The Nordic Model for a Liberalised Electricity Market

1. The market

When the electricity market is liberalised, 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 (Fig. 1).

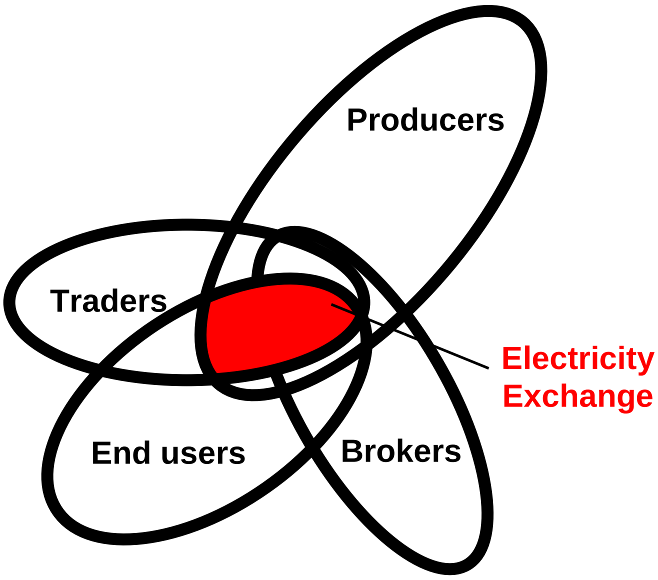

Fig. 1 The commercial players and the exchange

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 and Norway.

Nord Pool Spot is an exchange primarily servicing the players at the wholesale market for electricity. The customers of Nord Pool Spot are the producers, retailers, and traders who choose to trade with the electricity exchange. In addition, large end users trade with the electricity exchange.

In this article, the term "the Nordic area" denotes Denmark, Finland, Sweden & Norway. In this article, Island is not counted in, as there are no grid connections between Island and Denmark, Finland, Sweden & Norway.

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2. The Point Tariff System

In fig. 2, the water illustrates the electrical energy and the walls of the tanks illustrate the grid.

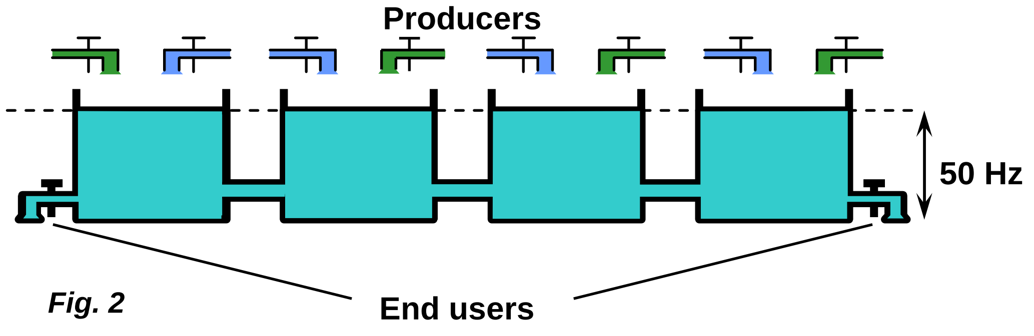

Fig. 2

The idea of the system of point tariff is that the producers pay a fee to the grid owner for each kWh they pour to the grid. Correspondingly, the end users pay a fee for each kWh they draw from 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 municipals, the counties and the state. For electricity, the grid functions like the roads – transporting the energy. Correspondingly, the grid is operated by non-commercial monopolies (fig. 3). For each local area, there is a local grid operator who handles the local low-voltage grid (cf. the municipals 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 his 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.

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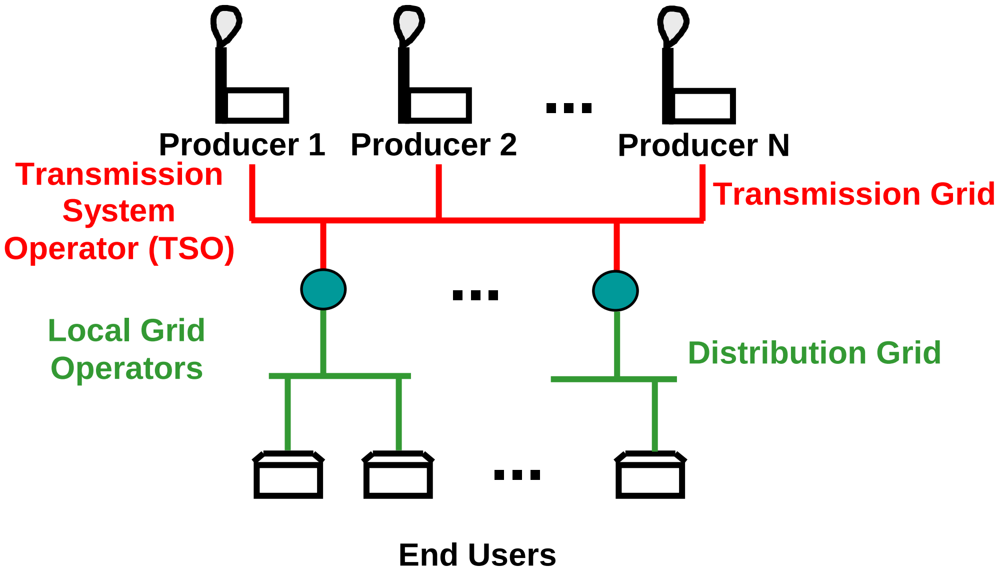

Fig. 3

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 liberalised: the financial domain.

4. The transmission system operator (TSO)

Naturally, it may happen that the consumption exceeds the production. 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 (fig. 2). In this case, the TSO is buying electrical energy from the producer(s). We say that the TSO is procuring "up regulating".

The production 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 production of electricity. In this case, the TSO is selling electrical energy to the producers – thereby causing the producers to reduce their production. We say that the TSO is procuring "down regulating".

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

The TSO is responsible for keeping his 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 Nordic countries 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. Fingrid is owned partly by the Finnish State. In Denmark, the TSO is the state-owned grid company Energinet.dk. Energinet.dk is TSO for both electricity and gas.

5. Balancing Energy

In the wholesale market electricity is bought and sold hourly. Fig. 4 illustrates an example where a retailer buys electricity for one particular hour at one specific date. The hour during which the energy 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).

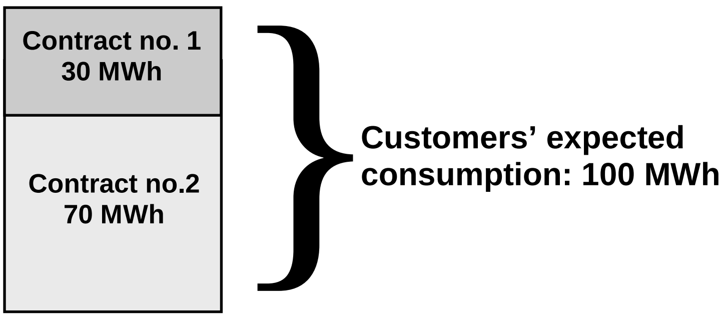

Fig. 4 The retailer's purchase of electricity for the hour 1pm – 2pm Sept. 23th, 2010

Before the hour of operation, the purchases must be made. After the hour of operation, the settlemet is done (fig. 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.

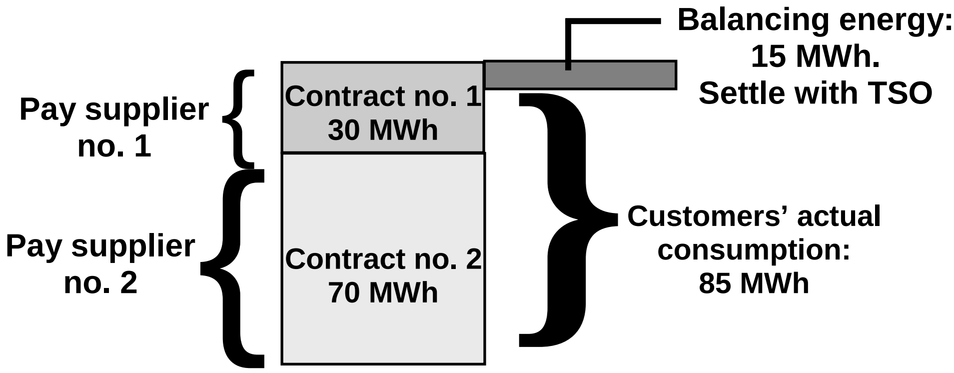

Fig. 5. Settling the consumption of electricity

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 energy.

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

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.

When the TSO sells balancing energy, the price is set the same way as when the TSO buys balancing energy: 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 min. before the hour of operation starts.

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

Hence, if a producer fails to produce according to his plan, the producer must also settle balancing energy 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-

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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 energy with the TSO, if his purchase and sale are imbalanced. Hence, in order to avoid settling balancing energy with the TSO, the trader must ensure that he is buying and selling the same amount of energy during each hour.

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

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

Players, who want to buy energy from Elspot, must send their purchase bids to Nord Pool Spot at the latest at noon the day before the energy is delivered to the grid.

Correspondingly, participants who want to sell energy to Elspot must send their sale offers to Nord Pool Spot at the latest at noon the day before the energy is delivered to the grid (i.e. gate closure is 12 o'clock).

Fig. 6 Bid/Offer from one player for the hour 1pm – 2pm of tomorrow.

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

Fig. 6 shows an example of bids 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 production 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 production 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 bids are aggregated to a demand curve. The sale offers are aggregated to a supply curve (fig. 7). The price can be read at the point where the two curves intersect.

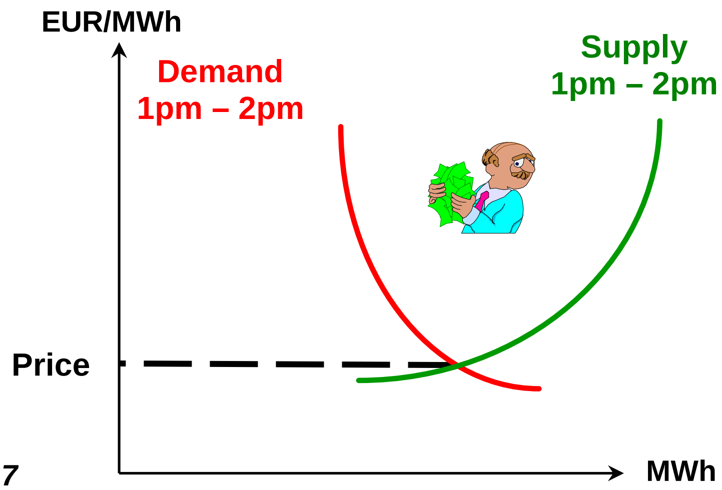

Fig. 7

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 bids (for many other auction types, only the buyers submit bids).

Hence, Elspot is called a day-ahead auction market (as the word "double" is cut out from the type description).

Fig. 8 shows the prices for one specific day.

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 energy for each player.

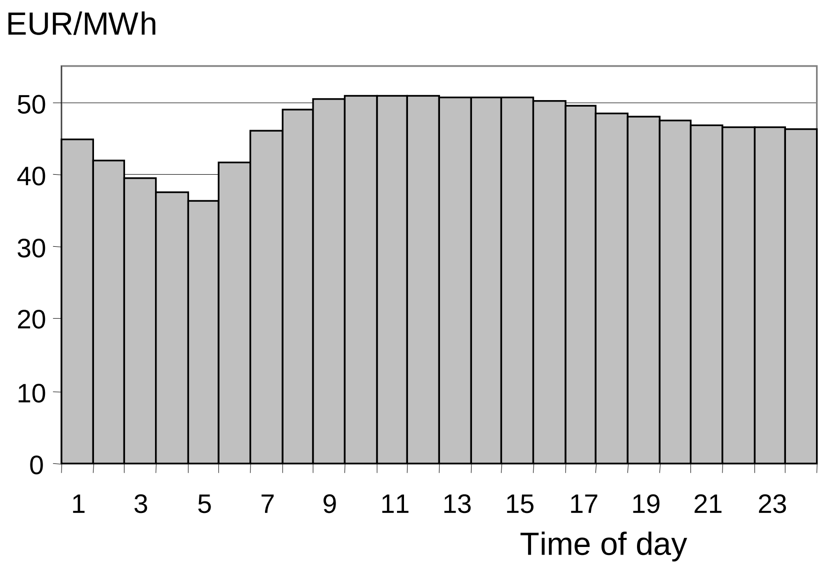

Fig. 8 System Price Friday, July 14th, 2006

The standard Elspot trading fee is 0.03 EUR/MWh. This fee is paid by both buyers and sellers.

7. 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 the were no grid bottlenecks: if there were no grid bottlenecks, we would have one common, Nordic day-ahead price for each hour.

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

For each Nordic country, the local TSO decides, which bidding areas the country is divided into. For Norway, the TSO normally divides the country into a number of bidding areas. The number of Norwegian bidding area can vary.

Eastern Denmark and Western Denmark are always treated as two different bidding areas. Sweden constitutes one bidding area. Also, Finland constitutes one bidding area. Currently, the areas Eastern Denmark, Western Denmark, Sweden and Finland are never internally split into more bidding areas.

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

Naturally, there are often hours, where neighbouring bidding areas have the same price. Likewise there may also be hours, where the whole Nordic area has the same price: for example, during 2005, the whole Nordic area had the same day-ahead price during 32% of the hours.

8. Day-ahead Congestion Management: Market Splitting

Apart from calculating day-ahead prices, the Elspot market is also used to carry out day-ahead congestion management in the Nordic area.

This day-ahead congestion management system is called market splitting.

To explain market splitting let us consider a bottleneck with a capacity of 600 MW. We'll consider one, given hour of the following day. Assume Nord Pool Spot during the calculation of the day-ahead prices discovers that there will be different prices on the two sides of the bottleneck during this hour: One side of the bottleneck will be a low-price area whereas the other side will be a high-price area.

In this case Nord Pool Spot will purchase 600 MWh extra in the low-price area and sell 600 MWh extra in the high-price area.

The extra sale and the extra purchase are made the day before the day of operation. The next day, when the given hour is reached, the extra purchase in the low-price area will cause a production surplus of 600 MWh in this area: in the low-price area, there are producers who will produce the extra 600 MWh. However, in the low-price area, there is no corresponding local consumption. Due to the production surplus, electricity must flow out of the low-price area.

Likewise the extra sale in the high-price area will lead to a production deficit of 600 MWh in this area: in the high-price area, there are end users who will consume the 600 MWh. However, in the high-price area there is no corresponding local production. Due to the production deficit, electricity must flow towards the high-price area.

Hence, once Nord Pool Spot has made the extra purchase the low-price area and the extra sale in the high-price area, the laws of nature will do the rest: the next day, during the hour in question, electricity will flow from the low-price area into the high-price area.

Naturally, the extra purchase will increase the price in the low-price area. Likewise, the extra sale will decrease the price in the high-price area. Thus, market splitting also implies that the bottleneck capacity is used to level out price differences as much as possible.

By means of market splitting, the Nordic electricity exchange Nord Pool Spot carries out the day-ahead congestion management on the interstate links between Denmark, Norway, Sweden and Finland.

Furthermore, Nord Pool Spot carries out the day-ahead congestion management on the domestic bottlenecks in Norway by means of market splitting.

9. Day-ahead Congestion Management: Market Coupling

In case of market splitting one electricity exchange creates the day-ahead plans for the cross-border energy flow in its own area.

Consider a border where two electricity exchanges meet. The two electricity exchanges can carry out the day-ahead congestion management on the border using the principle described above: when the electricity exchanges during the calculation of the day-ahead prices realise there is a price difference on the border, extra electricity is bought from the electricity exchange in the low-price area, and extra electricity is sold to the exchange in the high-price area. When we arrive at the hour in question the next day, the extra purchase will create a production surplus on the low-price side of the border. Correspondingly, the extra sale will create a production deficit on the high-price side of the border. Hence, the energy will flow out from the low-price area towards the high-price area.

Market coupling is the name of this day-ahead congestion management, where two electricity exchanges are involved.

10. Cross-border trading

Inside the Nordic area, all the capacity on the inter-state links is handled by Nord Pool Spot: only Nord Pool Spot can carry out trading on these links. Besides, all the capacity on the links connecting the Norwegian bidding areas is also handled by Nord Pool Spot: only Nord Pool Spot can carry out trading on these links.

Hence, inside the Nordic area, only Nord Pool Spot can carry out cross-border electricity trading[1].

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.

In order to trade with each other, Nordic players in different bidding areas can use the financial electricity market (fig. 9). The two players can trade the energy with Nord Pool Spot or with a player situated in their own bidding area (i.e. the energy is traded locally). In addition the two players have a settlement in accordance with the financial contract.

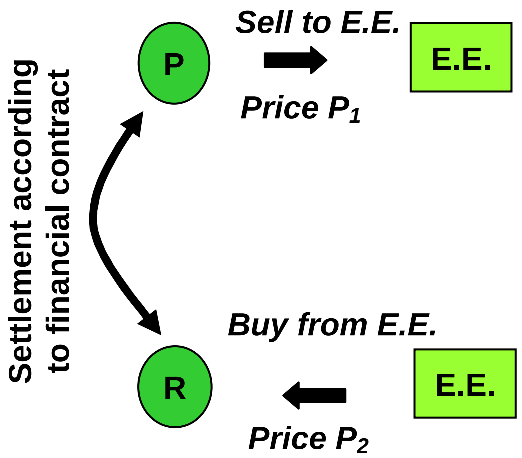

Fig. 9 The capacity on the Nordic bottlenecks is given to the E.E. (Electricity Exchange). How can a producer P and a retailer R trade, if they are separated by one or more bottleneck(s)? Answer: They trade the energy with the E.E. or with another local counterpart. Furthermore, they have a financial contract.

The idea of this principle is the following: you can always buy or sell electrical energy. For example, you can trade with Elspot. Hence, what is interesting for the commercial

[1] Here, the "border" needs not be a border between two countries. It may be a border between two bidding areas inside a country.

players is only the price. However by means of a financial contract, the players can lock the price.

11. 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.

Fig. 10 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 3,600 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 2010).

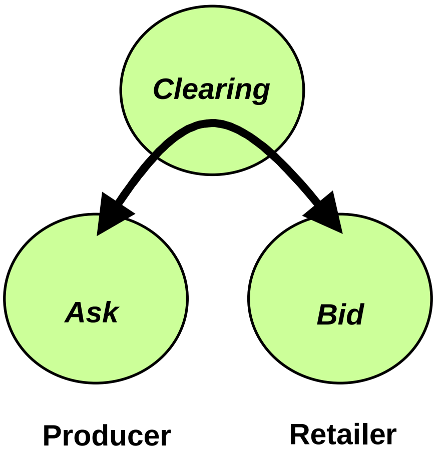

Fig. 10 Producer and retailer sign a future contract with hedge price 65 EUR/MWh: if, for instance, the average system price in the month concerned turns out to be 66 EUR/MWh: The producer pays the retailer 1 EUR/MWh * 3,600 MWh. If, for instance, the average system price in the month concerned turns out to be 63 EUR/MWh: The retailer pays the producer 2 EUR/MWh * 3,600 MWh. In the example, the parties have cleared the contract. Hence, the settlement runs via a 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 EUR/MWh * 3,600 MWh = EUR 3,600.

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 EUR/MWh * 3,600 MWh = EUR 7,200.

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 trading energy with each other. Only money is exchanged between them (therefore, the name "financial electricity market").

However, in addition, the retailer may submit a purchase bid 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 3,600 MWh by the end of a 30-days month:

5 MWh/h * 30 * 24 h = 3,600 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 have 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 3,600 MWh will be 65 EUR/MWh.

12. 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 (fig. 10). 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 fulfil 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.

13. Long-term contracts

At Elspot, the commercial players can trade energy 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 energy 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 energy from Elspot or from a local supplier.

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

14. 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 energy 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 Nordic area has been created.

15. 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 grid bottlenecks 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: towards the high price.

16. The electricity exchange in the year 2008

In 2008, the Elspot turnover was 298 TWh.

About 71% of the consumption of electricity in Denmark, Sweden, Finland and Norway was traded via Nord Pool Spot.

Nord Pool Spot's turnover was about EUR 15 billion. At the end of the year, Nord Pool Spot had 38 employees: 3 in Denmark, 8 in Finland, 5 in Sweden and 22 in Norway.