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Innovative Solutions for Sustainability

Nordic electricity peak prices during the winter 2009– 2010

Final report

30 September 2010
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1 Introduction

1.1 Background

During the winter 2009-2010 the market prices on some price areas of the Nordic electricity market were 1 000 euro/MWh or more in three occasions. Since 2001, the average yearly price level has been in the range 20–50 euro/MWh.[1]

High electricity prices have initiated public discussion in the Nordic countries about the functioning of the Nordic electricity market. These issues have been taken up also in political forums. A member of the Nordic Council submitted a question about the transparency of Nord Pool Spot market and the procedures related to revision planning to the Nordic Electricity Market Group (EMG)[2]. EMG is a group consisting of the representatives of the Nordic energy ministries.

This study has been commissioned by the Finnish Energy Market Authority (EMV) to evaluate the background of the high price situations during the winter 2009–2010. Study has been carried out by an independent Finnish expert organisation Gaia Consulting Oy who is responsible for the content of this report. The aim of the study is also to suggest possibly needed measures to improve transparency and operation of the wholesale market. This study provides factual basis for NordREG for their statement to EMG on the high price situations. NordREG is an organisation for the Nordic energy regulators. Its mission is to actively promote legal and institutional framework and conditions necessary for developing the Nordic and European electricity markets.

The functioning of the Nordic electricity market has been studied many times in the past. Nordic competition authorities have carried out joint studies in 2003[3] and 2007[4]. The 2007 study raised some questions about the functioning of the market. Cross-ownership was still considered widespread in the Nordic market, and something that could be problematic from a competition point of view. In addition, the possibility for market participants to affect bottlenecks was noted. Additional investments in the transmission network were advocated as per TSO plans, provided that they are socio-economic profitable.

Many studies have been made on the high price situations during the winter 2009–2010. Swedish energy regulator Energimarknadsinspektionen focused on the high prices in their half yearly report[5], as did the Norwegian NVE in their quarterly reports[6]. Finnish TSO (Transmission System Operator)

[1] Source: Nord Pool Spot.

[2] Nordic Council, Order of Business, 19 Aug 2010.

[3] Report from the Nordic Competition Authorities, A Powerful Competition Policy – Towards a more coherent competition policy in the Nordic market for electric power, 2003.

[4] Report from the Nordic Competition Authorities, Capacity for Competition – Investing for an Efficient Nordic Electricity Market, 2007.

[5] Energimarknadsinspektionen, Halvårsrapport om elmarknaden oktober–mars 2009/2010 (*in Swedish*), EI R2010:09.

[6] NVE, Kvartalsrapporter (*in Norwegian*), 4. kvartal 2009 and 1. kvartal 2010.

Fingrid investigated the price peaks of 17 December 2009 and 8 January 2010 from the Finnish point of view[7]. Swedish TSO Svenska Kraftnät also presented an analysis of the situation in 2009–2010 in their report on capacity situation for the upcoming winter[8]. These reports provide a common message of the main reasons for the high prices: the demand was high because of the cold weather and supply was limited because of problems in the Swedish nuclear power production.

The winter 2009–2010 was colder than typical winters in the whole Nordic area. The cold weather increased the use of electricity in heating. As a result, demand for electricity was higher than normal, even as the economic downturn had slowed the industrial demand.

Availability of Swedish nuclear power plants during the high price situations varied between 46–69 % of full capacity. All three Swedish nuclear production sites were affected with numerous problems. Many power plants underwent scheduled maintenance and modernization work that took much longer than originally planned.

This study analyzed the peak price situations from a common Nordic point of view. The previous analysis of the key physical underlying conditions for the high prices has been verified. The main focus has been in finding out if the market structure, participant behaviour, or the Nord Pool market model have affected the formation of high prices.

1.2 Methodology

There are several factors affecting market price formation in the Nord Pool spot market. To systematically go through all the elements affecting market prices, the analysis was divided into three stages as shown in Figure 1.1. Firstly, the main physical conditions include cost of electricity generation and capacity availability in the supply side, and temperature and the amount of flexible demand on the demand side. In addition the role of transmission grid conditions was included in the analysis. Secondly, market behaviour was analyzed on the basis of market participants' bids to Nord Pool and electricity transfers between price areas. Thirdly, an in depth analysis of the Nord Pool market model was carried out.

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[7] Fingrid, Sähköjärjestelmän toiminta joulukuun 2009 ja tammikuun 2010 huippukulutustilanteissa (*in Finnish*), 12 Feb 2010.

[8] Svenska Kraftnät, Kraftbalansen på den svenska elmarknaden vintrarna 2009/2010 och 2010/2011, 13 Aug 2010.

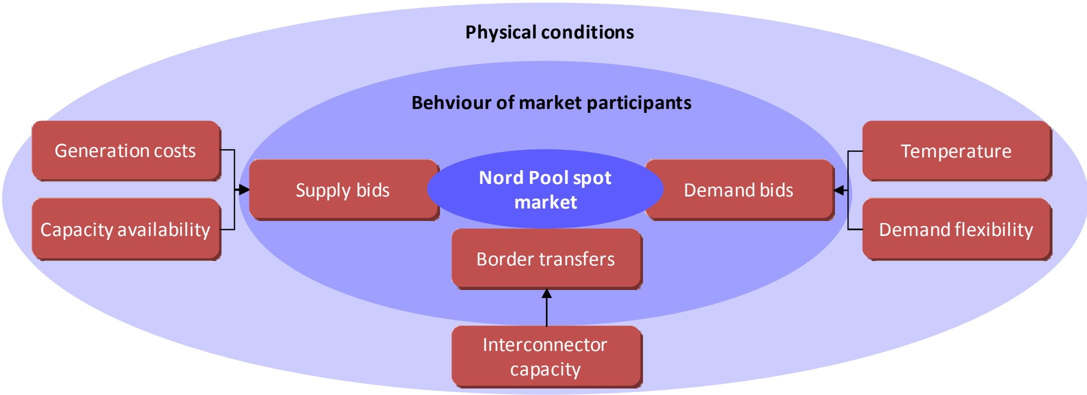

Figure 1.1. *Framework for the study.*

The study was performed as a desk study, using mostly existing publicly available data and reports. The literary review was amended with interviews with Nordic TSOs and Nord Pool Spot. Some interviews were also carried out with individual market experts to detail some specific issues or to gather opinions on policy recommendations.

In addition an economic analysis of the Nord Pool spot price model was performed. The analysis consisted of a theoretical overview of the market model as well as experimental simulation. The simulation was used to analyze how changes in the physical conditions or participant behaviour could have affected prices. The peak price situation on 8 January 2010 and specifically hour 8–9 was chosen for in depth analysis. For this analysis, Nord Pool Spot provided hourly supply and demand bidding curves for all the price areas during the peak price days and surrounding days. As this data is non-public, it is not replicated here in a format that can reveal any of the data.

The study was carried out between July–September 2010. The analysis and simulation of the Nord Pool spot price model was performed by Professor Markku Kallio from the Aalto University School of Economics, with assistance from Iivo Vehviläinen from Gaia Consulting Oy. Additional analysis was done by Marika Bröckl and Elina Virtanen from Gaia. The work was steered by a group consisting of Nordic energy regulators and competition authorities headed by Timo Partanen from the Finnish Energy Market Authority. Other participants were Vegard Magne Aandal, Norwegian Competition Authority, Stig-Arne Ankner, Swedish Competition Authority, Margareta Bergström, Swedish Energy Markets Inspectorate, Martin Groth Hjelmsø, Danish Competition Authority, Tor Arnt Johnsen, Norwegian Water Resources and Energy Directorate, Finn Pettersen, Norwegian Water Resources and Energy Directorate, Elin Söderlund, Swedish Energy Markets Inspectorate, and Valtteri Virtanen, Finnish Competition Authority.

Chapter 2 of this report presents briefly the key principles in the Nordic wholesale electricity market. The physical conditions during the peak price hours are analyzed in Chapter 3. Nord Pool market model and participant behaviour are presented in Chapter 4 while Chapter 5 presents some upcoming changes in the market. Finally Chapter 6 concludes with a summary of learnings from the winter 2009–2010 and recommended further actions.

2 Nordic wholesale electricity market

2.1 Generation and supply structure

2.1.1 Generation in normal conditions

Nordic electricity market is mostly supplied with hydropower and nuclear power. The production statistics for 2008 for the Nordic countries are presented in Table 2.1. In Norway, nearly all electricity is generated from hydropower. Sweden and Finland use a combination of hydropower, nuclear power, and conventional thermal power. Hydropower stations are located mainly in northern areas, whereas thermal power is prevalent in the south. Denmark relies mainly on conventional thermal power, but wind power is providing an increasing part of the demand for energy.

Table 2.1. *Nordic energy production in 2008 (TWh).*[9]

Energy source, TWh	Denmark	Finland	Norway	Sweden	Sum	Share (%)
Hydro power	0	17	141	68	226	57 %
Nuclear power		22		61	83	21 %
Coal	16	9		1	25	6 %
Biofuel	2	9	0	10	20	5 %
Natural gas	7	11	0	1	19	5 %
Wind power	7	0	1	2	10	3 %
Waste	2	1	1	1	5	1 %
Peat	0	6		0	6	2 %
Oil	1	0		1	2	1 %
Other	0			1	1	0 %
Total production	**35**	**74**	**143**	**146**	**398**	**100 %**

Figure 2.1 illustrates the supply structure in the Nordic area and how increased demand influences the marginal cost of production. Similar matching of the supply and demand balance occurs for each hour during the year. When production capacity is reduced this moves the curve and the marginal production price increases as more costly ways of producing electricity need to be taken into use to satisfy the demand.

[9] Source: Nord Pool.

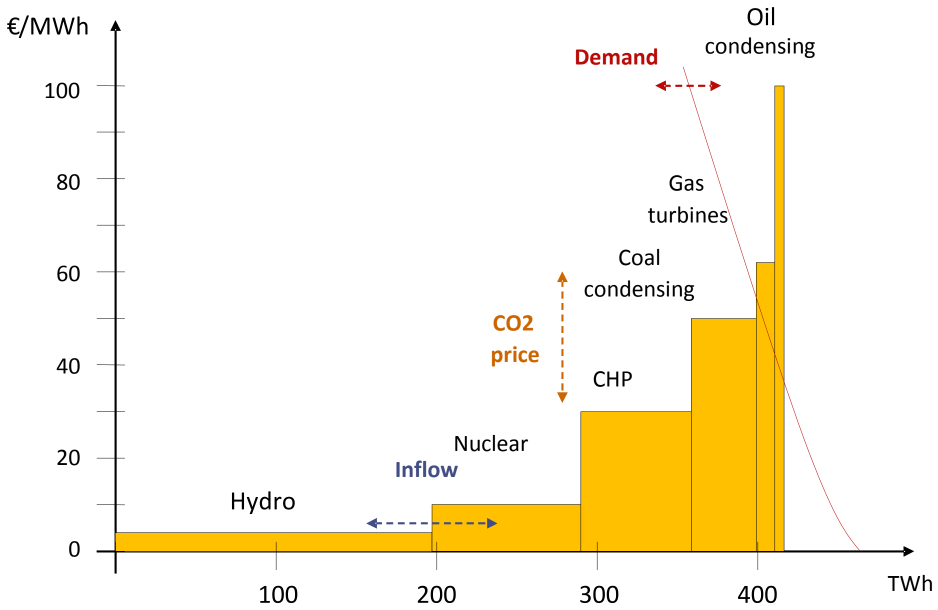

***Figure 2.1.** Illustrative yearly demand and supply balance in the Nordic market.*

Figure 2.1 gives also light to how changes in available base power, in the Nordic case especially hydropower with its yearly fluctuations, impacts production price. Similarly changes in availability and restrictions in the capacity of nuclear power have a direct influence on price. Reductions in production capacity naturally have the greatest influence on market price in the winter months as the demand increases because of increased heating needs. The impact is further strengthened when temperatures are extremely cold such as during winter 2009–2010, when temperatures were below average for extended periods of time in the Nordic area.

2.1.2 Peak reserve capacity

For the cases when the normal market capacity is not sufficient to meet the demand, Sweden and Finland currently maintain peak reserve capacity. The main principles of reserve capacity are as follows[10]:

- Power reserves should be made available to the market through Nord Pool spot market
- Power reserves should only be activated after all commercial bids have been activated
- Unused power reserve capacity after Nord Pool spot market can be transferred to the balancing power market

In practice peak reserve capacity is activated if there is not enough supply to meet the demand. Peak reserve is then included in the supply bidding curve at the level of the highest bid by the market participants. This guarantees that all market supply bids are activated.

[10] Nord Pool Spot, No.02/2009 Peak power reserves in Finland and Sweden to be made available for Elspot from 19 January 2009, 7 January 2009.

Current Finnish peak load reserves are 600 MW and Swedish reserves are 2000 MW. Effect reserves receive a capacity fee as compensation for being made available as reserve capacity.

2.2 Demand

About half of the consumption in the Nordic area consists of industrial consumption, while a third is made up of household consumption, see Figure 2.2. Household consumption includes electricity heating.

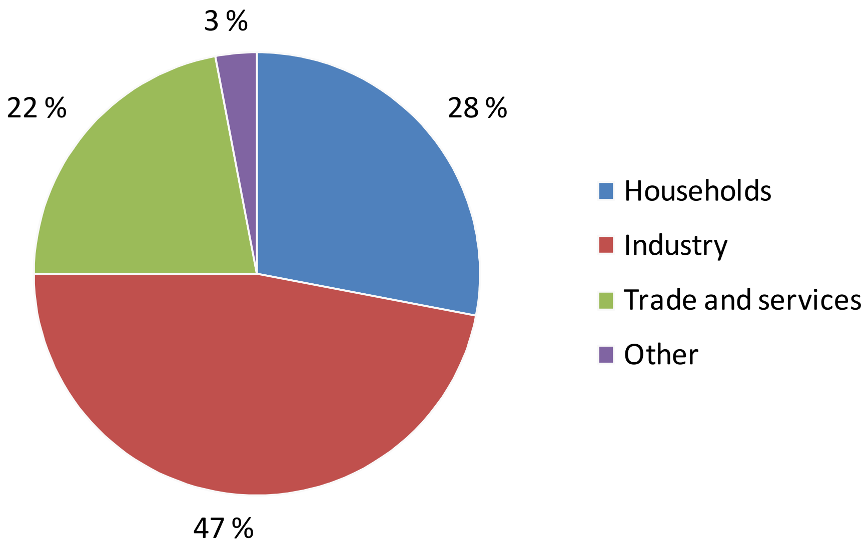

Figure 2.2. *The distribution of electricity consumption in the Nordic area.*[11]

Electricity heating has a large impact on demand for electricity when the weather conditions are cold. Electricity heating consumption prognosis can pose a challenge when temperatures are very low. The consumption prognosis for customers without hourly metering is based on load curves. After a certain point the load curves may not be as accurate with predicting consumption as at more normal temperatures, which may lead to an increased tendency to overestimate consumption in very cold temperatures such as were seen this winter.

2.3 Nordic grid infrastructure and interconnectors

The Nordic wholesale electricity market operates within the boundaries and with the restrictions set by the transmission grid. Transmission capacity is limited and the location of consumption and production plays an important role. Adequate transmission capacity, together with an efficient utilization of the transmission capacity, is one basic requirement to achieve sufficient competition in the electricity market in the Nordic area, and thus a well functioning and efficient electricity market.

[11] Nordel 2008 Statistics

The Nordic market has a large proportion of hydro power production, which fluctuates from year to year and affects energy trade. The arctic region has low consumption and long distances, which has lead to a relatively weak grid in this region. Planned increases in wind power and nuclear power capacity can have an influence on needed transmission capacity.

The Nordic transmission grid frequently experiences congestion which leads to different Nord Pool spot price areas. The cross-section between Sweden and Norway leads to a relatively high frequency of bottlenecks especially in the wintertime. Sweden, Norway, and Finland experience bottlenecks in the North - South direction. Norway has been divided to several price areas, but Sweden and Finland have used internal congestion management to maintain one single price area.[12,13]

The fundamental rule is that all available transmission capacity should be allocated for trade at Nord Pool spot market by the TSOs. Allocation is based on consumption and production prognosis which are made by the TSOs. The allocation is done before Nord Pool spot pricing. The available capacities for transmission are reported to Nord Pool pre bidding and are taken into account when price calculation is performed. Capacity constraints can lead to market splitting and different prices in different areas.

Figure 2.3. *The Nordic Power grid[14].*

[12] For Sweden, see e.g., Nord Pool Spot, Urgent Market Message, 6 January 2010, hour 7:54.

[13] For Finland, see e.g. Fingrid, Exchange Information No.90/2007 Advance information about long-term transmission capacity between Finland and Sweden, Nord Pool Spot, 21 December 2007.

[14] Nordel Annual report 2008.

2.4 Effects of congestion on the market

Congestion management and adequate grid investments both have a great impact on the efficient functioning of the electricity markets. A common coordinated congestion management and Nordic grid planning and investments are important in order to achieve a well functioning wholesale market and to further integrate the Nordic electricity market, as well as to develop the interaction with other European markets.[15]

The basic principles for congestion management in the Nordic market area are[16]:

- Congestion is in general handled where it is physically situated
- Structural congestion is removed or reduced by grid investments whenever socio-economically viable, otherwise market splitting is applied, i.e. dividing the market into separate price areas
- Temporary congestion shall be handled by counter trade (redispatching), if counter trade is possible

Nord Pool spot prices are determined for every hour of the next day for each Nord Pool spot price area. With no congestion the prices in different areas are the same. Market splitting is used if there is congestion. In practice this means that different Nord Pool spot area prices are determined to reduce power flows through congestion to the allowed limit.

The Nordic spot market was divided into nine Nord Pool spot areas at the beginning of September 2010. The boundaries of these areas are mainly the national borders, with the exception of Norway and Denmark that are subdivided into different price areas.

There is internal congestion within some countries, which causes reductions in the import and export capacities between the Nord Pool spot areas. Counter trade is used to guarantee the Nord Pool spot capacities if the situation is altered for example due to outages after Nord Pool spot market clearing. Counter trade or special regulations are also used as complements if there is congestion which cannot be entirely relieved by reduced export/import capacities.[17]

2.5 Legislation and regulation

2.5.1 The regulation of Nord Pool Spot

Nord Pool Spot operates the spot market for trading physical electricity in the Nordic countries (Elspot) as well as an intra-day market (Elbas). The spot market matches supply and demand bids and produces a spot price and associated trading volumes.

[15] NordREG

[16] Nordic Grid Master Plan 2008, Nordel

[17] Congestion management in the Nordic Market. Evaluation of different models. Hagman Energy, EA Analyses and COWI 2008

Nord Pool Spot is located in Norway, owned by Nordic transmission system operators (TSOs), and regulated by the Norwegian energy regulator NVE. The activities of Nord Pool Spot are governed by the Norwegian Energy Act. Nord Pool Spot operates within the framework of both the marketplace license issued by NVE and the license for cross-border power exchange issued by the Norwegian Ministry of Petroleum and Energy. [18]

The supervision of NPS is supported by the regulatory framework, which has as its aim to promote an efficient electricity market. The basis for the regulation is legislation, guidelines and conditions laid down in the Energy Act of December 1990 and additional concessions with accompanying conditions, including relevant EC Regulations made subsequently. [19]

Due to the close link between the physical spot market and the financial markets for electricity, the regulation of Nord Pool Spot requires information exchange between energy market authorities, competition authorities, and financial markets authorities within the Nordic countries. From 2002 there are Guidelines for Nordic co-operation in regulation of Nord Pool Spot, which has been organized as a task within NordREG.[20]

2.5.2 Market surveillance by Nord Pool

As a condition for its marketplace license Nord Pool Spot has an obligation to establish appropriate procedures to monitor the behaviour of parties in the organized marketplace. Nord Pool Spot's Market Surveillance performs this task. The aim of the market monitoring is to ensure that the parties behave in accordance with the objectives of the Energy Act and regulations issued.

The Norwegian Financial Supervisory Authority also requires the establishment of internal market surveillance by Nord Pool ASA. Nord Pool Spot's Market Surveillance cooperates with Nord Pool ASA's Market Surveillance, and monitors the trading activities in the spot and derivatives markets at Nord Pool. They conduct investigations of possible breaches of laws and regulations. Market Surveillance may also request information about physical trades outside the power exchange.[21]

2.5.3 Information available to market participants

There is an agreement between TSOs and Nord Pool which gives the framework to the type of information which TSOs are responsible for giving to the market[22]. In addition market participants and TSOs are responsible for informing about events which have a potential impact on price or which could make it possible to use inside information for trading purposes. Urgent Market Messages (UMMs) have to be given for planned revision and maintenance, unplanned outages, disturbances in production and for some consumption as well as for reductions in major transmission connections.

[18] NVE, Annual Report 2009

[19] NVE, Annual Report 2009

[20] NordREG Work programme 2009

[21] NVE, Annual Report 2009

[22] Data Publication Agreement, 2007.

3 Peak price situations in 2009–2010

3.1 Description of the peak price situations

During the winter 2009–2010 Nordic electricity market experienced several periods of high spot prices. The prices were 1000 euro/MWh or higher on three occasions:

- 17 December 2009 for between 16–18
- 8 January 2010 for between 7–10
- 22 February 2010 for between 7–12 and 17–19

All three peak price situations experienced in the winter of 2009-2010 have been studied in this project. The peak price situation on 8 January 2010 was chosen for in-depth analysis and is described more closely in Section 3.3. However, to frame the setting, an overview of physical conditions in the market during winter 2009–2010 is given first in the following section. The analysis focuses on the areas that most likely have contributed to the high price situation in winter 2009–2010.

3.2 Description and analysis of the physical underlying conditions

3.2.1 Supply

Nuclear power production availability

The Swedish production of nuclear power was reduced during the winter 2009–2010. The low availability of nuclear power was the result of the fact that revisions and maintenance of nuclear plants had been planned for the spring and summer of 2009. These revisions had not been completed before the winter period.

The availability of Swedish nuclear power during the winter 2009–2010 and previous two winters is shown in Figure 3.1. During the winter period between October and March, the availability of Swedish nuclear power was 61 % on average. During the price peak of 17 December 2009 the availability was at its lowest at 46 %, in 8 January 2010 availability was 69 % and 22 February 61 %. All three Swedish nuclear production sites, Forsmark, Oskarshamn and Ringhals, were affected with numerous problems. Many power plants underwent scheduled maintenance and modernization work that took much longer than originally planned.[23]

[23] EMI, Half year report about the electricity market October – March 2009/2010

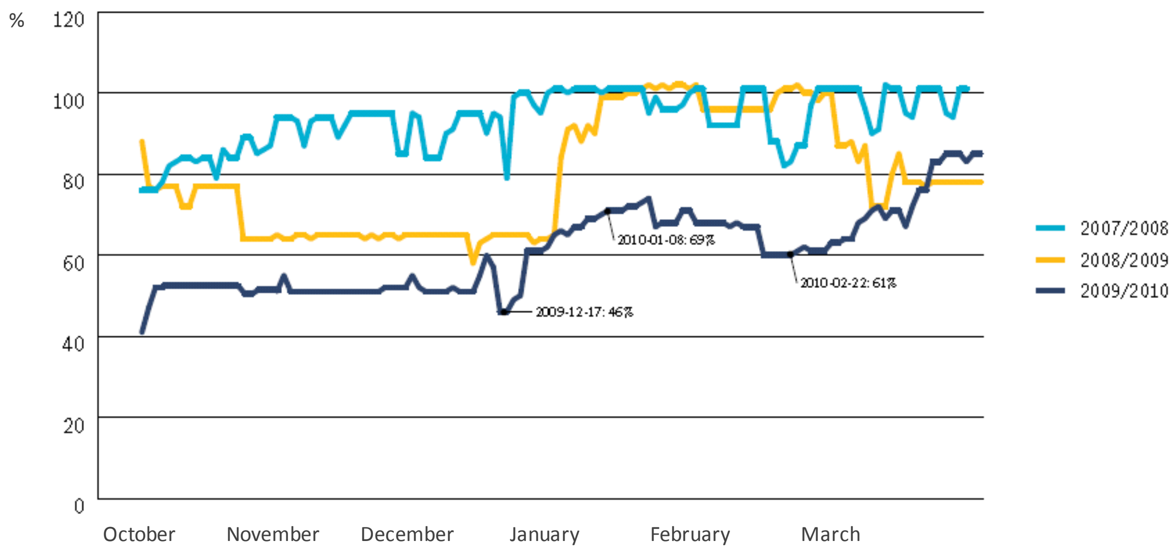

Figure 3.1. *The availability of Swedish nuclear power during winter times 2007–2010.* [24]

Finnish nuclear power production was running without major incidents in the period December 2009 – February 2010[25].

Several non-nuclear production units had production failures during the winter 2009–2010. The total number of market messages relating to production failures was over 400 in the Nord Pool market messaging system. The number of failures is on the same level as in the previous two winters[26]. All these failures have not been analyzed in detail, but it is estimated that the failures in smaller production units have had a more limited effect on market prices than the issues with Swedish nuclear production.

Hydropower reserves

In the beginning of November 2009, the hydrological situation was normal and the energy situation in Norway was considered to be good by the Norwegian TSO[27]. The levels in the Nordic hydro reservoirs were close to the median levels. However, hydropower reserves were depleted because of higher than normal production. The production was higher as hydro power was used to compensate low Swedish production and also the problems with the imports from the Netherlands. In addition,

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[24] Energimarknadsinspektionen, Halvårsrapport om elmarknaden oktober–mars 2009/2010 (*in Swedish*), EI R2010:09. Original source Monter Powernews. This data is not available from Nord Pool Spot.

[25] Fingrid, Sähköjärjestelmän toiminta joulukuun 2009 ja tammikuun 2010 huippukulutustilanteissa (*in Finnish*), 12 Feb 2010 and Nord Pool Spot Urgent Market Messages.

[26] Nord Pool Spot, On the basis of the Urgent Market Message database the total number of approved failures from all companies (excluding TSOs) from 1 October 2009 to 31 March 2010 was 414. With same conditions, the number of failures was 451 in winter 2007–2008 and 402 in winter 2008–2009. Database was accessed on 30 September 2010.

[27] Statnett, In Exchange Information, No 93/2009 Energy situation in Norway is good as winter looms, Nord Pool Spot, 4 November 2009.

despite the high snowfall in general, the snowfall did not favour the areas with high hydropower production capacity.[28] The development of the hydrological reserves is presented in Figure 3.2.

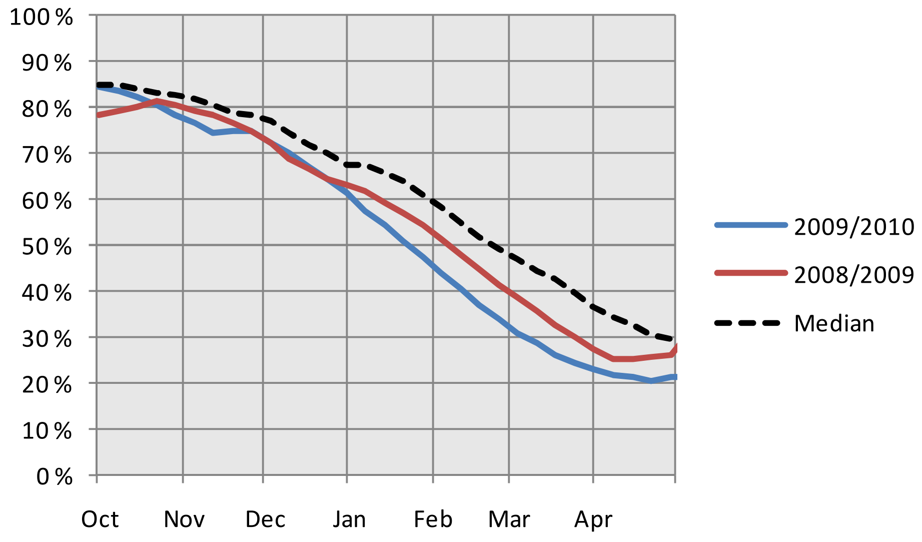

Figure 3.2. *Nordic water reservoir levels during the winter 2009–2010, the previous winter, and in typical conditions (median).*

3.2.2 Demand

Electric heating, which makes up an important part of electricity consumption in the Nordic area, was a contributing factor to the high levels of consumption. As a result of cold weather experienced during an extended period of time, electric heating consumption lifted the overall consumption of electricity on a Nordic level.

The temperatures were below average for extended periods of time in the winter of 2009–2010. For instance on 8 January 2010 the temperatures in the Nordic countries were 10–12 degrees below average. As an example, Figure 3.3 presents the deviation of Swedish temperatures from normal during the winter.

[28] Energimarknadsinspektionen, Halvårsrapport om elmarknaden oktober–mars 2009/2010 (*in Swedish*), EI R2010:09.

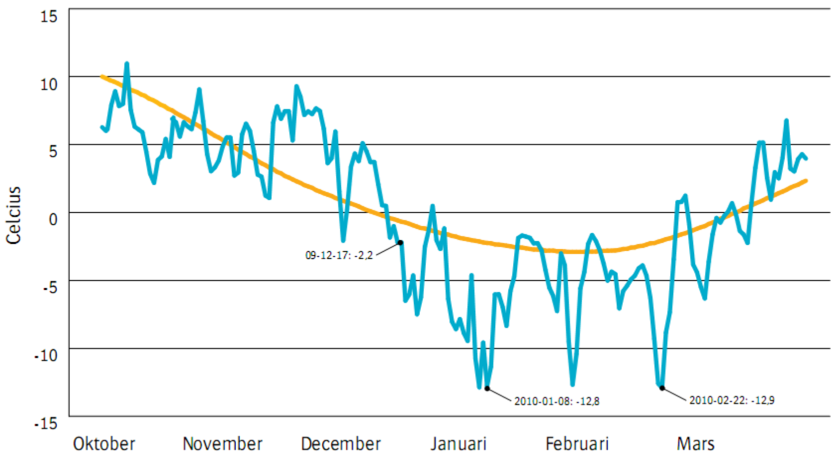

Figure 3.3. *The temperature for Sweden on peak price days.* [29]

Electricity consumption was higher on the peak price periods of winter 2009–2010 than during the two previous winters as seen from Figure 3.4.[30] The main reason for the high consumption was the low temperatures that increased the use of electric heating. Industrial demand was affected by the global economic downturn from 2008. In Finland and Sweden, industrial consumption was lowest during the winter 2008–2009, but recovered slightly for the winter 2009–2010[31]. In Norway, the industrial demand was lower during the winter 2009–2010[32] than in 2008–2009.

[29] Energimarknadsinspektionen, Halvårsrapport om elmarknaden oktober–mars 2009/2010 (*in Swedish*), EI R2010:09. Original data from SKM Market Predictor. Temperature data for the Nordic region is not publicly available.

[30] Nord Pool publishes data from the current and two previous years.

[31] Online database Statistics Sweden, accessed 30 September 2010, and Finnish Energy Industries, Monthly energies, 15 September 2010.

[32] NVE, Kvartalsrapport for kraftmarkedet (*In Norwegian*), 1. kvartal 2010.

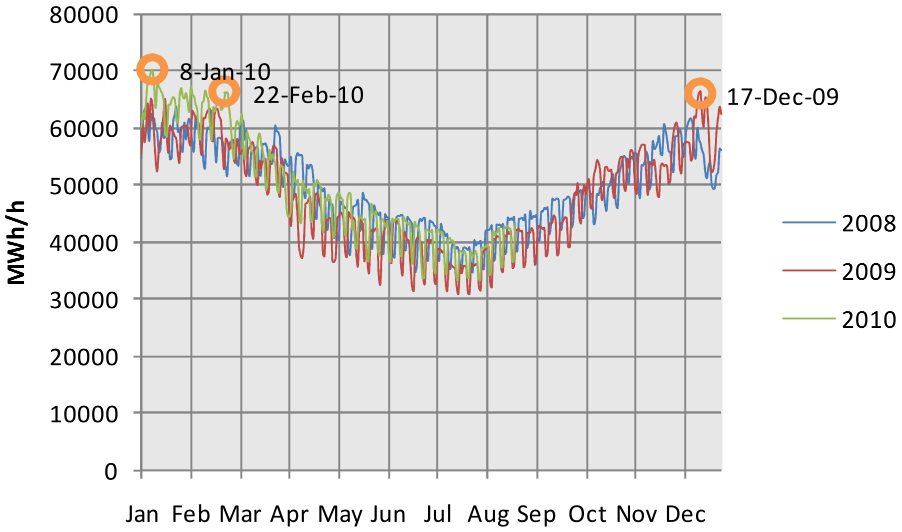

Figure 3.4. *Highest consumption during the day in the Nordic area 2008–2010 with the peak price dates highlighted.*[33]

3.2.3 Transmission capacity and its availability

The Nordic interconnection capacity was somewhat limited from the maximum technical capacity during winter 2009–2010. The major capacity restrictions were internal to Nord Pool.

The major external connections to the Nordic area from Germany, Russia, Estonia and Poland were operational during winter 2009–2010. However, the NorNed cable connecting Southern Norway and the Netherlands went out of operation on 29 January 2010.[34]

The technical transmission capacity between Southern Norway and Sweden had been reduced in certain situations for an extended period already in early 2009. The reason for the reduced availability is a cable failure in the so called Rød Hasle connection[35].

In addition, capacity allocated by the TSOs from Western Denmark to Sweden was reduced to half from 740 MW to 370 MW because of technical problems[36].

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[33] Date source: Nord Pool Spot. The highest consumption is calculated as a sum of the maximum consumption of the areas.

[34] Nord Pool Spot, Urgent Market Message, 1 February 2010, hour 13:03. Note the delay between the event and published information.

[35] Nord Pool Spot, Exchange Information No.45/2009 Net Transfer Capacity (NTC) from NO1 to SE, 4 May 2009.

[36] Nord Pool Spot, Urgent Market Message, 27 October 2009, hour 12:28.

3.3 Peak of 8 January 2010

3.3.1 Nord Pool Spot prices on 7-9 January 2010

The highest prices during the peak of 8 January 2010 were seen between 7 and 10 in the morning. The Nord Pool system price was 300 euro/MWh between 8 and 9. Because of capacity constraints in the grid, the Nordic area was split into different price areas.

Area prices for Sweden (SE), Finland (FI), Central and Northern Norway (NO2 and NO3) as well as Eastern Denmark (DK2) were 1 000 euro/MWh. Area prices for Southern Norway (area NO1) and Western Denmark (DK1) were 65 euro/MWh. The system price and the prices in the different areas during a 72 hour period 7–9 January 2010 are shown in Figure 3.5. Prices are lower on 9 January 2010 because of the lower demand as it was Saturday. Notice that the price in Western Denmark was below 3 euro/MWh on morning of the 9 January 2010. This was due to high wind production and limited transmission capacity to Germany that also had high wind production.[37]

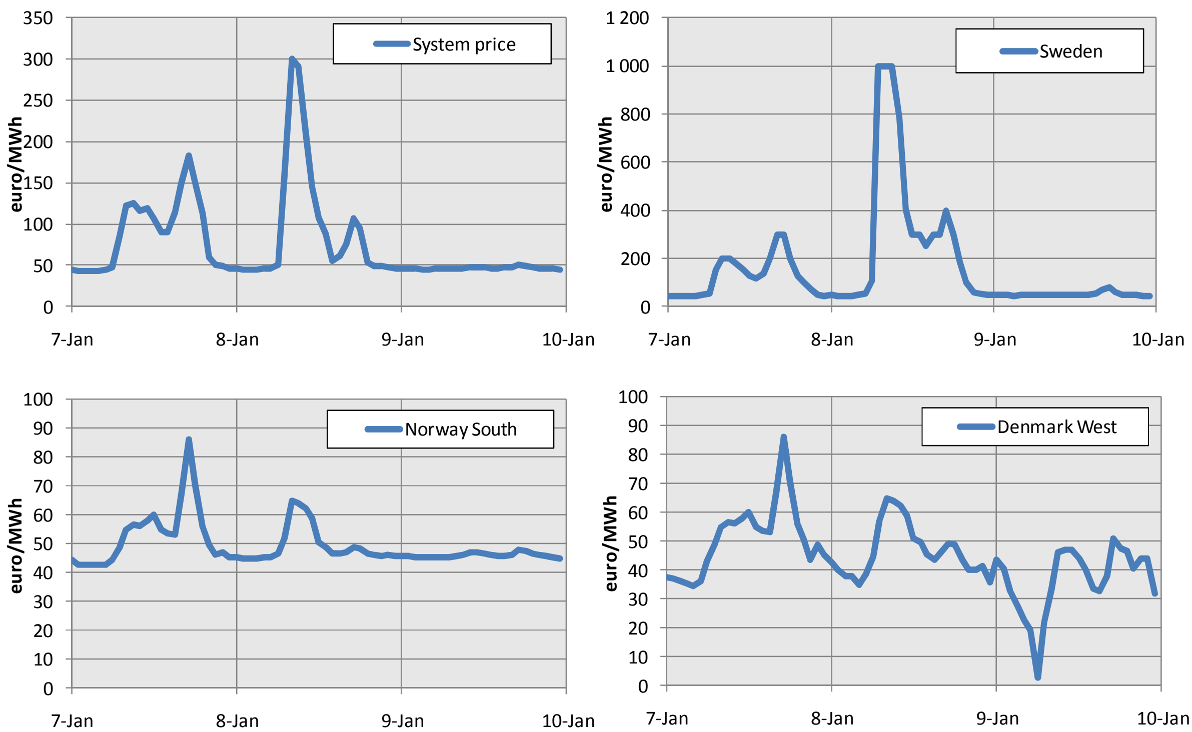

Figure 3.5 *System price and area prices for a 72 hour period 7-9 January 2010.*[38]

The hour between 8 and 9 had the highest system price and highest area prices in all the areas. It is analyzed in more detail below and also the following Chapter 4.

[37] Nord Pool Spot, Urgent Market Message, 8 January 2010, hour 08:26.

[38] Source: Nord Pool Spot.

3.3.2 Hour 08–09 on 8 January 2010

Situational overview

Figure 3.6 presents an overview of the key Nordic electricity market parameters on the hour 08–09 on 8 January 2010. The figure gives an overview of prices in different areas, transmission capacity available for Nord Pool trading, actual power flows, consumption prognosis made by TSOs, actual consumption and production in different price areas.

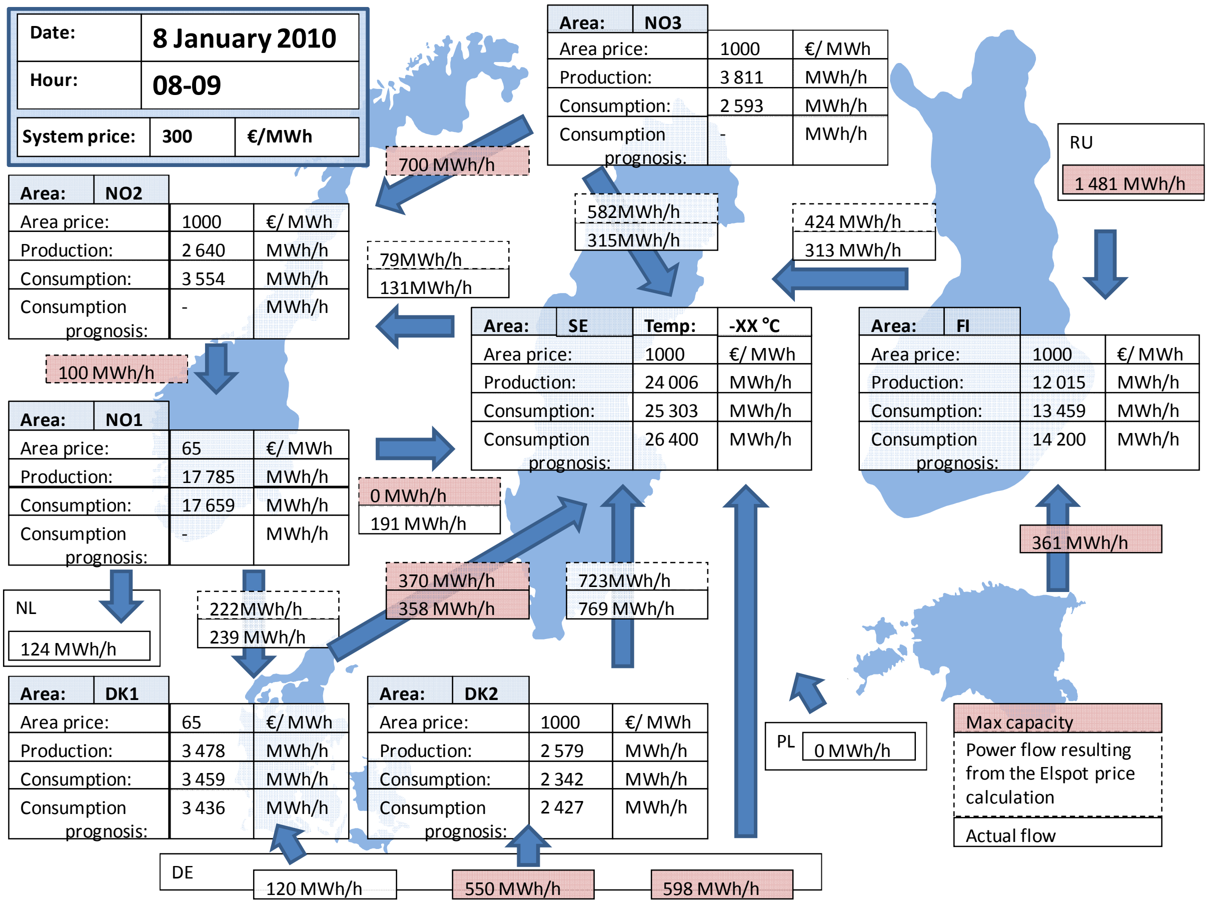

Figure 3.6. *Situational snapshot of the hour 08–09 on 8 January 2010. Constrained transmission capacities within the Nordic area are highlighted.* [39]

During the peak hour, the total Nordic production was 66 314 MWh and consumption 68 369 MWh. The net import to the Nordic area was 2 055 MWh. Production was lower than consumption in Finland, Sweden and Central Norway. Production and consumption were almost equal in Southern Norway and Western Denmark. Only areas with clearly higher production than consumption were Northern Norway and to lesser extent Eastern Denmark.

[39] Data from Nord Pool Spot.

Consumption and consumption prognosis

Consumption during the peak price situation was on a high level historically. However, the consumption prognosis made by the TSOs was even higher, as shown in Figure 3.7. The consumption during hour 08–09 on 8 January 2010 was lower than the prognosis by 1 097 MW in Sweden and by 741 MW in Finland. The prognosis by the TSOs is used as a basis for making the transmission capacity allocation.

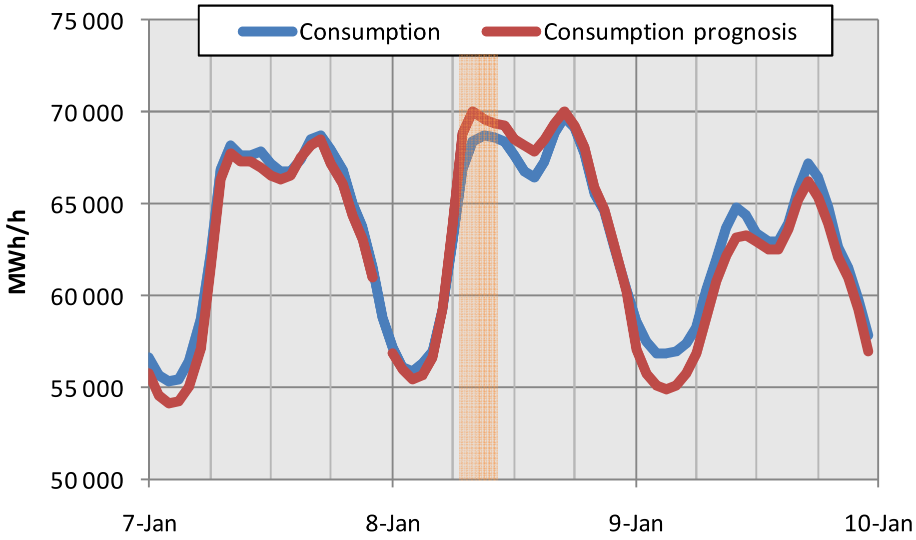

Figure 3.7. *Production, consumption prognosis, consumption and system price 7- 9 January 2010. The time of the high price hours is highlighted.*

It should be noted, that market participants have made their own consumption prognosis on the 8 January 2010. The Nord Pool Spot prices are matched on the basis of the bids that the market participants provide. The consumption prognoses made by the participants are not public, and they can differ from the prognoses made by the TSOs. Therefore, the higher consumption prognoses by the TSOs have not directly affected Nord Pool spot price formation.

Production availability

On 8 January 2010, 69 % of the Swedish nuclear power production capacity was available. Compared to a normal situation, this means that some 2 800 MW of nuclear production was unavailable. Otherwise there were some problems with smaller production facilities.[40]

Use of peak power reserves

The supply and demand bidding curves from the market participants failed to meet during the hours from 8–10 on 8 January 2010. There was not enough supply to meet the demand in the high price areas. Therefore, market price formation on 8 January required the activation of peak power reserves maintained by the TSOs.

[40] Nord Pool Spot, Urgent Market Messages, analyzed for the period 4–8 January 2010.

The amount of peak power reserves activated is shown in Table 3.1. The total production in the Nordic area was around 65 000 – 66 000 MW, and around 45 000 MW in the high price areas. The activated peak power reserves corresponded to around 0.3 % of the total production in the Nordic area.

Table 3.1. *The amount of peak power reserves activated on 8 January 2010.*[41]

Hour	Finland (MW)	Sweden (MW)	Total (MW)
07–08	20.5	143.1	163.6
08–09	45.4	145.4	190.8
09–10	35.3	86.9	122.2

Transmission capacities

The areas with high prices imported from the areas outside Nord Pool mostly at or close to the maximum technical capacity. Denmark and Sweden imported from Germany and Finland from Russia and Estonia. An exception was the transmission between Poland and Sweden, which was zero during the high peak price hour. The lower priced Southern Norway exported to Netherlands and the import from Germany to lower priced Western Denmark was lower than the maximum capacity.

Transmission capacity from the low price areas to high price areas was restricted to maximum allocated capacity during the peak hour. The transmission from Central Norway to Southern Norway was restricted to 100 MW, although the price in Southern Norway was lower than in Central Norway.

Capacity from Southern Norway to Sweden was reduced down to 0 MW because of the expected high load in the Oslo area[42]. Figure 3.8 shows the capacity available for the spot market in the Southern Norway to Sweden connection, the transmission resulting from the spot price calculation, and the actual physical exchange.

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[41] Nord Pool Spot, Urgent Market Message, 7 January 2010, hour 13:16.

[42] Nord Pool Spot, Urgent Market Message, 6 January 2010, hour 12:24.

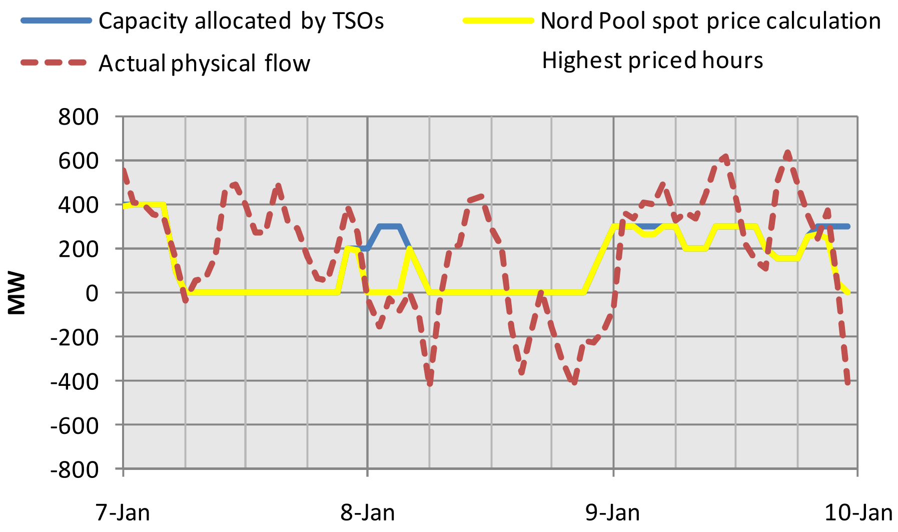

Figure 3.8. *The interconnection capacity available between Southern Norway and Sweden in 7–9 January 2010.*[43]

Internal management of price areas

Svenska Kraftnät announced on 6 January 2010 that it will use counter trade on 7 January 2010 to maintain operational security in the southern part of Sweden[44]. There was no similar announcement for the 8 January 2010. However for the 8 January 2010, E.On arranged 484 MW of gas and oil turbines[45] and Vattenfall a 240 MW oil turbine[46] to be used as reserve capacity. According to the announcements this capacity was withheld from the market. It is unclear from the announcements that how much of this reserve capacity was used for counter trade, and if additional capacity was used.

In addition, Svenska Kraftnät announced that available capacity between borders south of Cut 2 would be reduced in order to maintain Swedish power system security[47].

System balance and regulating market

As is illustrated by Figure 3.9 there was significant down regulation on 8 January 2010. The down regulation was over 2 000 MW between 8 and 9 and close to 2 500 MW from 9 to 10. A major part of the down regulation was at this time realised in Finland and Sweden, which were the high price areas.

[43] Data from Nord Pool Spot.

[44] Nord Pool Spot, Urgent Market Message, 6 January 2010, hour 7:54.

[45] Nord Pool Spot, Urgent Market Messages, 7 January 2010, hour 10:32, 10:33, 10:34, and 10:35.

[46] Nord Pool Spot, Urgent Market Messages, 7 January 2010, hour 15:12.

[47] Nord Pool Spot, Urgent Market Message, 7 January 2010, hour 8:27.

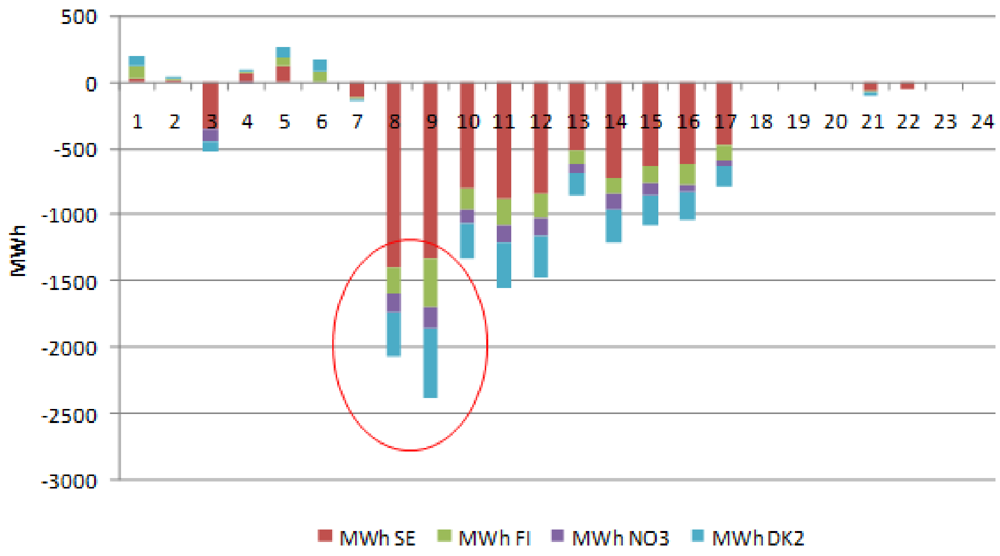

Figure 3.9. *Up and down regulation on 8 January 2010.*[48]

3.4 Other price peaks

3.4.1 Peak of 17 December 2009

The peak price situation on 17 December 2009 had similarities with the peak of 8 January 2010 described above in detail. The prices in the peak hours 16–17 were 1 400 euro/MWh. Finland, Sweden, Eastern Denmark and Central and Northern Norway formed a unified price area. The technical maximum price at Nord Pool was reached and effect reserves were activated by Nord Pool in Sweden and Finland to reach an equilibrium market price.

The transmission capacity from Southern Norway (NO1) to Sweden was 100 MW lower than in the surrounding hours, but not at the very low levels of 8 January or 22 February 2010. On 17 December 2010, only 46 % of the Swedish nuclear power capacity of 9 300 MW was available. Five nuclear plants with an installed capacity of 5 154 MW were out of production. During the day Oskarshamn 3 returned in production.

In short, the availability of Swedish nuclear capacity was even lower on 17 December 2009 than on 8 January 2010, but this was compensated by the lower consumption. As a result, the area prices on 17 December reached around the same level as on 8 January 2010.

3.4.2 Peak of 22 February 2010

Compared to 8 January 2010, a new price area had been added to Southern Norway. Again Finland, Sweden, Central and Northern Norway and Eastern Denmark formed a unified price area during the high price hours. Previously joint Southern Norway was divided into two price areas, NO1 and NO2.

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[48] Source: Nord Pool Spot.

Still, Southern Norway and Western Denmark had significantly lower prices than rest of the market areas. Spot prices in the high price areas were 1 000 – 1 400 euro/MWh in the morning between 8 and 10, and 1 000 euro/MWh in the evening between 17 and 19. The prices were over 1 000 euro/MWh for at total of seven hours on February 22.

The transmission between Southern Norway (NO1) and Sweden was again reduced, but this time not to zero but to 150 MW. Around 230 MW of peak effect reserves were activated through Nord Pool at this time to reach a market price. There were again problems with Swedish Nuclear power which was running at 61 % of maximum capacity.

4 Nord Pool spot price model

4.1 Introduction

The purpose of this Chapter is to review the basics of the Nord Pool spot price model, which is used for spot price calculation in the Nordic electricity market. We begin by discussing the theory of the Nord Pool spot price model or *Elspot* model. Then, an experimental Nord Pool spot price model with minor simplifications is presented. This model is used for analysis of some properties of the pricing model. For numerical tests, we first validate the experimental model aiming to replicate our base case of Jan 7-9, 2010, one of the periods with peak prices of electricity. Thereafter, a number of sensitivity analyses are carried out for the same 72 hour period. First, transmission capacity is varied for the bottle neck connection between southern Norway and Sweden. Second, the impact is tested if the capacity of the same bottle neck would have been determined jointly with price calculation. Third, we test the sensitivity of price calculation with respect to variations in price elasticity of demand. Fourth, we study possible incentives of exploiting market power by introducing variations in supply and in demand. Finally we discuss possible future uses of the experimental model and present some concluding remarks.

4.2 Theory of the Nord Pool spot price model

In this section, we cover the fundamental theory of the Elspot model. We begin by stating the setting considering time span, regional subdivision, bids offered to the market, and various transmission capacity restrictions. Thereafter, we discuss the chosen criterion being employed for matching supply and demand, and determining the bilateral trade flows between regions. Finally, we discuss how such market solution is calculated using an optimization model, the Elspot model. The market equilibrium leads to a socially optimal allocation of production, consumption and trade.

4.2.1 Basic setting in Nord Pool Spot

In the day-ahead market of Nord Pool, production, consumption and trade are balanced during a single day and separately in each of the 24 hours.

The model may in theory involve any number of regions. For example, in the case studies reported in this Chapter, we subdivide the relevant geographical domain into eight areas: Sweden, Finland, Denmark West, Denmark East, South Norway, Central Norway, North Norway and Germany.

During the preceding day, agents operating in the market areas submit to Nord Pool bids to buy and bids to sell by. Each agent may submit any number of bids. The volumes of the bids are not restricted, but the minimum price was -200 euro/MWh[49] and maximum price 2 000 euro/MWh[50] during the winter 2009–2010.

Simple bids to buy specify for a given hour of the day the maximum price one is willing to pay and the maximum quantity to be bought. Similarly, simple bids to sell specify the minimum price for selling and the maximum quantity.

Block bids concern a range of hours. If a block bid is accepted, then the quantities specified by the bid are delivered in each hour of the range. Hence, a block bid is accepted in full quantities or rejected, for the entire range of hours. Thereby block bids introduce *binary choices* in the market. A block bid to buy can only be accepted if the average market price during the time range is at most the bid price. Similarly, a block bid to sell can only be accepted if the average market price during the time range is at least the bid price.[51]

An agent may also submit linked block bids in which case a given bid can only be accepted given that another bid is accepted as well. Such linkage may be specified in a tree structure: acceptance of a bid may be a condition for a number of other bids, and each one of them may set acceptance conditions for further bids.

Finally, there are three types of physical restrictions concerning bilateral trade flows. First, grid capacities set upper limits on transmissions between any two areas. Furthermore, such limits are given separately in both directions. Second, there are multiple-channel bounds (cuts), which set upper limits on sums of bilateral trade flows. For example, in the case studies of this Chapter, there are three cut constraints: exports from Sweden to the south, exports from Denmark to Scandinavia and imports from Scandinavia to Denmark. Third, there are ramping restrictions, which require that the difference in transmission rate between any two consecutive hours is within given limits.

4.2.2 Nord Pool market solution for sales, purchases, trade and prices

Given bids offered to the market and the transmission restrictions, we now discuss how the Elspot model determines the quantities sold, bought and transmitted as well as the area prices and congestion charges. In Section 4.2.3 we consider the problem in case there are no binary choices to accept or reject block bids. This case defines the fundamental underlying assumptions in Elspot. The discussion is extended in Section 4.2.4 to account for the complicating restrictions of block bids: a block bid can only be accepted at 100% level of bid quantities.

[49] Nord Pool Spot, Exchange Information, No. 99/2009 Reminder: Implementation of negative price floor in Elspot, 18 November 2009.

[50] Nord Pool Spot, Exchange Information, No.98/2008 Adjustment of Elspot technical price ceiling in NOK and SEK, 19 December 2008.

[51] There are also flexible hourly bids, where the price and volume of a sales bid is fixed for a single hour. However, the exact time of the bid is not fixed. Instead, a range of possible hours is given and only a single hour in this range may be chosen for exercising the bid. Furthermore, flexible bids are accepted in full quantities or rejected, and bids cannot be accepted, if the price with respect to bid price is unfavourable. Because flexible bids play a minor role in the market, they are omitted in subsequent discussion.

4.2.3 Market equilibrium without binary choices

Consider the Elspot problem in case there are no binary choices of block bids. This is the case if at least one of the following conditions is satisfied:

- There are no block bids.
- Binary choice restriction for block bids is relaxed so that any level between 0% and 100% of bid quantities can be accepted. (This relaxation is used in the experimental model of Sections 3 and 4.)
- A combination of block bids is exogenously accepted in the Elspot problem. (Such cases are considered in Section 4.2.4)

In order to determine the bids to be accepted (fully or partially) and bilateral trade flows to balance the market in each area, standard competitive market equilibrium is employed. In a competitive market, agents are price takers: while solving individual optimization problems, an agent assumes that the choice does not have an impact in market prices.

Given market prices of electricity in each area and congestion charges for each transmission restriction, the *decentralized problems* of various agents are:

- For the producers, to choose optimal levels to sell.
- For the consumers, to choose optimal levels to buy.
- For trade agents, to choose optimal bilateral exports and imports.

Given bid data, optimal solutions for these problems are simple. For example, if the market price is lower (higher) than the bid price of a buyer offering a simple bid, then the bid quantity (zero quantity) is optimal. In case the market price is equal to the bid price, then any quantity between zero and the bid quantity is optimal. For a trade agent, if the price difference of import area and export area is lower (higher) than the congestion charges, then optimal export quantity is zero (infinite). If such price difference is zero then any nonnegative export quantity is optimal.

Competitive equilibrium conditions are satisfied if the area prices and congestion charges are such that optimal levels of agents' decentralized problems satisfy

$$\text{demand} + \text{export} = \text{supply} + \text{import, for all areas and hours, and}$$

$$\text{transmission restrictions are satisfied, for all channels and hours.}$$

Samuelson's idea (1952) proves useful for computing such a competitive equilibrium[52]. This approach employs the concepts of producer and consumer surplus defined as follows. For a given area and hour, if the bid price of a buyer is p and the market price is m, then the price gain for the bidder is p-m (which may be positive, negative or zero). Given quantity q bought, the *consumer surplus* (p-m) times q represents the welfare gain of the agent. Similarly, for a simple bid to sell with price p and quantity q sold, the *producer surplus* is (m-p) times q.

For computing the market equilibrium, define a single optimization problem to

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

maximize the total consumer and producer surplus

(summing over all areas, hours and bids)

subject to:

quantities of bids offered to sell and buy,

nesting requirements for block bids,

demand + export = supply + import, for all areas and hours, and

all transmission restrictions.

Then optimality conditions[53] for this problem are equivalent to conditions of a competitive equilibrium. Hence, optimal solution provides equilibrium levels of exercising bids to sell and bids to buy, and bilateral exports and imports. Furthermore, equilibrium prices and congestion charges are available from optimal dual solution.

Example 1. As a simple example consider a case with a single area, and a single producer, who submitted three simple bids 1, 2 and 3, to sell with respective prices 1, 2, 3 and quantities 4, 2, 1. For the sake of simplicity, suppose all demand bids (in decreasing price order) are specified by a price function p=16-2q, which yields the total quantity q bought given market price p. Hence, we replace the piece-vice constant price function resulting from bids to buy by a linear function. From a graphical inspection (see Figure 4.1) we conclude, that the equilibrium price is p=3 and the total quantity bought and sold is q=4+2+0.5=6.5. For comparisons below, observe that the producer surplus is 10.

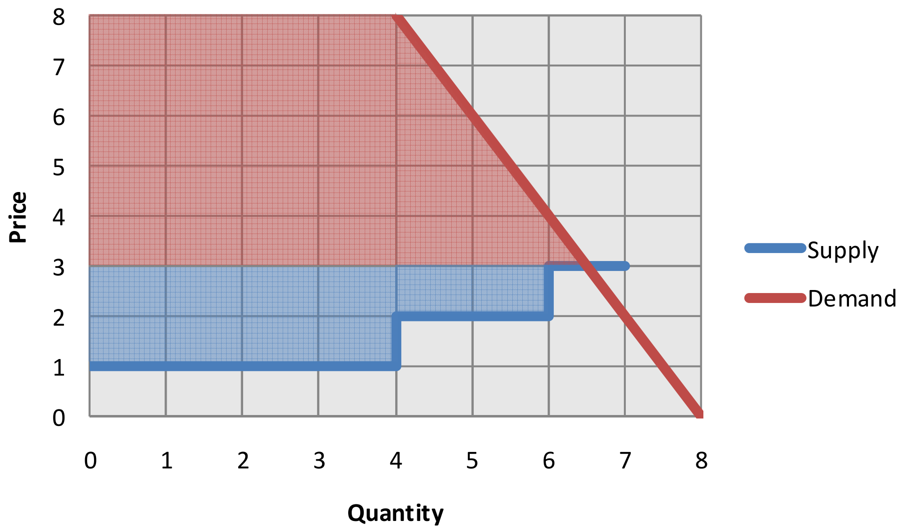

Figure 4.1. *Simple price formation in Example 1. In addition to the supply and demand bid curves, the suppliers' surplus (blue) and partially consumers' surplus (red) is shown.*

[53] So called Karush-Kuhn-Tucker conditions.

4.2.4 Market equilibrium with block bids and nesting conditions

With block bids in the market, due to binary choices involved, computation of the market equilibrium becomes more complicated. In equilibrium, for an accepted block bid to sell, average price (over the range of hours) must be at least the bid price. Similarly, an equilibrium condition for an accepted block bid to buy requires the average price to be at most the bid price.

Given a fixed combination of block bids accepted, we may employ the optimization of Section 4.2.3 and obtain optimal prices and quantities. However, the prices can be such that market equilibrium conditions for block bids are not satisfied. For example, average market price for a block bid to sell may be too low for a bid accepted in the combination under consideration.

Hence, the equilibrium problem is of combinatorial nature. The task is to determine such a combination of accepted block bids that the resulting prices meet the equilibrium conditions for all block bids. Such a combination may not be unique so that the market equilibrium may not be unique. Among such alternatives, the Nord Pool Spot price model chooses one with maximal total surplus.[54]

Example 2. Consider Example 1 modified so that bids 2 and 3 are block bids, each to be accepted in full quantity or rejected. If all bids are accepted, the market price is p=16-2(4+2+1)=2, which is not high enough for bid 3 to be accepted. If we accept bid 2 and reject bid 3, we find an equilibrium with price p=4, q=6 and producer surplus 16. Observe that the binary restrictions introduced here lead to an increased market price and to an increased producer surplus in comparison with Example 1. Note that an alternative equilibrium results by accepting bid 3 and rejecting 2 ending up with p=6 and q=5. However, the total surplus is less that in the first alternative.

Finally we consider a nesting condition for block bids. Again, nesting means additional restrictions and consequently, we might expect an increase in market price. We illustrate this by the following example.

Example 3. Consider Example 2 modified so that bid 2 can only be accepted if bid 3 is accepted. Then the preferred equilibrium results by accepting bid 3. Then the market price is p=6, the quantity is q=5, and the producer surplus is 23. The nesting condition introduced here leads to an increase in market price and in producer surplus compared with Example 2.

4.3 An experimental model of Elspot

4.3.1 Numerical model

To gain further understanding of the Elspot model, we develop an experimental version using *AMPL (Advanced Mathematical Programming Language)*. This model involves some minor simplifications:

- We allow block bids to be accepted at any level between 0% and 100%. This relaxation is minor in the sense that in the total surplus maximization problem, optimal levels in most cases are either 0% or 100%. For example, in the base case of 8 January 2010, reported in Section

[54] Recently, an efficient solution procedure for this problem was provided by Martin, Müller and Pokutta (2010, http://fauam2m.am.uni-erlangen.de/optimization/edom/staff-members/mueller-johannes).

4.3.2, only 1 % of block bids are accepted at levels strictly inside the interval from 0% to 100%.

- We omit ramping restrictions[55].
- We fix export and import of non-Nordic areas[56].

Actual data for bids to sell and bids to buy was received from Nord Pool Spot for the peak period 7–9 January 2010.[57] The data was given for all price areas as hourly bid curves. Also separate block bids were received. Data was given in a format where individual bidders cannot be identified, nor was the analysis of individual participant behaviour the purpose of this study.

4.3.2 Base case of 7–9 January 2010

For numerical analysis, the model is first validated using as base the period of 7–9 January 2010. The system prices and some representative area prices over the period of 72 hours during 7–9 January 2010 are shown in Figure 4.2. The area price for Sweden, Finland, Central and Northern Norway and Eastern Denmark were almost identical during the time period. Actual prices in Nord Pool Spot as well as the prices obtained from our experimental model are shown. The model replicated the actual prices reasonably well so that reliable results from sensitivity analysis cases can be expected.

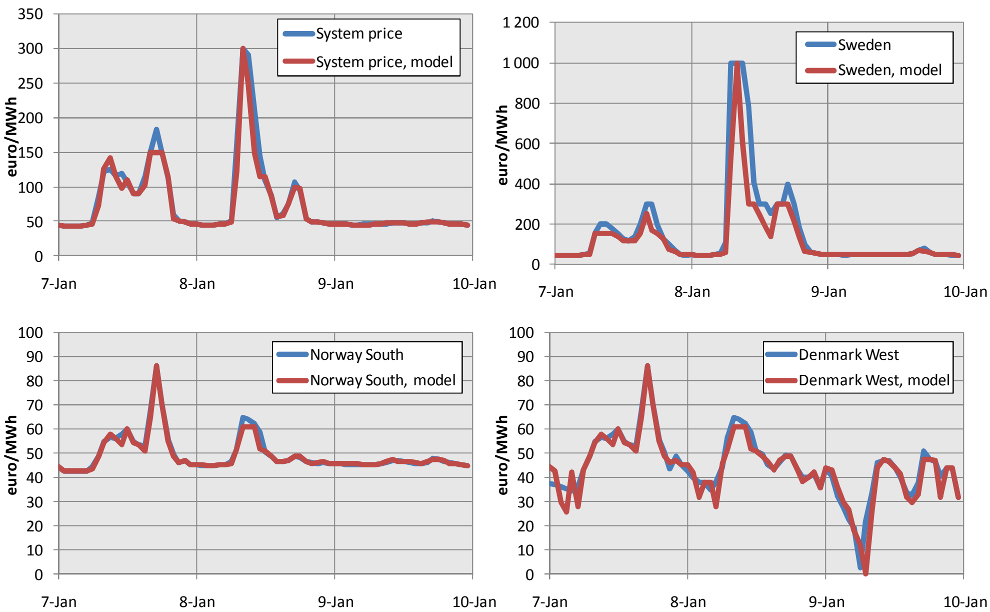

Figure 4.2. *Actual prices compared to model prices during 7 Jan 2010 – 9 Jan 2010 (note scales).*

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[55] The technical modeling of the ramping restrictions was beyond the scope of this project. The effect is relatively small and affects only time periods when transmission volumes have been changing quickly.

[56] In practice, this affects only the transmissions to Germany as other transmission capacities do not affect price formation directly. Transmissions from other countries are handled by bilateral agreements outside Nord Pool spot. The volumes from Germany have been fixed to the same level that they actually affected the price formation.

[57] Data was also received for the periods 16–18 December 2009 and 21–23 February 2010. Though the modelling of the spot price remains the same, the extensive effort required to convert data from Nord Pool to the model prohibited analysis of all three cases given the time and resources for the study.

Deviations between actual prices and model prices are greatest when there are large price differences. This is to be expected, because the deviations are a result of the modelling simplifications, more specifically the omission of transmission ramping restrictions and the simplification in block bid calculation. Note that for example for the Swedish area price, the differences in prices are big when the prices are high. Despite this the difference in volumes are relatively small. The phenomenon reflects the shape of the bidding curves: very small changes in volumes can have large price impacts.

4.3.3 Effect of capacity variation in the Hasle-corridor

Hasle-corridor connects southern Norway and Sweden. During the peak price hours in 8 January 2010, the transmission capacity allocated to the spot price calculation was reduced to zero. In this section, the effect of increased transmission capacity is studied.

Figure 4.3 shows the capacity available through Hasle-corridor from Southern Norway to Sweden in Nord Pool spot price calculation on 8 January 2010. The allocation is based on the decisions of the TSOs and made prior to the spot price calculation. During the day time the maximum capacity in the spot price calculation was set to zero. The figure shows also the actual flow from Southern Norway to Sweden during that day. At noon the actual flow exceeds 400 MW.

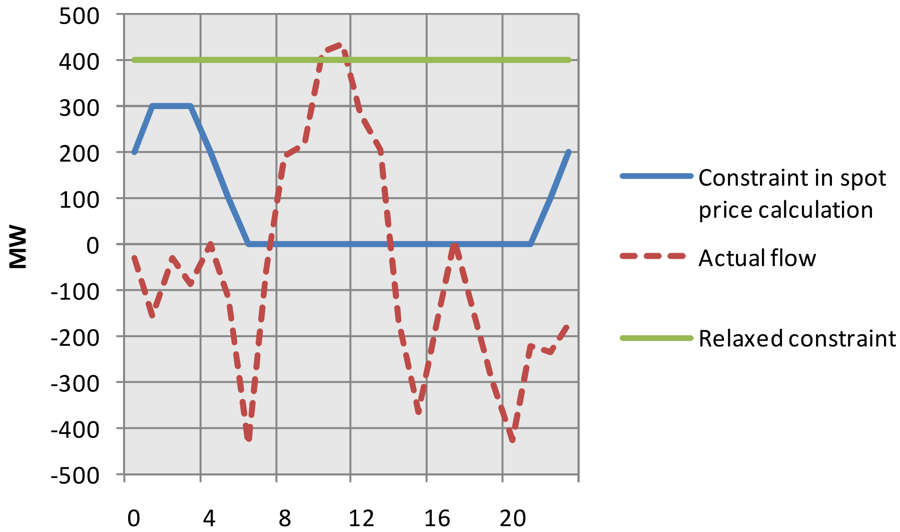

Figure 4.3. *Transmission capacity allocated to the spot price calculation (blue line), actual flow of electricity (dotted red line) and relaxed model constraint (green line) in the Hasle-corridor on 8 January 2010.*

We test the impact if the capacity of 400 MW would have been available in Nord Pool Spot for price calculation during the entire day of 8 January 2010. Model area prices with the same constraints that were used in Nord Pool Spot ranged from 61.1 €/MWh in Southern Norway and Western Denmark to 1000.1 €/MWh in other price areas for the hour in question. With relaxed capacity of the Hasle corridor, the range of area prices became 100.0 €/MWh to 401.4 €/MWh.

Prices in Sweden, Finland, Central and Northern Norway and Eastern Denmark dropped and the prices in Southern and Western Denmark increased. Hence, a relatively small relaxation in the bottle neck resulted in major changes in area prices.

4.3.4 Endogenizing capacity of the Hasle corridor

In this section, the impact of endogenizing capacity of the Hasle-corridor to spot price calculation model is analyzed. In this experiment, the capacity constraint and spot price are calculated at the same time. The transmission capacity of the Hasle-corridor from Southern Norway (NO1) to Sweden (SE) depends on the load in the Oslo area; see Figure 4.4.

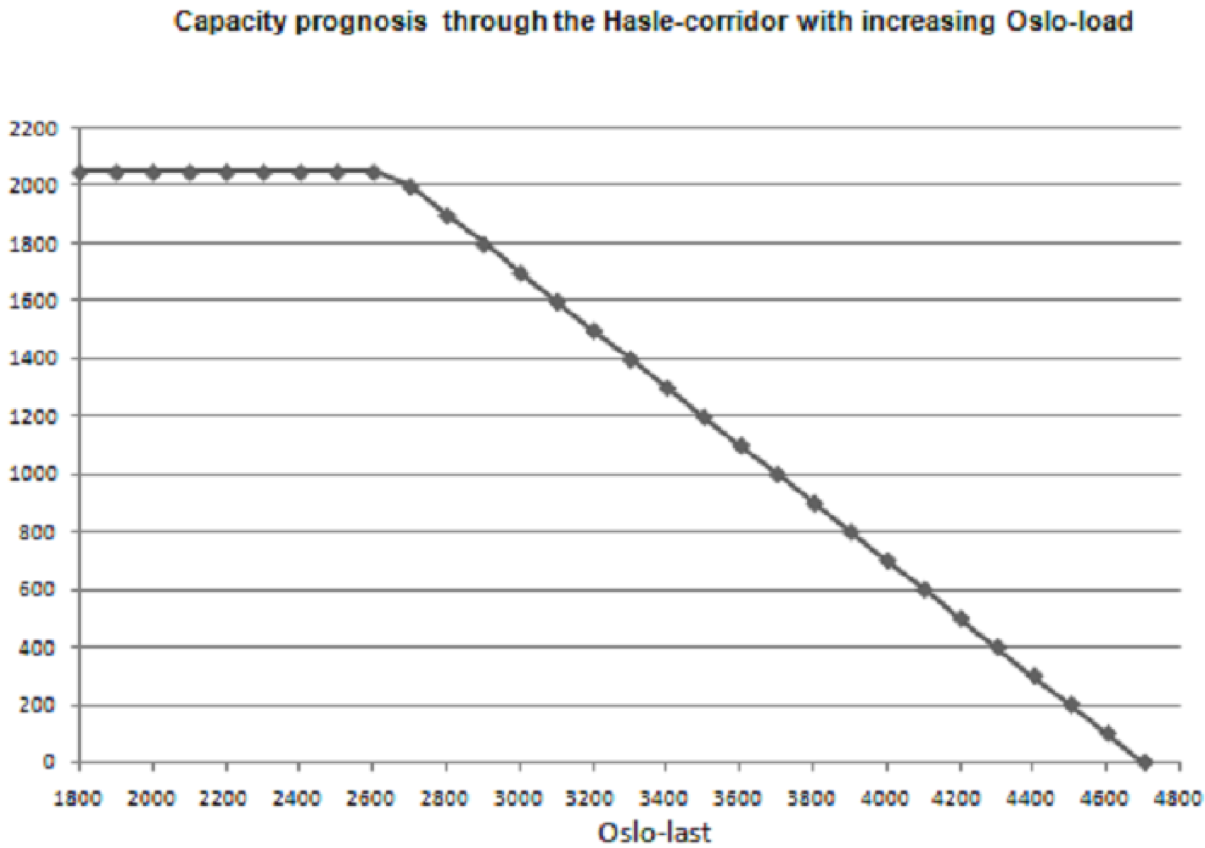

Figure 4.4. *Transmission capacity allocated to Hasle-corridor with increasing load in the Oslo area.*

The transmission capacity available for Nord Pool spot price calculation is determined on the basis of the prognosis of the Oslo load. Employing an additional transmission constraint, we implement the rule of Figure 4.4 and determine the capacity of the Hasle-corridor simultaneously with price calculation[58]. While actual area prices ranged from 61.1 to 1000.1 €/MWh, with endogenized capacity of the Hasle corridor, the range became from 97.0 to 609.5 €/MWh.

Again, prices in Sweden, Finland, Central and Northern Norway and Eastern Denmark dropped and the prices in Southern and Western Denmark increased. Hence, the impact is quite significant although weaker than in the relaxation case described in the previous section.

[58] The modeling is based on the demand in the NO1 area, as there were no detailed data of which bids were from the Oslo area. Volume dependency for NO1 area corresponding to the Oslo dependency was modeled with the help of actual consumption in NO1 and actual flow to Sweden.

4.3.5 Variations in price elasticity of demand

This section presents the results from an empirical analysis with the price model. The sensitivity of price calculation was tested with respect to variations in price elasticity of demand.

The price elasticity of demand is relative change in demand divided by the relative change in price. During the observed peak hours, demand elasticity is close to zero. This means that large changes in price have limited effect on demand volume. We test an increment of elasticity by factor 10 by turning the price function to become less steep. In particular, we turn the graph around the point with a reference price m=50 euro/MWh. Then for a bid to buy with bid price p, the revised bid price becomes p+(p-m)/10. Hence, for p>m, the revised price is less than p, and for p<m, the revised price is greater than p.

Table 4.1 shows the result for the price peak day of 8 January 2010 with actual average daily price in the Nord Pool spot model, average daily price resulting from modified price functions, relative change in average price, and relative change in quantity of electricity bought. Due to elasticity increment, the decrease in average price over all Nordic areas is 37 %. In low price areas NO1 and DK1 the price change is insignificant because the actual prices in these areas are close to the reference price m.

Table 4.2 shows corresponding result for 9 January 2010, which represents a more typical day with respect to price levels. In this case average area prices in Nord Pool spot were close to the reference price m. Therefore, elasticity increment in this case did not have a significant impact in area prices. Note that turning of price function at price level m increases demand at prices less than m. This explains the overall increase in quantity by 4.8 %

Table 4.1. *Effect of 10 times increase in demand elasticity on 8 January 2010, when the prices peaked.*

	daily average price (€/MWh)		relative change (%)	
area	actual*	modified**	price	quantity
se	223	135	−39	−0.4
fi	218	132	−39	0.6
dk1	47	46	0	0.2
dk2	237	142	−39	0.0
no1	49	49	1	8.3
no2	214	130	−39	1.3
no3	207	123	−40	−0.2
total	173	109	−37	1.9

* actual price in Elspot   ** price after incrementing elasticity

Table 4.2. *Effect of 10 times increase in demand elasticity on 9 January 2010, with typical price level.*

	daily average price (€/MWh)		relative change (%)	
area	actual*	modified**	price	quantity
se	49	49	1	0.4
fi	49	49	0	3.3
dk1	36	36	0	0.0
dk2	49	50	0	0.0
no1	46	48	4	15.9
no2	49	50	2	6.0
no3	49	49	1	1.3
total	48	48	1	4.8

* actual price in Elspot   ** price after incrementing elasticity

4.3.6 Impact of decreased supply

In this and the following section, the empirical model is used to test for possible incentives of exploiting market power.

A decrease in supply tends to increase market price. Is it profitable for producers, given that prices increase but quantities decrease? We carry out a crude test by decreasing supply by 1 %, the same percentage for all bids to sell.[59]

Table 4.3 shows the result for 8 January 2010. Due to decreased supply, the increase in average price over all Nordic areas is 28 % while the quantity only decreases marginally. Consequently, the total producer surplus increases by 19.8 % indicating a strong incentive for producers to adjust supply. However, during a normal day of 9 January 2010 in Table 4.4, the increment in producer surplus is only 0.3% referring to a much weaker incentive compared to the case of 8 January 2010.

[59] Note that this does not take into account the differences of individual suppliers' production capacities and production costs.

Table 4.3. *Effect of decreased supply of all supply bids by -1 % on 8 January 2010.*

area	daily average price (€/MWh) actual*	modified**	relative change (%) price	quantity
se	223	292	30	−0.1
fi	218	284	30	−0.2
dk1	47	51	8	0.0
dk2	237	310	30	0.0
no1	49	52	6	−0.1
no2	214	279	30	−0.2
no3	207	274	32	−0.1
total	173	223	28	−0.1
increase in producer surplus (%) =				19.8

* actual price in Elspot ** price after decreased supply

Table 4.4. *Effect of decreased supply of all supply bids by -1 % on 9 January 2010.*

area	daily average price (€/MWh) actual*	modified**	relative change (%) price	quantity
se	49	51	4	0.0
fi	49	51	4	−0.1
dk1	36	38	5	0.0
dk2	49	52	4	0.0
no1	46	46	0	−0.0
no2	49	51	3	−0.9
no3	49	50	3	0.0
total	48	49	3	−0.1
increase in producer surplus (%) =				0.3

* actual price in Elspot ** price after decreased supply

4.3.7 Impact of increased demand

An increase in demand tends to increase market price; see Figure 4.5. In the normal situation on the left, the intersection of the price function E and supply function U leads to a normal market price P_N. On the right, the price function is shifted to the right revealing an extreme demand situation, and at any price level, there is an increase in quantity compared with the normal situation. The resulting market price P_E is much higher than P_N.

Due to vertical integration, firms may submit bids to buy in Elspot, and sell for free in Elbas the quantities bought. Thereby there is an increase in demand and it tends to increase market price. Again, we carry out a simple test of increasing demand by 1 % to see if it profitable for firms.

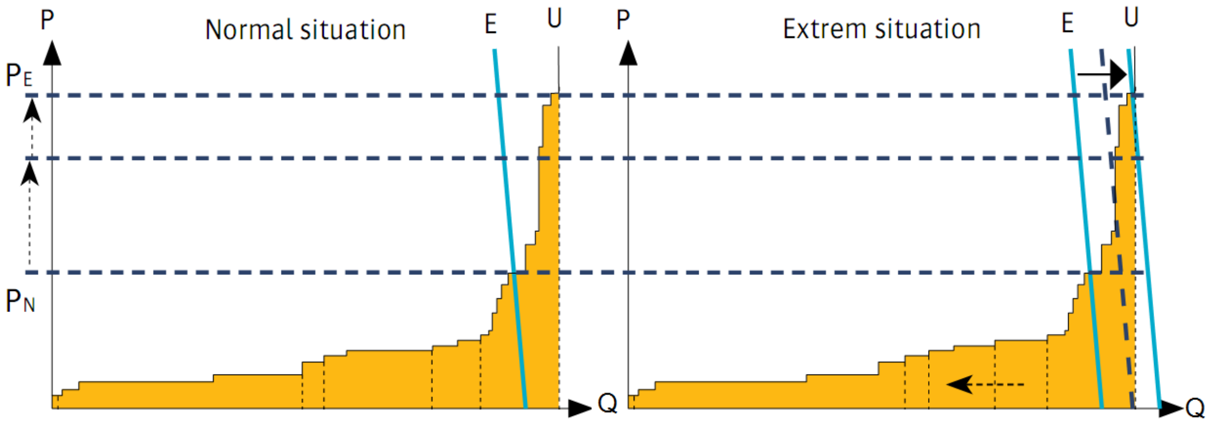

Figure 4.5. *Impact of increased demand in market price.*[60]

Table 4.5 shows the result for 8 January 2010. Due to increased demand, the increase in average price over all Nordic areas is 28 %, the quantity increases almost by 1 % and the total producer surplus increases by 20.0 %. Again, there is a strong incentive to adjust demand during such tight day in the market. For a normal day of 9 Jan 2010 in Table 4.6, the increment in producer surplus is only 0.9 % referring to a weak incentive.

[60] Picture modified from Energimarknadsinspektionen, Halvårsrapport om elmarknaden oktober–mars 2009/2010 (*in Swedish*), EI R2010:09.

Table 4.5. ***Effect of increased demand in all demand bids by +1 % on 8 January 2010.***

	daily average price (€/MWh)		relative change (%)	
area	actual*	modified**	price	quantity
se	223	292	30	0.8
fi	218	285	30	0.7
dk1	47	50	7	1.0
dk2	237	310	30	1.0
no1	49	51	5	0.8
no2	214	280	30	0.7
no3	207	273	31	0.9
total	173	223	28	0.9
increase in producer surplus (%) =				20.0

* actual price in Elspot   ** price after increased demand

Table 4.6. *Effect of increased demand in all demand bids by +1 % on 9 January 2010.*

	daily average price (€/MWh)		relative change (%)	
area	actual*	modified**	price	quantity
se	49	51	4	1.0
fi	49	51	4	0.9
dk1	36	36	1	1.0
dk2	49	52	4	1.0
no1	46	46	0	0.9
no2	49	51	4	−0.1
no3	49	50	3	1.0
total	48	49	3	0.9
increase in producer surplus (%) =				0.9

* actual price in Elspot   ** price after increased demand

4.4 Possible future uses of the model

Many issues could be addressed using the experimental model or its variations. Naturally, the other price peak day cases of 17 December 2009 and 22 February 2010 could be analyzed similarly as the 8

January 2010 in this Chapter. However, it seems unlikely that much new would be discovered from the basic dynamics of the model. More important issues concern, for instance,

- Other regional subdivisions; for example, Sweden subdivided into four areas as of 2011, and integration of European price regions.
- Impacts of grid investments; see e.g., Nordic Grid Master Plan 2008.
- Simultaneous price-capacity-calculation with bids to be submitted by nodes of the transmission grid.
- Testing discriminatory price auctions where prices of buyers and sellers are not uniform within areas.
- Testing oligopolistic market models; Cournot equilibrium, conjectural variations' equilibrium.

4.5 Summary and conclusions

This Chapter discusses the theory and some numerical properties of the Nord Pool Spot model.

Competitive equilibrium is the basic underlying principle in Nord Pool Spot in allocating the bids and the transmission capacity to production, consumption and bilateral trade among areas. Traditionally, such spatial equilibrium is computed maximizing the total producer and consumer surplus and the equilibrium prices and quantities are obtained from optimal solution of this maximization problem. However, in Nord Pool Spot there are complicating constraints, binary choices, which require that block bids can only be accepted at 100% level of bid quantities or rejected completely. This leads to a combinatorial equilibrium problem. Simple examples show that such block bid requirements can, in theory, result in an increase in market price and in producer surplus. Also nesting conditions can further increase prices and producer surplus.

An experimental Elspot model was implemented for numerical analysis. For model validation, the Elspot prices were replicated in the 72 hour period of 7–9 January 2010, one of the periods with peak prices of electricity. Sensitivity analyses were carried out for the same 72 hour period.

Transmission capacity was varied in the bottle neck connection between southern Norway and Sweden. During the peak price day of 8 January 2010, actual capacity in Elspot was zero during the hours 7-22. Small relaxation of this capacity had a major impact in market prices. Similar impact was achieved, when the capacity of this bottle neck was determined simultaneously with price calculation.

Tests concerning the sensitivity of price calculation with respect to variations in price elasticity of demand indicated a major impact in market prices during 8 January 2010, a tight market day. However, during a more normal day of 9 January 2010, such impact was much weaker. Tests concerning variations in supply and demand indicated strong (weak) incentives of exploiting market power during 8 January 2010 (9 January 2010).

Possible future studies may concern changes in regional subdivision, simultaneous price-capacity-calculation, impacts of grid investments and alternative auction mechanisms.

5 Planned and upcoming changes

5.1 Transmission and grid capacity

The prevailing model for the TSO mandate in the Nordic region is that TSOs are obliged to perform grid investments in accordance with a socio-economic criterion. For the purposes of a common Nordic market, the criterion should be Nordic benefit, but in practice investments are approved in national processes.

Several transmission grid investments are being carried out and others are planned. Table 5.1 presents the estimated increases to net transfer capacities by 2015. These investments are in line with earlier plans to strengthen the grid capacity.[61]

Table 5.1. *Estimated changes in Net Transfer Capacities by 2015.*[62]

Reinforcement	Estimated time of completion	Total NTC between areas	Change	Resulting	Status/Notes
Great Belt HVDC link 600 MW	2010	DK1 → DK2	+600	600	Procurement finished
		DK2 → DK1	+600	600	
Fenno-Skan 2 HVDC link 800 MW	2011	SE → FI	+500	2550	Procurement finished
		FI → SE	+800	2450	
Estlink 2 HVDC link 650 MW	2014	EE → FI	+650	1000	Preliminary agreement signed
		FI → EE	+650	1000	
Jutland - Germany	2011	DK1 → DE	+500	2000	Letter of intent
		DE → DK1	+550	1500	
Ørskog - Fardal 420 kV AC	2014	NO → SE	+200	800	
		SE → NO	+200	800	
Oslofjord cables	2012	NO → SE		2050	Will increase capacity up to former
		SE → NO		2000	levels and increase time of maximum
Skagerrak IV HVDC link 600 MW	2014	DK1 → NO	+600	1550	License application
		NO → DK1	+600	1600	
South-West link 400 kV	2015	SE → NO			Letter of intent
		NO → SE			

A new connection with a capacity of 600 MW has been opened between Eastern and Western Denmark in August 2010[63]. This would have limited the area price differences during the peak price situations of last winter as Western Denmark was a low price area and Eastern Denmark a high price area.

[61] Report from the Nordic Competition Authorities, Capacity for Competition – Investing for an Efficient Nordic Electricity Market, 2007.

[62] ENTSO-E, Estimated NTC Capacities 1.1.2015, updated 20 April 2010, available through Nord Pool Spot, www.nordpoolspot.com.

[63] Nord Pool Spot, Exchange Information No. 27/2010 NPS - Market framework for the Great Belt Power Link, 15 April 2010.

5.2 Nord Pool market

5.2.1 New market areas and connections

Nordic market is in continuous change. The changes relate to the development of the Nordic market and the increased market integration with continental Europe.

Since the price peaks of last winter, the market has already experienced some changes. The price areas in Norway have been changed to deal with major and long-term congestions in the regional and central grid system. Norway has currently five price areas.[64] These changes have divided Norway to more price areas that should in theory make it at least more transparent with regard to the transmission bottlenecks.

Estonian market was connected to the Nordic market on 1 April 2010, and further integration with the Baltic market is expected.[65] This change would have had a limited effect on the prices as the import capacity from Estonia was at full capacity in any case during the high price situations.

A major development in the year 2011 will be the division of Sweden into four different price areas as of 1 November 2011. The measure is based on an EU Commission decision made in April 2010. The EU Commission deemed Sweden’s internal congestion management discriminatory to customers outside Sweden.[66] The change can have a significant impact on market dynamics.

With regards to the European integration, transmission system operators (TSOs) of the Central West Europe and Nordic Regions are implementing market coupling for day-ahead markets. Market coupling is a method whereby TSOs and power exchanges cooperate in matching day-ahead energy trades and cross-border transmission capacities in one integrated process. The objective is to ensure an efficient use of interconnection capacity and to give the right price signals and flows across the coupled area.[67]

Further market integration is expected as three market exchanges are looking for a deeper European integration. If successful, the electricity price formation will in the future be coordinated in Portugal, Spain, France, Germany, Austria, Switzerland, Denmark, Norway, Sweden, and Finland.[68]

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[64] Statnett, In Exchange Information No. 11/2010 NPS - New Elspot/Elbas bidding area in Norway, Nord Pool Spot, 23 February 2010.

[65] Nord Pool Spot, No. 24/2010 NPS – Estonian market successfully opened during Easter, 6 April 2010.

[66] Svenska Kraftnät, In Exchange Information No. 33/2010 NPS - Svenska Kraftnät decides on implementation of four bidding areas, Nord Pool Spot, 25 May 2010.

[67] Nord Pool Spot, Exchange Information No. 42/2010 NPS - CWE/Nordic coupling joint target launch date, 29 July 2010.

[68] Nord Pool Spot, Exchange Information No. 82/2009 Cooperation of Power Exchanges on European Price Coupling Concept, 5 October 2009.

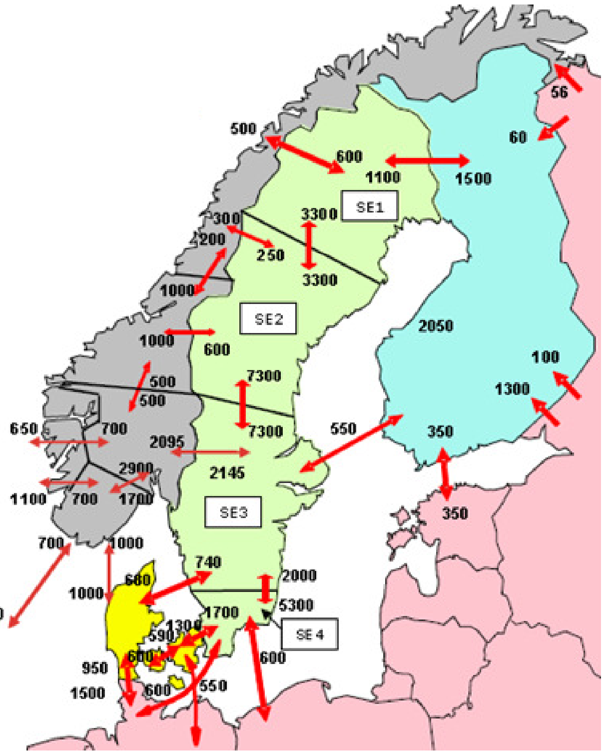

Figure 5.1. *The figure shows the maximum net transfer capacities after Sweden has been subdivided into four bidding zones from 1 November 2011.*[69]

5.2.2 Changes to market information

Transparency is needed in order to achieve well-functioning, efficient, liquid and competitive wholesale markets. Timely and correct market information is needed by market actors to follow the electricity market, to make the correct decisions and manage their business risks properly.

Nord Pool has been in the process of increasing available market data. The development is not directly linked with peak prices situations of last winter and has started earlier. The new data which has been added during 2010 includes:

- Consumption and production forecasts for the Nordic area
- Imbalance price for consumption (balancing power)
- Wind power forecast and realized wind power production
- Detailed data related to the system price curves

The system price curves are published on the same day as the auction takes place. The price curve information includes numerical data, which makes it possible to render the complete curves.

Nord Pool is launching an improved website in 2010, which is intended to contribute to greater transparency and easier access to data. However, no major changes to actual published information are planned at the moment.

[69] Source: ENTSO-E. Note that values for interconnectors to other countries might change before this date.

6 Conclusions and recommendations

These conclusions and recommendations have been made on the basis of the study made on the peak price situations during winter 2009–2010 and analysis on the Nordic electricity market model and key upcoming developments. During the study, TSOs in the Nordic countries, Nord Pool, and selected other market participants have been interviewed. In addition, Nordic power market regulators and competition authorities in the steering committee have been able to comment on the conclusions and recommendations. However, these conclusions and recommendations are made independently by Gaia Consulting Oy and do not necessarily reflect the views of any other parties.

6.1 Key learnings from the winter 2009–2010

Cold weather lead to a high demand

Nordic temperatures were below average for extended periods of time in the winter of 2009–2010. For instance January 8, one of the peak price dates studied, the temperatures in the Nordic countries were 10–12 degrees below average. As a result of cold weather experienced during an extended period of time, electric heating consumption lifted the overall consumption of electricity in the Nordic region. The consumption levels were high even historically, despite the global downturn and reduced industrial consumption.

Problems with Swedish nuclear power resulted in low supply

The low availability of Swedish nuclear power reduced the available supply during the whole winter 2009–2010. On average, only 61 % of Swedish nuclear power was available during the winter period between October and March.

The low availability was the result of the fact that many revisions of nuclear plants had been planned for the spring and summer of 2009 and that these had not been completed before the winter period.

High demand and low supply lead to high prices

Electricity supply needs to meet demand at all time points. In the deregulated Nordic markets, each producer makes independent business decisions on generation capacity investments and each consumer decides on investments to demand flexibility[70]. The deregulated Nordic model assumes that new investments are made on the basis of price signals received from the market.

High prices are *the one and only* market mechanism that should steer both supply and demand side investments in the current market model. Therefore, fundamental contributors to the price peak situations during the winter 2009–2010 were the high demand and low supply.

[70] Investments are used here in a broad sense to mean investments to physical equipment or investments to changes in processes or behaviour.

Nordic transmission bottlenecks lead to high area price differences

The internal capacity between some Nordic price areas was scarce and resulted in very high price differences between the price areas. As an example, a relatively small increase in transmission capacity from Southern Norway to Sweden would have resulted in significantly lower area price differences during the times of highest peak prices according to the model analysis. Prices in Eastern Denmark, Finland, Central and Northern Norway and Sweden would have been reduced, and price in Southern Norway and Western Denmark increased.

Some steps have already been taken to increase transmission capacity from the low price areas to the high price areas. New transmission link between Eastern and Western Denmark can help to reduce as high area price differences as seen during winter 2009–2010 in the future.

The effect of counter trading within price areas is unclear from this study. As for example Sweden has been only one price area, there have been problems with more production in the northern parts of Sweden and more consumption in the southern parts of Sweden. The TSOs have their internal procedures to carry out counter trading, but these are not transparent.

Current market model can have some misaligned incentives

Transmission capacities between the areas are allocated by the TSOs. The allocation is based on consumption and production prognosis. During the peak price situations the allocation principles affected especially transmission between Southern Norway and Sweden. The consumption prognosis in the Oslo region affects capacity allocation when temperatures are low. Higher consumption in the Oslo region reduced cross border transmission capacity between Southern Norway and Sweden.

During the peak price hours of 8 January 2010, no transmission capacity was allocated for the Nord Pool spot market between Southern Norway and Sweden by the TSOs. Partly as a result of low transmission capacity, the area price differences were high. The area price for Southern Norway was 65 euro/MWh, while the price in neighbouring Sweden and most other areas was 1000 euro/MWh.

With the current system of allocating the transmission capacity beforehand, Southern Norway did not have economic incentive to reduce consumption while the other price areas had high prices on 8 January 2010. If there is no transmission capacity between the regions, the supply and demand decisions of the regions do not affect each other. If some transmission capacity would have been available, it would have been used to export electricity from the cheaper Southern Norway price area to the higher priced Swedish price area. This export would have competed with the local demand in Southern Norway and would have resulted in higher prices in Southern Norway and lower prices in Sweden[71].

In case there are price area differences, TSOs receive bottleneck income that is based on the difference between the area prices. Unless this income is clearly directed to reduction of bottlenecks, the TSOs have limited incentive to reduce bottleneck as they would reduce their source of income at the same time.

[71] And through Sweden, lower prices also in other high price regions.

According to the model analysis, suppliers and vertically integrated market participants have strong incentives to reduce supply or increase demand during high price situations. This seems to be mainly a result of lack of demand response to high prices. A large part of Nord Pool spot demand is purchased at any cost.

It should be noted that no analysis of individual market participants has been made in this study and no implications are intended. The point of view here is that regulation should ensure that market incentives are aligned to the direction of well-functioning, competitive Nordic market.

Smart metering and demand flexibility are not fully used

Most household consumers in the high price areas have fixed price contracts, which give weak incentives to reduce consumption in situations when the system is under stress.

In Finland, the consumption for most of the fixed priced end user contracts is still based on a load profile system developed in the 1990's. During cold temperatures, the mathematical temperature correction in the load profile system seems to lead to an overestimation of demand. However, retail companies are obliged to bid according to the load profile scheme to meet current regulations. At least in theory, this leads to inflated demand and higher than necessary spot prices. Installed household smart meters provide in principle a more accurate solution to the problem. The progress to take the smart meters in use has been slow although the problems have been known for a long time[72].

Also in Sweden, the current legislation requires that all retail companies follow monthly measurements. Therefore the costs of hourly peak prices cannot be accurately directed to those causing the actual demand, and incentives to reduce consumption at high prices are reduced.

Market required the use of peak load reserves

Peak load reserves were activated in Sweden and Finland in all three peak price situations during the winter 2009–2010. Peak load reserves in Sweden and Finland receive a compensation to keep them available in case the normal market mechanisms are unable to match supply and demand.

Peak load reserves are typically gas and oil turbines that have a high marginal production cost. They do not run under normal price levels. If they are needed, the current rules stipulate that peak load reserves are added to the Nord Pool spot price calculation at the level of last market based bid.

6.2 Actions to relieve peak price situations

Increase market transparency

Nord Pool already provides a lot of market data. However, current publicly available data has three major drawbacks:

[72] See for example Helsinki Energy, Helen – Lehti Sidosryhmille (*In Finnish*) 3/2008.

- Market participants seem still to be in unequal position. Those that control larger production and/or consumption array have more detailed and more real-time knowledge on the market than those participants that have more limited or no physical assets.
- The scientific community does not have enough access to data to make independent analysis on how the market operates. Independent and transparent monitoring by the academic world is crucial to ensure that the behaviour and incentives of market participants follow the market rules and regulation.[73]
- The analysis of current market data is cumbersome. The amount of provided data is huge, but available for limited time, and contains some inconsistencies and errors[74].

This report cannot take position in how much and what data exactly should be made public. The exact decisions should be made carefully, as too much public data could lead to the possibilities of collusion. The risk of collusion is further emphasised as both the demand and supply structures change relatively slowly over time. However, the risk of collusion should be weighed against the current information asymmetry that favours larger market players. Data that could be considered to be published includes area price level bidding curves with some delay and a combined real time situational overview of production and transmission availability.

One area where transparency could clearly be improved is the actions and decisions taken by the TSOs and Nord Pool. These include for example on what socio-economic basis transmission capacity allocation decisions are made and how counter trading and peak load affect other parts of the market.

Activate demand flexibility in the spot price market

According to the model analysis, increased demand flexibility could have a sizeable impact especially on high price situations. The demand flexibility should increase as a result of the high prices, because there is a clear incentive for them to do so.

Demand reductions are the easiest way to influence pricing in situations where production capacity is approaching levels when peak load reserves are needed, as for instance during the peak hours in the winter of 2009-2010. Demand reductions can be industrial disconnectable load, which is an easy way to reduce consumption or it can be reductions of electricity consumption by households, mainly by reduced electricity heating at peak hours.

The regulator needs to follow the development of demand flexibility carefully. Demand flexibility is not beneficial for all market participants. In the case of distribution companies, the profits of the companies can be indifferent or negatively affected by allowing customers to exercise demand

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[73] Also, the necessary background data for analysis is not available from public sources. These data include for example temperature data, hydrological inflow data, and sectoral consumption data. It should be noted that the analysis of such data is currently being made on commercial basis by independent private companies, but the costs of data can be prohibitive e.g. for academic studies.

[74] Data in general is available only for the past three years. Examples of inconsistencies and technical errors include several different names used for same facilities in the UMM database, consumption prognosis data has errors, data is presented in various and changing formats, changes in area price structure require cumbersome recalculations, etc.

flexibility in their market area. According to the model analysis, vertically integrated retail companies do not necessarily have incentives to increase demand flexibility and reduce high prices.

One of the key arguments for smart metering and hourly measurements is the ability for consumers to have more control over their electricity consumption. However, there is currently no guarantee for the consumers to utilize their smart meters to benefit from demand reduction during high price situations. The lack of market based solutions can motivate regulatory actions if the market is considered to function in a suboptimal manner.

Until the hourly measurements are activated in the balancing calculations, the Finnish load profile system should be studied in detail. Revisions to the system should be made if it indeed causes an automatic demand overestimation in the spot price calculation and inflates the prices artificially. The apparent lack of industrial demand flexibility in the spot market and some of the phenomena seen on the after spot balancing should be studied in more detail. In addition to the regulatory and technical changes, demand flexibility could be increased through increased awareness. This however, is not a necessarily task for the regulators.

Prepare for long-term market changes

The Nordic market seems to have been unprepared for a situation like the winter 2009–2010. While of course not foreseen beforehand, the problems with the Swedish nuclear power did not occur for the first time, nor did the cold weather. Future energy market is facing unprecedented changes as climate change mitigation aims to increase both energy efficiency and carbon free production. The effects of these plans should be analysed on Nordic level in conjunction with the planned transmission and other investments.

Ensure correct market incentives for TSOs

Bottlenecks in the market create income for the Transmission System Operators (TSOs) that are responsible of the border transmissions. If this bottleneck income is not earmarked for new transmission capacity investments to reduce the bottlenecks in question, the TSOs do not have economic incentives to reduce bottlenecks and their own income.

For the common market area, a key issue regarding grid investments is that the Nordic (European) value of such investments must be visible to the TSO and the country that is making the investments.[75]

TSOs have the authority to determine transmission capacity for the Nord Pool spot price calculation. The capacity allocation is made on the basis of the principles agreed with the regulators and the TSOs. However, TSOs have no responsibility for the capacity allocation decisions and the consequences for the market price levels and are price differences. Currently TSOs are making decisions on balance between the system security and transmission related costs without having to bear the costs. The principles used in decision making could be reviewed to ensure that the balance is as intended.

[75] For further details see e.g. NordReg, Grid investments in a Nordic perspective, Report 3/2010.

Consider alternatives for peak reserve capacity

Normal Nord Pool market mechanism failed to provide an equilibrium market price on the three high peak price situations. As a result, TSOs activated peak reserve capacity to ensure the functioning of the market.

According to the current rules, the peak reserve capacity enters the market at the level of the highest market supply bid. This guarantees that all suppliers' bids are accepted. The system is motivated by that it should maintain the incentives for new capacity investments. However, it also creates opportunities for the suppliers. For example, an arbitrarily small volume bid at or close to maximum price can lift prices in the case peak reserves are activated. Also, the model calculations seem to indicate current suppliers do not have an incentive to invest in capacity that could reduce peak prices in any case.

For the consumers at large, it could be beneficial to pay the peak reserve capacity rent and to bid it to market at marginal cost, if they avoid peak price situations by doing so.

One alternative for the current peak reserve capacity system could be an introduction of a capacity market, whereby the current system could be made more transparent and open. Another alternative is to include the peak reserve capacity to the market bidding at some relevant cost level. While these alternatives could alleviate peak price formation, they could endanger the incentives for new capacity investments. In any case, the issue seems to warrant a further study.

Consider stricter regulation of revisions and maintenance

Low availability of nuclear power was a major contributor to the high prices. Technical problems in two cables contributed to the high differences in area prices. In both cases, the current market model would seem to give some adverse incentives for the suppliers and TSOs.

If the market incentives seem to be uncertain, and correct market incentives cannot be guaranteed, the regulator could take a more active role in verifying that revisions and maintenance work are carried out without unnecessary delays. A light version is to collect information of all production and transmission revisions and to coordinate possible times of scarcity.

Consider to include capacity allocation to the pricing model

Current Nordic market model assumes that TSOs are able to take care of internal congestions within the price areas and to make optimal transmission capacity allocation decisions. The benefit of the current system has been a relatively common system price that has supported for example the development of the financial market and risk management tools.

However, some of the identified problems during the high price situations are related to the current market model. An alternative would be to include physical transmission contracts to the spot price calculation. Thereby the price in each smaller market area, or a node, should reflect more accurately the true costs of production, consumption, and transmission. If the problems with the current market model warrant it, the topic should be studied in detail to create a balanced view on the costs and benefits of such a change.

Consider alternative market models

Nordic market model is based on the assumption that market prices give signals for market participants to make investments. High peak prices should encourage new investments to meet these peak prices.

Even though they are an expected result in the current market model, high prices raise two considerations. Firstly, there have been high price situations in the past. Secondly, the model calculations indicate, that suppliers have incentives to withhold production during high prices. Both of these considerations should be analyzed in detail to determine if the current market model delivers the promise of enough market based investments.

There is a wide range of alternatives for the current spot price market model. For example, discriminatory auctioning could reduce the potential market power in the case of high prices or an additional capacity market could provide more transparent set of incentive compared to current peak reserve system. As with the case of nodal pricing model above, these should be studied in more detail to ensure that they would meet the objectives for the well-functioning market better than the current system.

It should also be noted, that with the ongoing integration to with the Nordic and European markets, the possibilities of independent changes become more limited. On the other hand, this can also give the Nordic countries an opportunity to continue as a frontrunner in deregulated electricity markets.

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