

The Nordic Electricity Exchange and The Nordic Model for a Liberalized Electricity Market



1 The market

When the electricity market is liberalized, electricity becomes a commodity like, for instance, grain or oil. At the outset, there is – as in all other markets – a wholesale market and a retail market and there are the three usual players: the producers, the retailers and the end users.

However, for electricity, a more advanced trading pattern quickly develops. New players enter the scene: the traders and the brokers (Figure 1).

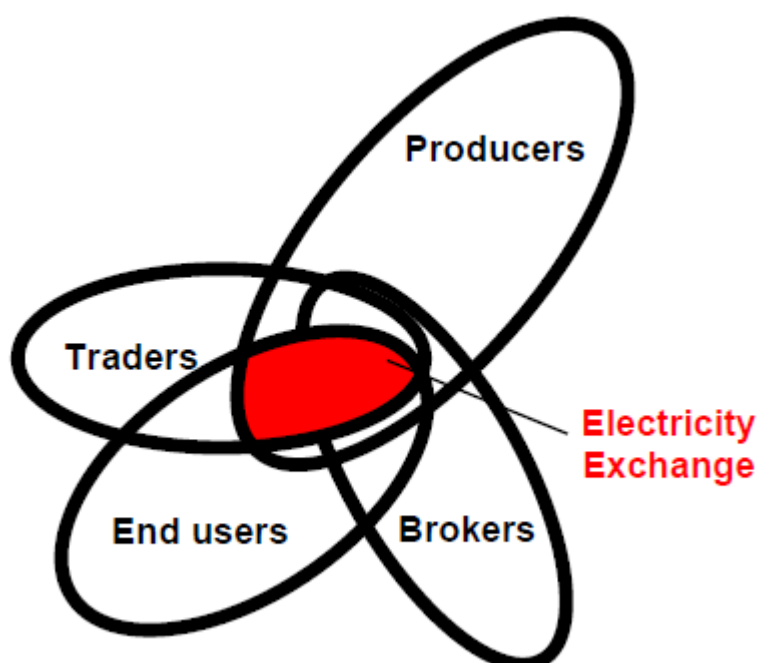


Figure 1: The commercial players and the electricity exchange

A trader is a player who owns the electricity during the trading process. For example, the trader may buy electricity from a producer and subsequently sell it to a retailer. The trader may also choose to buy electricity from one retailer and sell it to another retailer and so forth: there are many routes from the producer to the end user.

The brokers play the same part in the electricity market as the estate agent in the property market. The broker does not own the commodity – he acts as an intermediary.

A retailer may, for example, ask the broker to find a producer who will sell a given amount of electricity at a given time.

The Nordic electricity exchange Nord Pool Spot covers Denmark, Finland, Sweden, Norway and Estonia. Nord Pool Spot is an exchange primarily servicing the players at the wholesale market for electricity. The customers on Nord Pool Spot are the

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producers, retailers, and traders who choose to trade on the electricity exchange. In addition, large end users trade on the electricity exchange. In this article, the term “the Nord Pool Spot exchange area” denotes Denmark, Finland, Sweden, Norway and Estonia.

2 The Point Tariff System

In Figure 2, the water illustrates the electrical power and the walls of the tanks illustrate the transmission grid.

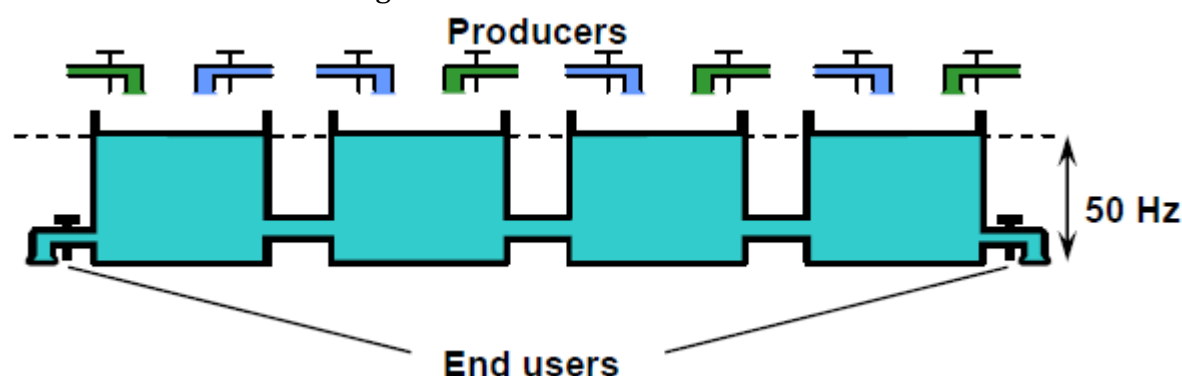


Figure 2: Illustration of the Nordic Point tariff system

The idea of the system of point tariff is that the producers pay a fee to the grid owner for each kWh they pour into the grid. Correspondingly, the end users pay a fee for each kWh they draw from the grid.

This means for example, that a retailer in Southern Sweden may buy electricity from a producer in Northern Sweden. Of course, such a deal does not cause the producer’s electricity to travel all the way from Northern Sweden to Southern Sweden. The principle is simply that for each hour somewhere a producer has to pour an amount of electricity to the grid which corresponds to the amount the retailer’s customers have tapped from the grid.

3 The non-commercial players

The roads in the Nordic countries are operated by monopolies: The municipalities, the counties and the state. For electricity, the grid functions like the roads – transporting the power. Correspondingly, the grid is operated by non-commercial monopolies (Figure 3). For each local area, there is a local grid operator who handles the local low-voltage grid (cf. the municipalities and counties operating the local roads). The high-voltage grid is operated by the transmission system operator (TSO) – just as the motorways are operated by the state.

In addition to owning and operating the high-voltage grid, the TSO is responsible for the security of supply in its country. Consequently, the TSO rules and controls the electricity system in his country. Basically, the physical control and maintenance of

the electricity system is done in the same way, whether you have market economy or planned economy.

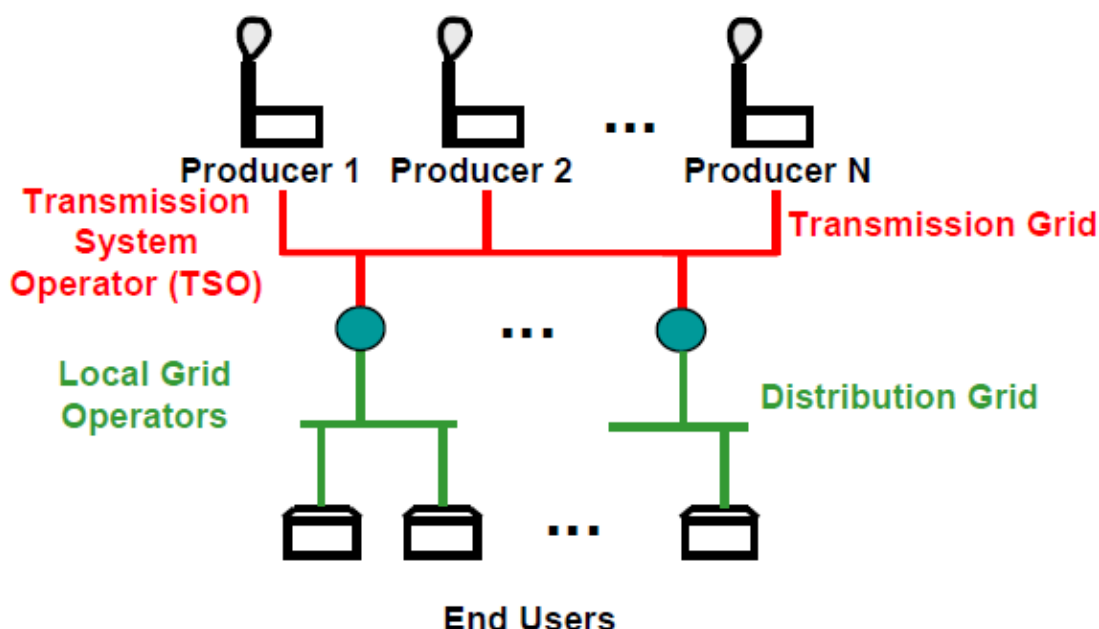


Figure 3: The grid connection between producers and End-users

Only the financial organization is changed when we shift from planning economy to market economy. This is because the laws of nature are the same whether we have planned economy or market economy.

This also holds for corn flakes: the machine filling the corn flakes into cartons does not care whether there is market economy or planned economy. It makes no difference to the physics whether there is planned economy or market economy.

The commercial players are not and cannot be responsible for the security of supply. If a South Swedish retailer, for example, has bought electricity from a North Swedish producer, the North Swedish producer cannot guarantee that there will be electricity in the plug at the retailer's customers.

What the commercial players deliver to each other and the end users are only the prices (and the bills). Hence, the commercial players deliver financial services only. The commercial players work in the domain which is changed when the electricity market is liberalized: the financial domain.

4 The transmission system operator (TSO)

The TSO is responsible for keeping the respective area electrically stable. Technically, this means that the frequency must be kept at 50 Hz. In other words, the TSO is responsible for the commodity (electricity) arriving at the end users' sites.

The TSO must be a non-commercial organization, neutral and independent of commercial players. The TSOs in the exchange areas thus have the responsibility for both the high-voltage grid and the security of supply. In Norway, the TSO is the state-owned grid company Statnett. In Sweden, the TSO is the state-owned grid company Svenska Kraftnät. The TSO in Finland is the grid company Fingrid and is owned partly by the Finnish State and partly by Finnish insurance companies. In Denmark, the TSO is the state-owned grid company Energinet.dk. Energinet.dk is TSO for both electricity and gas. The TSO in Estonia is Elering and is fully owned by the Estonian state.

5 Regulating power market

The regulating power market is managed by the TSO in order to obtain stable frequency in the transmission grid. It may happen that the consumption exceeds the generation. In this case, the frequency of the alternating current will fall to a value below 50 Hz. When this happens, the TSO must ensure that one or more producers deliver(s) more electricity to the grid (Figure 2). In this case, the TSO buys more electrical power from producer(s) who has proclaimed excess generation capacity. We say that the TSO is procuring "up regulation".

The generation of electricity may also be too big – exceeding the consumption. In this case, the frequency will rise to a value above 50 Hz. Now, the TSO must ensure that one or more producers reduce(s) the generation of electricity. In this case, the TSO is selling electrical power to the producers – thereby causing the producers to reduce their generation. We say that the TSO is procuring "down regulation".

The electricity, which the TSO in this way trades with selected market players, is called regulating power. Hence, the regulating power is traded by the TSO in order to regulate the frequency to keep it at 50 Hz.

To illustrate the setting of prices in the regulating power market an example is presented. The green rectangles in Figure 6 illustrate up-regulation orders, e.g. producers with available generation capacity. The orange rectangles illustrate down-regulation orders, e.g. consumers being able to reduce consumption. All regulating power orders submitted to the TSO's are ranked with increasing price (merit-order).

Assume there is a need for 400 MW up regulations. All the up-regulation orders with lowest prices are activated until 400 MW is reached. The price of the last up regulated MW sets the up-regulation price. The orders with prices below the up-regulation price have a profit, equal to the difference between final regulation price and the offered price. The same procedure is used to find the down-regulation price.

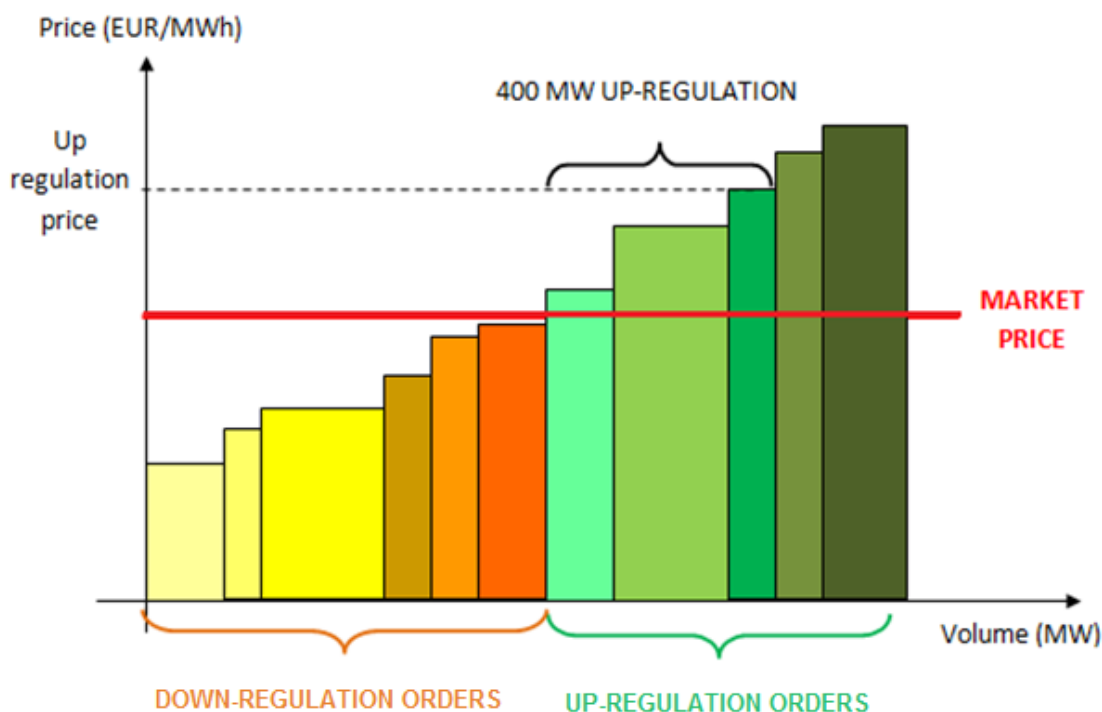


Figure 4: Price setting in the regulating power market

6 Balancing Power

In the wholesale market electricity is bought and sold hourly. Figure 4 illustrates an example where a retailer buys electricity for one particular hour at one specific date. The hour during which the power is delivered and consumed is called the hour of operation.

In the example, the retailer has two contracts of 30 MWh and 70 MWh, respectively: the retailer expects that his customers will consume 100 MWh during this hour of operation (1 MWh is 1,000 kWh).

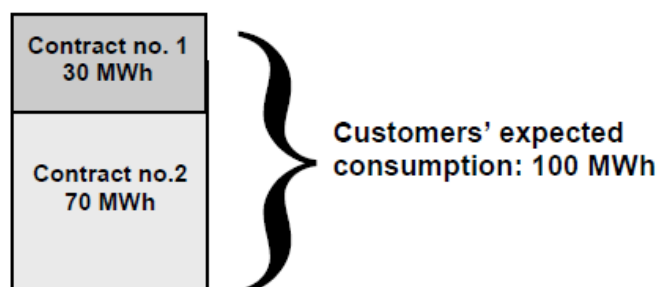


Figure 5: The retailer's purchase of electricity for the hour 1pm - 2pm on September 23th 2010

Before the hour of operation, the purchases must be made. After the hour of operation, the settlement is done (Figure 5). The retailer pays the suppliers for the 30 MWh and the 70 MWh.

Assume that the retailer's customers have only used 85 MWh during this hour of operation. In this case, the retailer has per definition sold the 15 MWh to the TSO. The TSO pays the retailer for the 15 MWh.

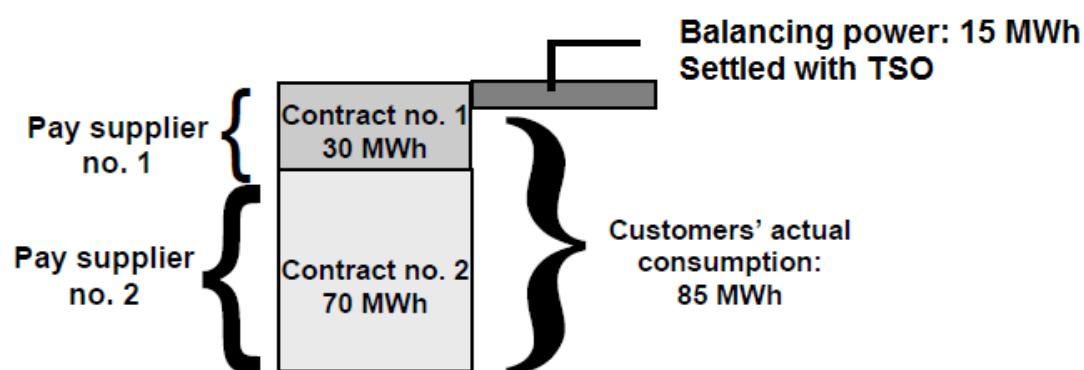


Figure 6: Settling the consumption of electricity

This trade with the TSO creates a balance between the retailer's total trading and the retailer's customers' consumption. The electricity, which the retailer trades with the TSO, is therefore called balancing power, or often referred to as regulating power.

If the TSO had to procure up-regulation during this hour, the TSO will pay the retailer the up-regulating price for the balancing power (i.e. the retailer will get the same price as the producers, who sold up-regulating power to the TSO during this hour). Normally, the up-regulating price will be higher than the market price (in this article, the "market price" is the day-ahead exchange price for this hour).

If the TSO had to procure down-regulation during this hour, the TSO will pay the retailer the down-regulating price for the balancing power (i.e. the retailer will get the same price as the producers, who bought down-regulating power from the TSO during this hour). Normally, the down-regulating price will be lower than the market price.

In a different case, assume the retailer's customers have used 110 MWh during this hour of operation. This is 10 MWh more than the retailer bought before the hour of operation. In this case, the retailer has to buy the additional 10 MWh from the TSO. In this situation, the TSO will invoice the retailer for the 10 MWh.

7 Settlement in the balancing market

When the TSO sells regulating power, the price is set the same way as when the TSO buys regulating power : if there was up-regulation during this hour, the TSO will invoice the up-regulating price (normally higher than the market price). If there was down-regulation, the TSO will invoice the down-regulating price (normally lower than the market price).

Suppose one of the retailer's suppliers is a producer whose plant breaks down just before the hour of operation starts. As the market closes one hour before the hour of operation, the producer cannot buy electricity from another supplier if his power station breaks down 10 minutes before the hour of operation starts.

The retailer has to pay the producer, even though the producer has not produced anything. In this case, the TSO sells balancing power to the producer, and the producer resells the power to the retailer.

Hence, if a producer fails to produce according to his plan, the producer must also settle balancing power with the TSO. However, for the producers the price is set a bit differently: during an hour with up-regulation, producers producing too much will only get paid the market price (not the up-regulating price). During an hour with up-regulation, producers producing too little will be invoiced the up-regulating price (normally higher than the market price).

During hours with down-regulation, producers producing too much will get paid the down-regulating price (normally lower than the market price). Producers producing too little will be invoiced the market price (not the down-regulating price).

That a trader 'owns' electricity means in practice that the trader must settle balancing power with the TSO, if his purchase and sale are imbalanced. Hence, in order to avoid settling balancing power with the TSO, the trader must ensure that he is buying and selling the same amount of power produced or consumed during each hour.

8 Elspot – Nord Pool Spot's Day-ahead Auction Market

Elspot is Nord Pool Spot's day-ahead auction market, where electrical power is traded.

Players, who want to trade power on the Elspot market, must send their purchase orders to Nord Pool Spot at the latest at noon the day before the power is delivered to the grid.

Correspondingly, participants who want to sell power to Elspot must send their sale offers to Nord Pool Spot at the latest at noon the day before the power is delivered to the grid (i.e. gate closure is 12.00).

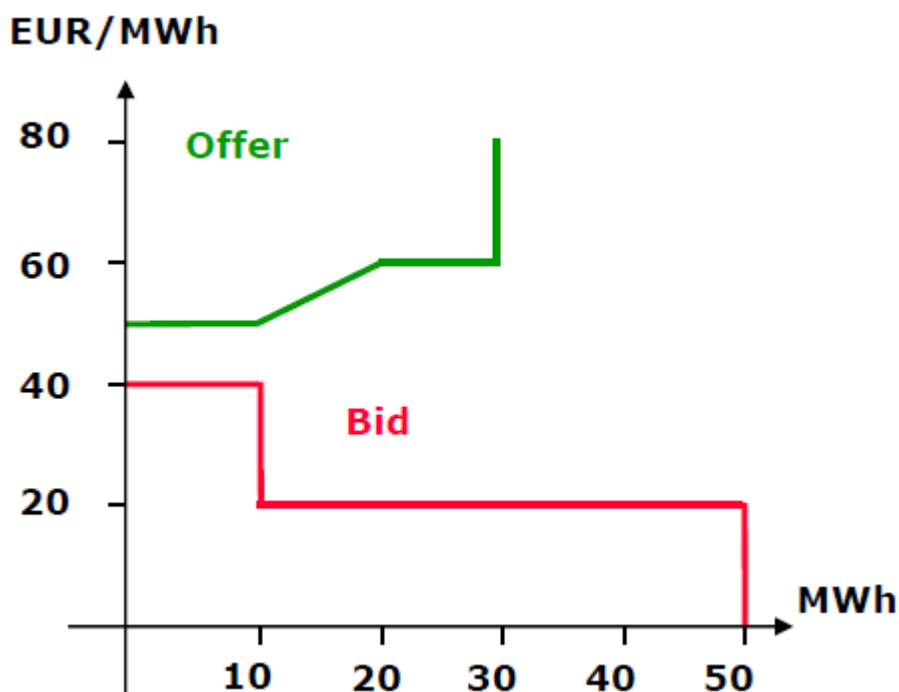


Figure 7: Bid/Offer from one player for the hour 1pm – 2pm of tomorrow.

The orders and offers are sent electronically to Nord Pool Spot in Oslo: the participants send the orders to Nord Pool Spot via the Internet.

Figure 7 shows an example of orders submitted by a retailer for one hour of the following day. The retailer expects that his customers will consume 50 MWh during this hour.

This retailer has his own generation facility. Hence, he can choose whether he will either:

- buy the 50 MWh from the exchange and therefore not produce anything himself.
- buy some of the electricity from the exchange and produce the rest himself.
- produce precisely 50 MWh.
- or sell electricity to the exchange and consequently produce more than 50 MWh.

The retailer in the example has informed the electricity exchange that he will buy 50 MWh from Elspot, if the exchange price for this hour turns out to be 20 EUR/MWh or less.

If the exchange price for this hour turns out to be 40 EUR/MWh, the retailer will buy 10 MWh. In this case, the retailer will produce the remaining 40 MWh at his own generation facility. The retailer will sell 10 MWh if the price turns out to be 50 EUR/MWh. If the price is between 50 and 60 EUR/MWh, the retailer will sell an

amount corresponding to the sloping curve. If the price is 60 EUR/MWh or more the retailer will sell 30 MWh.

At Nord Pool Spot, the purchase orders are aggregated to a demand curve. The sale offers are aggregated to a supply curve (Figure 8). The intersection of the two curves gives the market price for one specific hour.

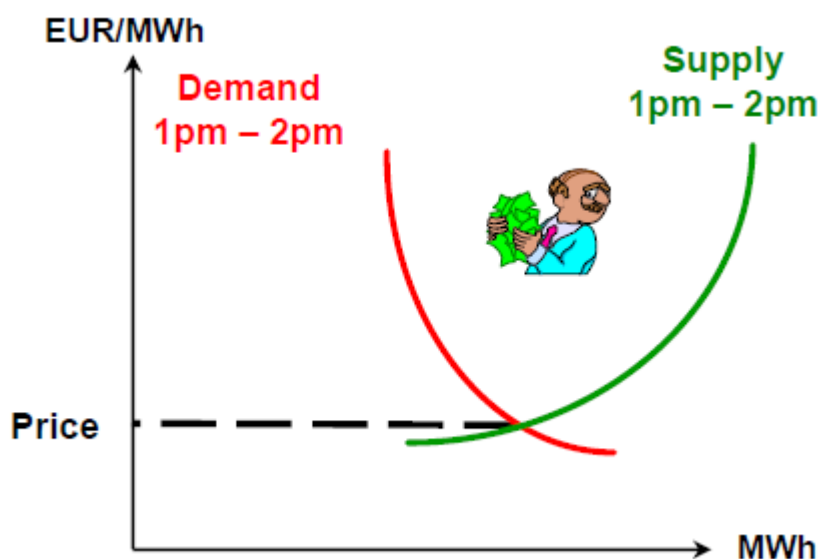


Figure 8: Aggregated supply and demand curves

Nord Pool Spot calculates a price for each hour. Elspot is a day-ahead market, as this is trading for the following day.

This way of calculating the price is called a double auction, as both the buyers and the sellers have submitted orders (for many other auction types, only the buyers submit orders). Hence, Elspot is called a day-ahead auction market (as the word “double” is cut out from the type description).

Figure 9 shows the prices during one specific day, July 14th 2006..

At noon, Nord Pool Spot’s computer in Oslo starts calculating the day-ahead prices. Having finished the calculation, Nord Pool Spot publishes the prices. At the same time, Nord Pool Spot reports to the participants how much electricity they have bought or sold for each hour of the following day. These reports on buying and selling are also sent to the TSOs in the Nord Pool Spot area. The TSOs use this information, when they later calculate the balancing power for each player.

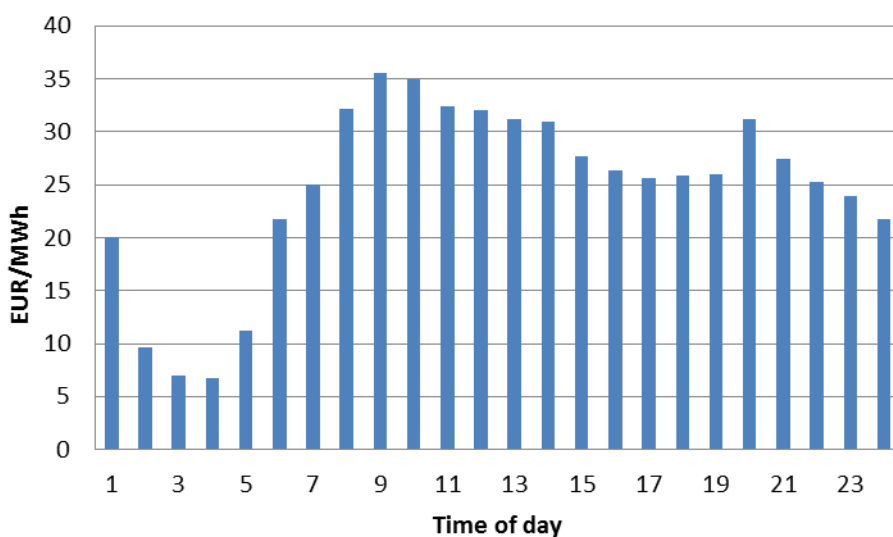


Figure 9: System price Thursday September 22nd 2011

There is a standard Elspot trading fee in EUR/MWh which is paid by both buyers and sellers.

9 Bidding areas

Actually, chapter 6 describes how the so-called System Price is calculated. The System Price is the theoretical, common price we would have in the Nordic area if there were no grid bottlenecks.

Due to the bottlenecks, the Nord Pool Spot exchange area is divided into a number of bidding areas. For example, when a producer in Eastern Denmark sends his orders to Nord Pool Spot, he must specify that these orders are submitted for delivery in the bidding area Eastern Denmark.

The TSO's decides the number of bidding areas its boundaries. Eastern Denmark and Western Denmark are always treated as two different bidding areas. Sweden constitutes one bidding area until November 2011 when it is to be divided into four bidding areas. Also, Finland and Estonia constitutes one bidding area while Norway currently (August 2011) has five bidding areas.

Nord Pool Spot calculates a price for each bidding area for each hour of the following day.

Naturally, there are often hours, where neighboring bidding areas have the same price. Likewise there may also be hours, where the whole exchange area has the same price: for example, during 2010, the whole exchange area had the same day-ahead price during 10 % of the hours.

10 Day-ahead Congestion Management: Implicit Auction

Apart from calculating day-ahead prices, the Elspot market is also used to carry out day-ahead congestion management in the Nord Pool Spot exchange area through an implicit auction.

In the price calculation supply and demand orders are aggregated. The intersection of the curves gives the market price and turnover. Depending on available transmission capacity in the transmission grid, the spot markets in the different bidding areas are integrated to maximize the overall social welfare in both (or more) markets.

Some areas have surplus of power while others have deficit of power. The area in deficit is dependent on import from surplus areas. If there is insufficient transmission capacity between the two areas bottlenecks occur and price differences arise. The surplus area will have a lower price than the deficit area as more power is available compared to consumption.

The export of power from surplus area to deficit area is reflected as an additional purchase in the surplus area, and additional sale in the deficit area. An example with Norway as surplus area and Sweden as deficit area is used to illustrate the principles. The demand supply curves are chosen randomly. If no transmission capacity were available between the two areas they would have different prices. Norway would have a price of 200 NOK/MWh, while Sweden would have a price of 300 NOK/MWh.

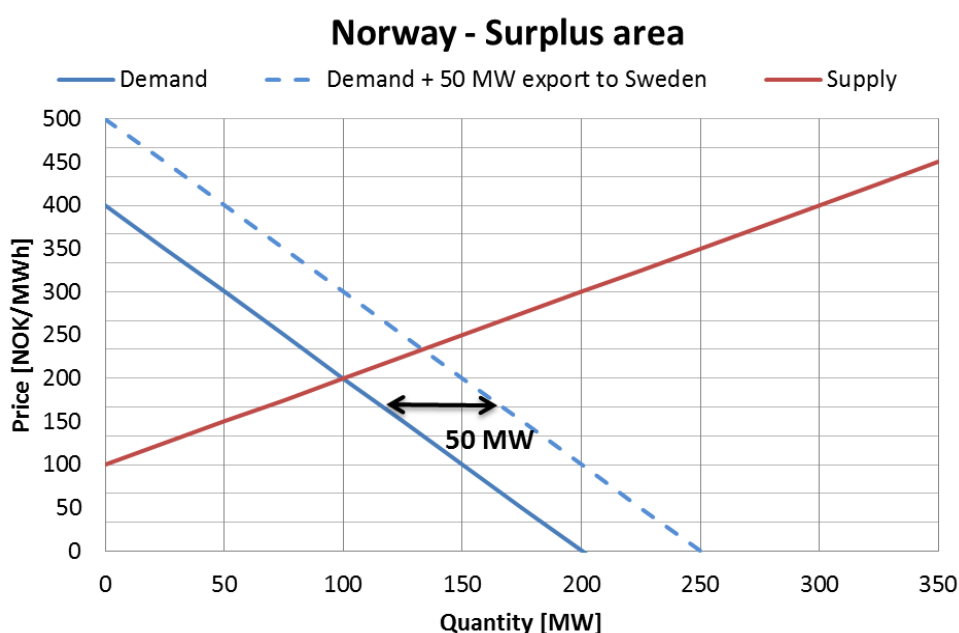


Figure 10: Export of 50 MW from Norway to Sweden

Sweden - Deficit area

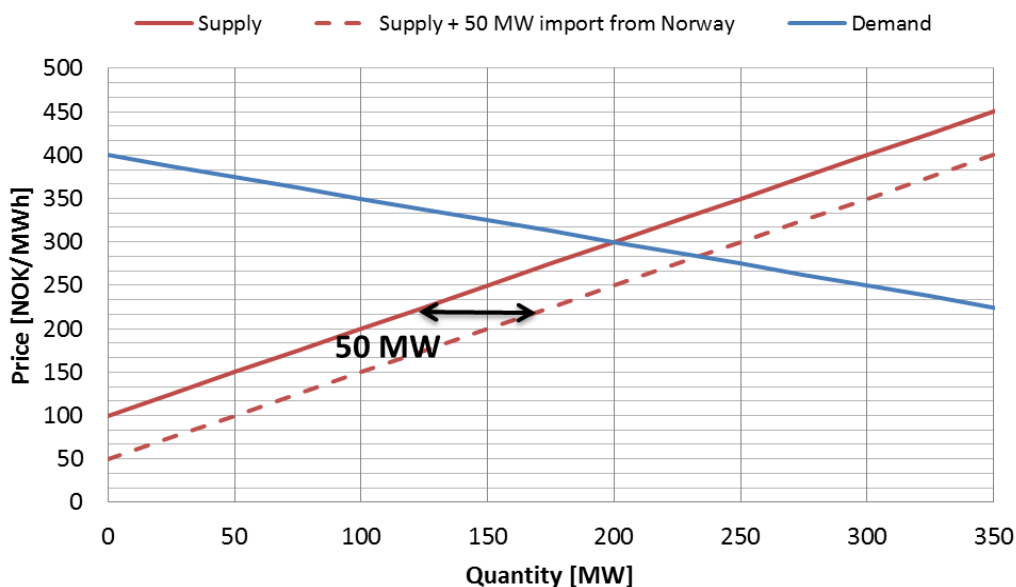


Figure 11: Import of 50 MW to Sweden from Norway

Assume there is 50 MW available transmission capacity between Norway and Sweden. The price in Sweden would be lowered to 233.33 NOK/MWh due to additional available production. The price in Norway would increase to 283.33 NOK/MWh due to higher consumption.

Available transmission capacity	0 MW exchange	50 MW exchange CONGESTION
Bidding area	[NOK/MWh]	[NOK/MWh]
Norway	200	233.33
Sweden	300	283.33

In the implicit auction the available transmission capacity is used to level out price differences as much as possible.

Nord Pool Spot carries out the day-ahead congestion management on both external and internal transmission lines between and within Denmark, Norway, Sweden, Finland and Estonia.

11 Day-ahead Congestion Management: Market Coupling

When a bottlenecks occur on the cross-border between two exchange areas the flow on this needs to be determined in cooperation between the two involved power exchanges. This is called market coupling and exists today between the Nordic, German and Central Western European exchange areas, which is shown in Figure 12.

Each single power exchange gives their orders to a central organ, European market coupling company (EMCC). EMCC performs a price calculation with implicit auction which determines the power flow on the cross-border lines, shown as green in Figure 12. This flow is used as input in the local price calculation performed by each single power exchange.

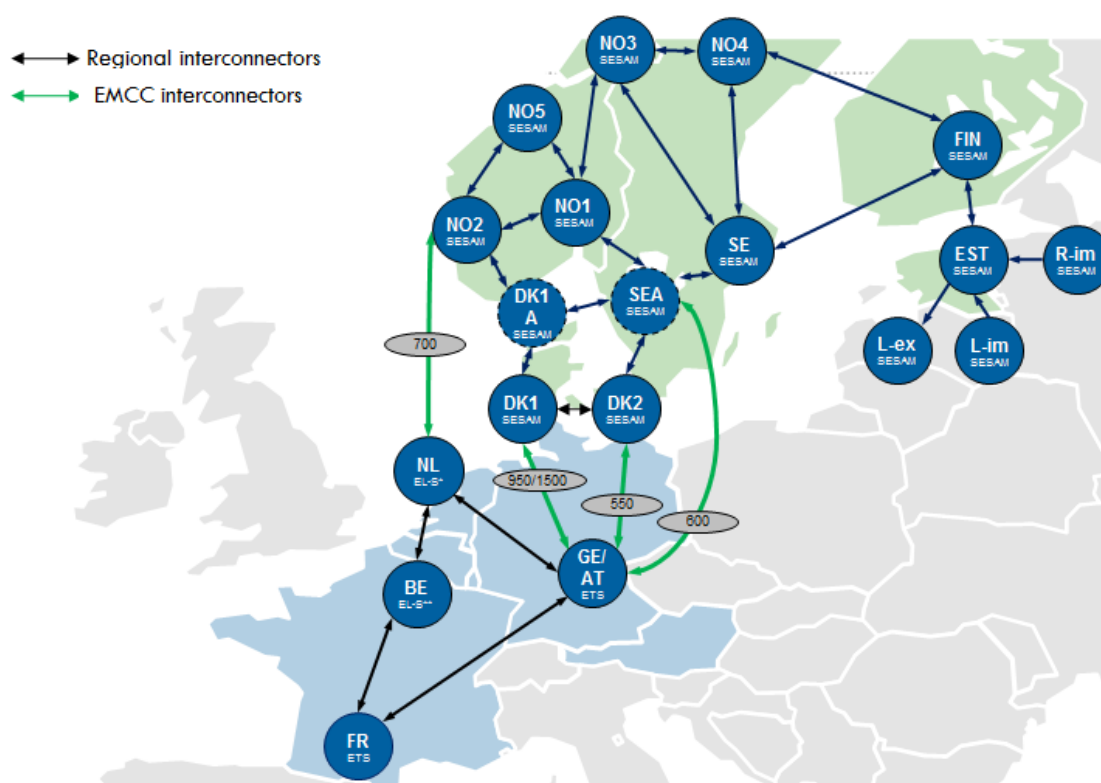


Figure 12: Market coupling between the Nordic, German and Central Western European exchange areas.

12 Cross-border trading

Inside the Nord Pool Spot exchange area, all the transmission capacity on the external transmission lines is handled by Nord Pool Spot through implicit auction during price calculation.

Two Nordic commercial players situated in different bidding areas cannot trade electricity with each other. This is because Nord Pool Spot handles all the trading capacity on the cross-border links, on behalf of the Nordic TSO's.

In order to trade with each other, Nordic players in different bidding areas can use the financial electricity market (Figure 13). The two players can trade the power on Nord Pool Spot or with a player situated in their own bidding area (i.e. the power is traded locally). In addition the two players have a settlement in accordance with the financial contract.

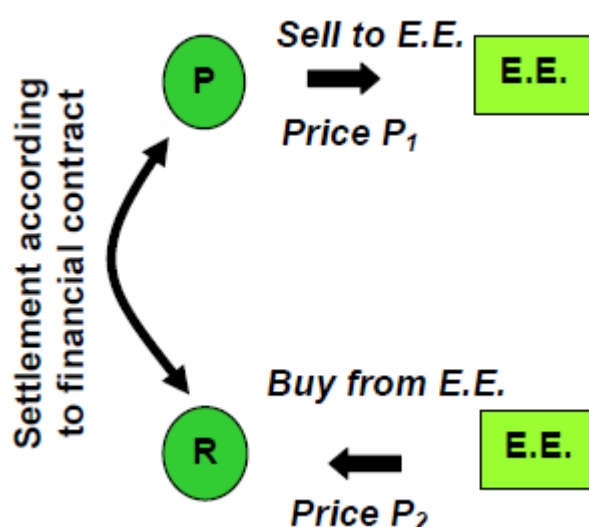


Figure 13: The capacity on the Nordic bottlenecks is given to E.E. (Electricity Exchange). How can a producer P and a retailer R trade, if they are separated by one or more bottleneck(s)? Answer: They trade the power with E.E. or with another local counterpart. Furthermore, they have a financial contract.

The idea of this principle is the following: you can always buy or sell electrical power. For example, you can trade on the electricity exchange. Hence, what is interesting for the commercial players is only the price. However by means of a financial contract, the players can lock the price.

13 The financial electricity market

At the financial electricity market you cannot trade one single kWh. As mentioned above, the financial market is used for price hedging and risk management.

Figure 14 illustrates how a financial contract works. The example illustrates a financial contract of the type called a “futures” contract.

In the example, a retailer and a supplier have entered into a futures contract with a volume of 4 MWh and a hedge price of 65 EUR/kWh. In the example, the contract's so-called “delivery period” is a specific month (for instance, it may be June 2014).

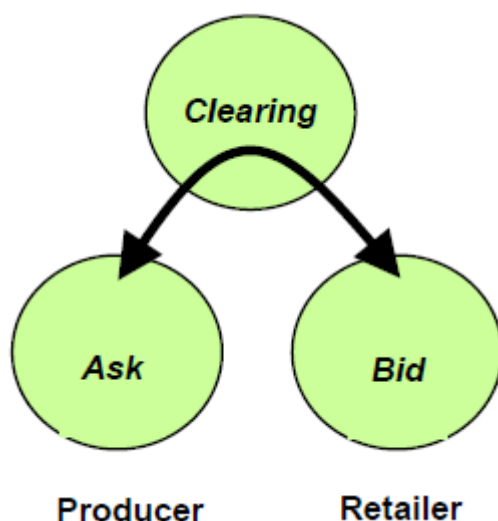


Figure 14: Producer and retailer sign a future contract with hedge price 65 EUR/MWh; If, for instance, the average system price in the month concerned turns out to be 66 EUR/MWh; The producer pays the retailer 1 EUR/MWh * 4 MWh. If, for instance, the average system price in the month concerned turns out to be 63 EUR/MWh; the retailer pays the producer 2 EUR/MWh * 4 MWh. In the example, the parties have cleared the contract. Hence, the settlement runs via clearing house.

The parties have a mutual insurance (and a mutual obligation). Suppose the average system price for the month in question turns out to be 66 EUR/MWh. A high price on the wholesale market is obviously disadvantageous for the retailer. However in this situation, the supplier will compensate the retailer. The supplier pays the retailer
 $1 \text{ EUR/MWh} * 4 \text{ MWh} = 4 \text{ EUR}$.

Suppose instead the average system price for the month in question turns out to be 63 EUR/MWh. A low price on the wholesale market is obviously disadvantageous for the supplier. In this situation, the retailer will compensate the supplier. The retailer pays the supplier
 $2 \text{ EUR/MWh} * 4 \text{ MWh} = 8 \text{ EUR}$.

The contract is therefore settled by comparing the hedge price of the contract with the average system price for the period in question. The difference in price is multiplied **by** the contract's volume. Eventually, this amount of money is transferred between the parties.

It is important to note that the parties of a financial contract are not delivering physical power with each other. Only money is exchanged between them (therefore, the name "financial electricity market"). However, in addition, the retailer may submit a purchase order with an unspecified price to Elspot. The retailer can notify Elspot that he will buy 5 MWh each hour during the month irrespective of the price. With a purchase of 5 MWh each hour during the whole month, the retailer will in total have bought 3600 MWh by the end of a 30-days month:

$5 \text{ MWh/h} * 24 \text{ h} * 30 \text{ days} = 3600 \text{ MWh}$.

The retailer does not need to worry about the price. If it is higher than 65 EUR/MWh, he will be compensated. On the other hand, if the price is lower than 65 EUR/MWh, he has to compensate the opposite party of the futures contract.

The retailer, therefore, has two trade arrangements: a purchase on Elspot and a futures contract. In total, the two trade arrangements guarantee his price for the 3600 MWh will be 65 EUR/MWh.

14 Clearing of financial contracts

The two parties of a financial contract can choose to clear the contract – using a clearing house. In this case, the clearing house takes care of the settlement of the contract (Figure 14). Furthermore, the clearing house guarantees the settlement: the clearing house will ensure that the settlement is carried out, even if one of the parties cannot fulfill his obligations.

If the parties have entered the contract via a financial electricity exchange, clearing is mandatory. This is because the trading at the financial exchange is anonymous: the parties do not know each other's identity. Hence, the contract must be cleared, so the clearing house sits between the parties.

15 Long-term contracts

At Elspot, the commercial players can trade power day-ahead. Now, let us take a look at the market for long-term contracts.

For example, let us consider a retailer who has sold 100 MWh to an end user at a price of 67 EUR/MWh for the following year. The retailer now has to make a corresponding purchase on the wholesale market.

However, the retailer does not need to buy the power immediately. In order to hedge his position, all the retailer needs now is a futures contract. For example, the retailer has earned 2 EUR/MWh if he enters into a futures contract with a hedge price of 65 EUR/MWh.

Next year, the retailer can simply buy the power from Elspot or from a local supplier.

Therefore, the financial market is also the market for long-term contracts.

16 The day-ahead price must be reliable

As it appears, the Elspot day-ahead price is used, when the financial contracts are settled. We say that the day-ahead price is the underlying reference for the financial contracts.

A reliable day-ahead power price is an absolutely essential basis for a financial market. It is imperative that all the players regard the day-ahead price as the true market price. For obvious reasons, only in this case the players will be interested in making financial contracts, with the day-ahead price as the underlying reference.

Through Nord Pool Spot's Elspot market such a reliable day-ahead price in the Nord Pool Spot exchange area has been created.

17 Why an electricity exchange?

For society, the Elspot market provides **price transparency**. For example at www.nordpoolspot.com, everybody can see the wholesale market's day-ahead price.

In addition, the day-ahead price is used as the underlying reference for financial electricity exchanges. Via their quotation of financial contracts, price transparency is also provided for long-term contracts. For example, via the financial electricity exchanges, you can see the market players' estimate of next year's electricity prices.

The electricity exchange also provides another service to society: the electricity exchange handles transmission capacity in a market-oriented way. With this, there is a neutral and fair day-ahead congestion management. The system secures that the day-ahead plans send the commodity in the right direction: from low-price areas towards the high price areas.