation will be raised up to 460 MW.

In Norway, a substantial amount of DR resources are bid in the regulating power market via RKOM. The RKOM contractors are obliged to bid contracted reserves in the regulating power market. RKOM is a common purchase arrangement for disturbance reserves and load forecast reserves. Statnett may apply any bid in the regulating power market for the both purposes.

Voluntary bidding by the hydro generators onto the regulating power market provides sufficient reserves during the summer season. The amount purchased depends on expectations about temperature and load flow patterns for next week. E.g. in week 4/2006 Statnett purchased 1481 MW from demand side contractors in RKOM. Contractors receive an option premium for being available in the regulating power market. The weekly premium of winter 2005/6 season has varied from 100€/MW to 400 €/MW. The contractors themselves decide their bid price in the regulating power market.

In Sweden, Svenska Kraftnät has contracted 90 MW fast active disturbance reserve of which 48 MW can be activated within 15 minutes and the remaining 42 MW can be activated within 30 minutes.

In fact, all the TSOs give a predictable compensation for having the operating reserves.

6.4 Reserves for regulating power market

6.4.1 Requirements for reserves in the regulating power market

The national TSO regulating power market requirements relevant for DR participation are the following:

Issue	DK-west	DK-east	Finland	Norway	Sweden
Activation time (minutes)	15	15	10	15	10
Minimum volume (MW)	Min. group of 10 MW	Min. group of 10 MW	10	25	10
Aggregation allowed	Only by balance providers	Only by balance providers	Not yet dis-cussed	Yes	Yes, within the same bottleneck area
Min. duration (hours)	No formal requirements (no limitations allowed)	No formal require-ments	No formal requirements	1	1
Max resting time (hours)	No limitations allowed	No formal require-ments	No formal requirements	8	No formal re-quirements
Contract period	Monthly, in addition some bilateral con-tracts of longer duration	On hourly basis (one day ahead) in addition some bilateral contracts of longer duration	On hourly basis (one day ahead)	Week	On hourly basis (one day ahead)
Contracted testing	Yes	Yes, several times a year	Yes	Yes	No
Verification	Scada	Scada	Scada	Scada, other	Scada

6.4.2 Status of demand participation in the regulating power market

In Denmark, there are no demand side bids in the regulating power market, in excess over the contracted volumes listed in Section 6.3. In Eastern Denmark the DR reserves are used as regulation power reserves, and in Western Denmark there are at the moment no separate categories for regulating power reserves and disturbance reserves.

In Finland and Sweden, there are practically no demand side bids in the regulating power market, but Finnish TSO has contracted DR resources as fast active disturbance reserves that can be activated in the regulating power market in case no other bids are available.

In Norway, RKOM revenues cover the operating costs of participation in the regulating power market. During winters 2001...2006, large industrials have been activated four times in the regulating power market in Norway. E.g. 150 MW was activated in the regulating power market on 20 January, 2006.

Statnett is encouraging retailers (balance providers towards end-users) to bid aggregated demand as reserves in RKOM/the regulating power market. However, certain precautionary actions have to be undertaken and realistically it will take at least months to aggregate sub-stantial volumes. In Norway, there are two RKOM-pilots with two retail companies. Each company now bids ca 25 MW in the regulating power market.

6.4.3 Considerations about the incentives and barriers for demand participation

In fact, the Nordic TSOs have basically two different approaches for enhancing DR as reserves in the regulating power market, which are for brevity called centralised or decentralised model in the following text:

- *Centralised* model where TSO pays capacity payment for *DR* participation in the regulating capacity options market (RKOM) and where contractors are obliged to bid in the regulating power market. DR becomes visible for TSO which helps in the grid operation as described later.

- *Decentralised model* without any other payments for *DR* participation in the regulating power market than the received up/down regulation price. Although the demand can participate directly in the regulating power market, practically no DR appears there.

The centralised model has been chosen in Norway and Denmark, where the TSO has a responsibility to provide always sufficient operating reserves and where TSO is financially accountable for forced load shedding. The decentralised model is applied in Finland and Sweden, where no such liabilities exist.

Paying the capacity payment makes a crucial difference between centralised and decentralised models as DR is regarded and thus the most suitable means to enhance DR may depend on what is the basic model chosen. A key issue is also how the rules of the balance management are organised.

The incentives for market players to keep their balances come from the rules of balance management and from the expected imbalance costs. These incentives are stronger in the decentralised model, where they enhance the bilateral and intracompany DR also called self-regulation or non-visible DR.

In the centralised model, the capacity payment paid by TSO gives an additional incentive to bid demand in the regulating power market.

The most important means to enhance DR in the regulating power market are capacity payments in the centralised model and the rules in the balance management in both of the models. In addition, common means for both models are:

- to send a signal about the tight balance situation
- to relieve terms and fees that complicate bidding of demand resources
- to raise the preparedness of end-users by targeted information

6.4.4 Incentivisation by capacity payments

Based on the experiences from Norway described in Section 6.4.2, the demand side bidding in the regulating power market seems to require predictable revenues, i.e. capacity payments.

For the time being, the incentive given by the capacity payments has still been far stronger than the price signals from the regulating power market, since end-users have often high costs of cutting demand. It is also quite cost intensive to bid continuously in the regulating power market. Revenues from the regulating power market compared to costs remain low, if the demand side bids are accepted only during some high price peaking hours. Thus many end-users may not bid their resources in the regulating power market as they consider the probability to gain a profit to be very low. In Norway, the revenues from RKOM (capacity payments) cover these bidding costs and subsequently there are bids from demand.

With capacity payments to participants in the regulating power market, DR becomes visible for TSO, which helps in the grid operation. Especially, if congestions are aimed to be solved by DR, the visibility gains more importance. The alternative to visible DR, i.e. self-regulation, through DR or generator dispatch, may conflict with the secure grid operation especially in weak grids, since it may overload some parts of the grid unnecessarily. On the other hand, self-regulation may not be optimal from the individual player's viewpoint, because other players may have more efficient resources to provide. By bidding DR in the regulating power market, retailers can reduce the financial risk of large imbalance costs which subsequently enhances competition.

In general, the advantage of a centralised model with a liquid regulating power market is that it gives the TSO information for operational purposes, but the counter-trade costs of the TSO may also be reduced. Having large- and medium-sized demand as resources in the regulating power market, forced load shedding may be avoided in scarcity situations.

6.4.5 Incentivisation by rules of balance management

Whether we talk about the centralised or decentralised model the costs of balancing put on the balance providers should guide them to adjust their imbalances to a minimum, which reduces the need of TSO regulations. When the cost of balancing energy will rise, like during periods of tight power balances, the incentives to minimise the imbalances will become higher. In the decentralised model, where the market players are allowed to adjust their plans until the latest, these effects may be stronger than in the centralised model. In extreme situations the hourly price in the regulating power market may come close to the socio-economic cost of forced load shedding.

Thus market players with an imbalance will have to pay a high price in scarcity situations.If the imbalance costs during tight capacity situations are approaching the costs of forced load shedding, it would further encourage the participants to reduce the balance deviations through DR. The risks of balance management will increase considerably, because the Nordic power balance seem to become tighter. These risks will be emphasised, if there are no proper signals from the regulating power market. The hedging by market players against the risks described will enhance DR even from the smaller end-users. A wider use of hourly recording meters with two-way communication is a natural reaction to prepare oneself for a tightening power balance with the associated risks.

Due to the increased incentives from balance management, balance providers and other suppliers will have more risks and thus more interest for hourly metering, but the meters itself belong to distribution companies, whose interests are fully unbundled from the supplier interests. So the market players don't have proper tools to hedge against the risks, if the distribution companies are not ready to invest in hourly recording meters and deliver the necessary data to suppliers. Therefore, it would be useful, if authorities would promote the use of hourly recording meters as a necessary, but maybe not sufficient measure. Existence of hourly recording meters would incentivise suppliers to have dynamic end-user tariffs with signals to the end-users about the need of DR.

Since the imbalances at TSO level are partly due to profiles settlement applied to smaller customers, like customers with electric space heating, there is a link between the metering practices of end-users, the risks of the market players and security of supply in the operating hour.

As regards the security of supply, the behaviour of electric space heating is quite crucial in tight winter situations. The temperature dependency of total Nordic electricity demand is at least 600 MW/°C that is largely due to electric space heating. Therefore, the space heating constitutes a major potential for increasing DR. Hourly recording meters and end-user tariffs with clear price signals or remote demand control might be crucial for harnessing the DR potential and for reducing the power system peak demand.

6.4.6 Incentivisation by signalling

Since the regulating power market prices are published 2 hours after the expired hour according to the rules of the Nordel System Operation Agreement, the prices do not give any direct signal to bid at a short notice. However, Nordel has established a practice of applying a power shortage signal in tight balance situations. TSOs also sometimes ask in the operational phase for extra bids in regulating power market.

In case the market participants would receive more information on the actual state of the system, they might bid their resources when the probability to be activated increases and they would be better aware about the risks in the current situation.

Signalling may have different effects in the centralised and the decentralised model:

- In the decentralised model, after the signal is released, there is typically a production imbalance as the generators try to be on the safe side and the big end-users are adjusting their demands down. There are concerns about excess self-regulation in the operating hour. Signalling does not usually get demand side bids to the regulating power market to appear, but it seem to be a signal to balance providers to keep control of their balance. Provided that the incentives from the balance management are the right ones, during periods of tight power balance the signalling might help TSO to cope with the power balance, but also the market players would be better aware of their imbalance risks and could reduce the risks through DR.
- In a centralised model, publishing real time information on the system balance in tight situations, i.e. whether the system is subject to upward or downward regulation, may result in extra bids from the demand side, since the bidders are likely to get a predictable revenue. Having had a weekly RKOM auction, there is a good chance that all demand-side bids have not been purchased. In a tight situation a signal (phone call) to the participants who still have bids left asking if their unsold bids are still available may give additional DR.
- Both in the decentralised model the balance providers, who take care of their balance, and in the centralised model the balance providers, who have bid consumption price-elastic in the regulating power market, may benefit from signalling.
  In the decentralised model, the signal could be transmitted by the balance providers to their customers or directly to electricity consuming appliances such as electric space or water heating through hourly recording kWh-meters with a two-way communication. This, of course, requires bilateral agreements and appropriate tariffs. Such customers should be at least hourly metered for verification purposes.
  In the centralised model, a power shortage signal could be transmitted to the balance providers and stimulate them to bid (aggregated) demand. This requires preparatory actions, like marketing interruptible contracts, installing enabling technologies and establishing administrative routines.

6.4.7 Final remark

Since the TSO approaches to DR in the regulating power market is so different in the Nordic countries, it is difficult to give any recommendation on how TSOs jointly could enhance DR in the regulating power market. The activities related to DR in the regulating power market remain national, unless the market related issues of DR in the regulating power market are harmonised.

7. SUMMARY ON ENHANCEMENT OF DEMAND RESPONSE

An increased price elasticity of demand is of paramount importance to market functioning. Higher elasticity in the day-ahead market would reduce the risk that day-ahead market fails to clear, as well as the financial risks of market participants and the possibilities to abuse market power. An increased demand side competition in the day-ahead market would reduce price peaks and lead to enhanced market credibility. Therefore, the demand response should be primarily activated in the day-ahead market.

Although demand response (DR) would be very important for the good functioning of the markets, the incentives for end-user direct bidding for DR may be too low. The visible DR in the day ahead market is relatively small compared to the potential. The scarcity of DR may depend on many factors, such as the lack of human resources to follow up the market, the insuitability of the products available or their inadequate promotion to market players, the uncertainty end-users meet to gain revenues from DR, high transaction costs or absence of frequent price spikes. In addition to the visible DR in the market, there are intracompany or bilateral DR arrangements between end-users and the suppliers that take advantage of DR, but there is no public information thereof.

The DR should be attractive and profitable also for the end-user. The available services and products should be more customer friendly to help end-users bid for DR. More information about DR possibilities for end-users and market players should be delivered. Barriers for customer participation should be removed as far as possible.

It would be best for the market functioning, if the demand participated directly in the day-ahead electricity market. But also the intracompany or bilateral DR arrangements between end-users and the suppliers are useful to reduce the peak load during tight power situations. From the system security point of view the TSOs need to have the necessary ancillary services to handle imbalances at any situation and there demand and generation resources have an equal role. There is lot of need for DR both for the market and for the TSOs. Luckily, there is also a great potential of DR that can still be increased. However, in general the DR seems to require predictable revenues from the markets to cover transaction costs.

One of the main drivers for demand peaks during cold weather is electric heating. Hourly recording meters and end-user tariffs with clear price signals or remote demand control are crucial for reducing the power system peak demand. The temperature dependency of total Nordic electricity demand, which is mainly due to electric space heating, is at least 600 MW/°C. Therefore, the electric heating constitutes a major potential for increasing DR.

Financial market
In principle, financial products tailored to hedge the risk of price peaks might also promote DR. However, for the time being there are no standard financial products at Nord Pool ASA. The main concern is about the liquidity of such products. Such financial products can hardly compete with direct DR in most of the Nordic market.

Day-ahead market
The volume of DR in the day-ahead market is still relatively small except in Norway. The Nord Pool Spot has a flexible hourly bid for one hour and the block bid with the minimum duration of 4 hours. Neither of these seem to be attractive for end-users. There is no major customer wish for better products, although a block bid duration of 2 - 3 hours might be more suitable for big industries. The day-ahead market has not experienced frequent price spikes, which has limited the potential profits of DR from this market.

Regulating power market
In the regulating power market, the costs for demand participation may be higher due to the short notice time compared to day-ahead market. On the other hand, price spikes in the

regulating power market are more frequent. If DR resources bid in the regulating power market, the useful information about the demand resources becomes visible to TSO.

In general, incentives from the balance settlement rules for the balance providers to keep their balances will encourage DR. If the imbalance costs during tight capacity situations are approaching the costs of forced load shedding, it would further encourage the participants to reduce the balance deviations through DR. Hourly recording meters with sufficient communication facilities and associated dynamic tariffs would promote DR. Facing the tightening Nordic power balance DR will become a more important risk hedging tool in the balance management of market players.

Information about approaching tight operational situations might also motivate market parties or end-users to DR.

Demand as ancillary services
Appropriate terms and conditions in the procurement of ancillary services may enhance demand response. The demand participation in the ancillary services would intensify competition lowering TSO procurement costs and leading to a better utilisation of the resources in the power system. The business opportunities for demand participation would increase.

Recommendations

> *Nord Pool Spot for physical trade and Nord Pool ASA for financial trade are encouraged to develop their products and services to enhance DR bidding in the market places. E.g. decrease of the minimum duration of block bids to Elspot could win favour with the end-users.*
>
> *The competent authorities should consider a further enhancement of hourly metering for the end-users to promote the flexibility of the end-users to adapt to changing market situations. The end-users with electric space heating could be the first target group for consideration.*