The 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 consumers.

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

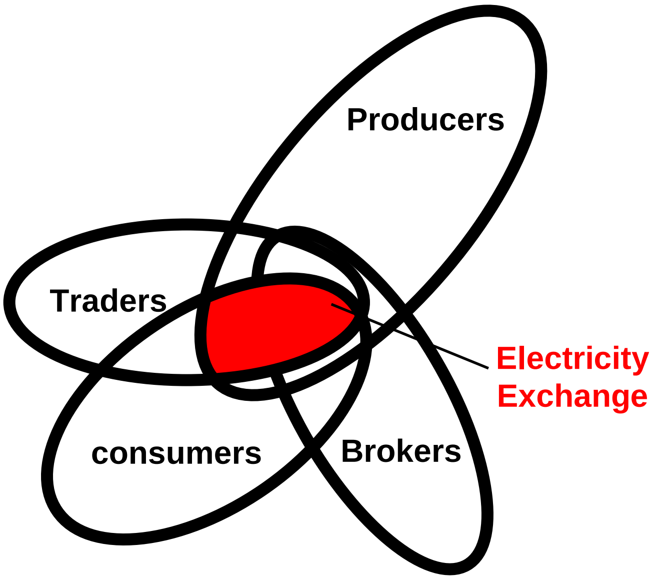

Fig. 1 The commercial players and the exchange

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

The players can trade with each other, or they can trade with an electricity exchange. The latter is an exchange, where you can buy and sell electrical energy.

With the Nordic electricity market as a case, this article describes, how a liberalized electricity market may be organised.

The Baltic-Nordic electricity exchange Nord Pool Spot has price quotations in Denmark, Estonia, Finland, Latvia, Lithuania, Norway and Sweden. The owners of Nord Pool Spot are the seven transmission system operators in the Baltic-Nordic countries.

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 consumers may trade with the electricity exchange.

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

2. The Point Tariff System

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

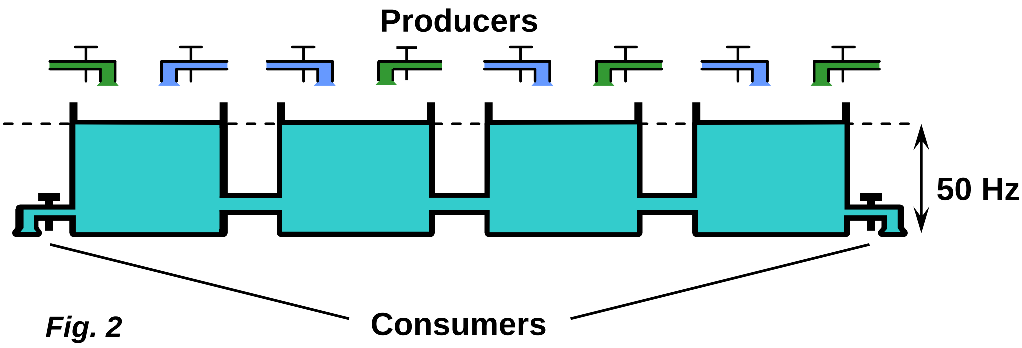

Fig. 2

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

For example, this means a retailer with customers in Southern Finland may buy electricity from a producer in Northern Finland. Of course, such a deal does not cause the producer's electricity to travel all the way from Northern Finland to Southern Finland. The principle is simply that for each hour somewhere a producer has to inject an amount of electrical energy 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.

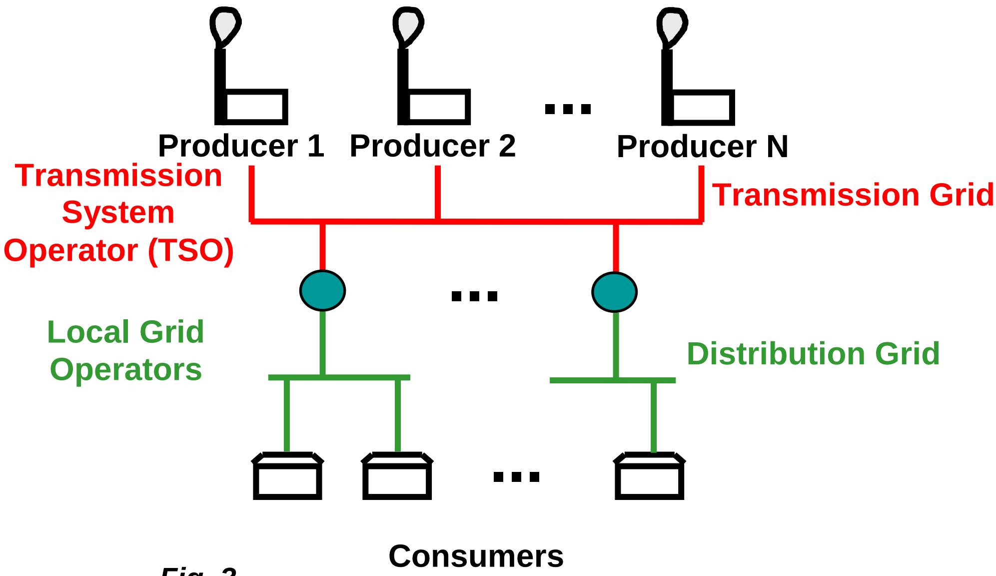

Fig. 3

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. Only the financial organization is changed when we shift from planned 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. For example: if a retailer with customers in Southern Finland has bought electricity from a North Finnish producer, the North Finnish producer cannot guarantee that there will be electricity in the plugs at the retailer's customers.

What the commercial players deliver to each other and the consumers 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)

Naturally, it may happen that the consumption exceeds the production. In this case, the frequency of the alternating current will fall below 50 Hz[1]. When this happens, the TSO must ensure that one or more producers deliver more electricity to the grid (fig. 2). In this case, the TSO is buying electrical energy from the producers. 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 above 50 Hz. Now, the TSO must ensure that one or more producers reduce 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 electrical energy, 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 (electrical energy) arriving at the consumers' sites.

The TSO must be a non-commercial organization, neutral and independent of commercial players.

[1] In Europe, the frequency of the alternating current is 50 Hz. In other regions, the frequency is 60 Hz.

As can be seen: TSOs have the responsibility for both the high-voltage grid and the security of supply.

5. Balancing energy – the Nordic model

At 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 produced 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).

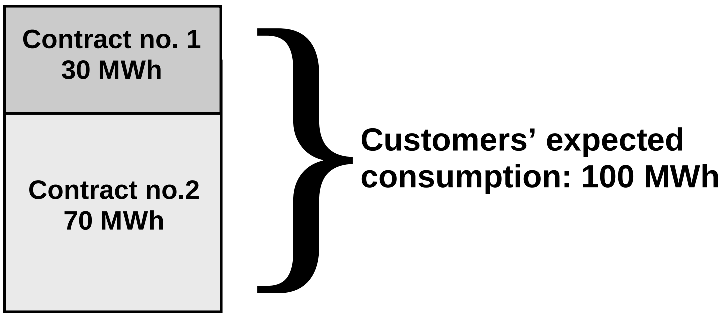

Fig. 4 The retailer's purchase of electricity for one given hour

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

Assume 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.

This trade with the TSO creates a balance between the retailer's total trading and the consumption of the retailer's customers. 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 (ie, 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 exchange's day-ahead price for this hour – please refer to chapter 6).

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 (ie, 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.

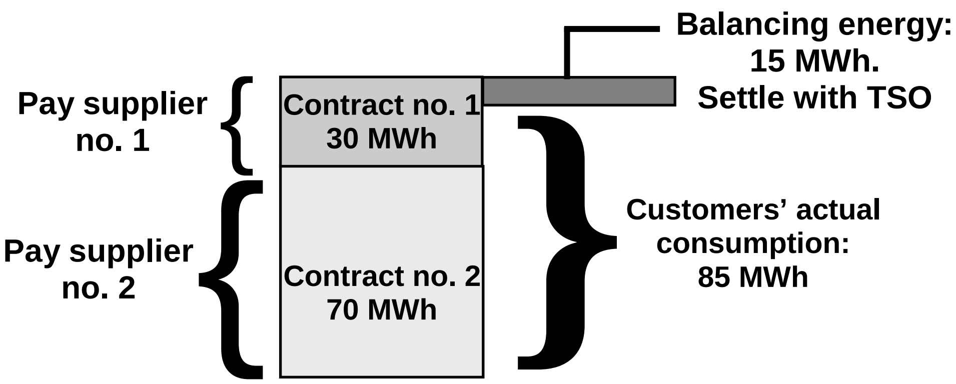

Fig. 5. Settling the consumption of electricity

On the other hand: assume the retailer's customers have used 110 MWh during this hour of operation. This is 10 MWh more than what 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 to a retailer, 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).

Let us consider the settlement of imbalances for a producer: 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 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. The Baltic-Nordic spot market Elspot

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

Players, who want to buy energy from the spot market, must send their purchase bids to Nord Pool Spot at the latest at noon the day before the energy is delivered to the grid (ie, gate closure time is 12 o’clock Central European Time the day before the day of operation).

Correspondingly, participants who want to sell energy to the spot market must send their sale offers to Nord Pool Spot at the latest at noon the day before the day of operation.

The bids and offers are sent electronically to Nord Pool Spot: 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 his customers will consume 50 MWh during this hour.

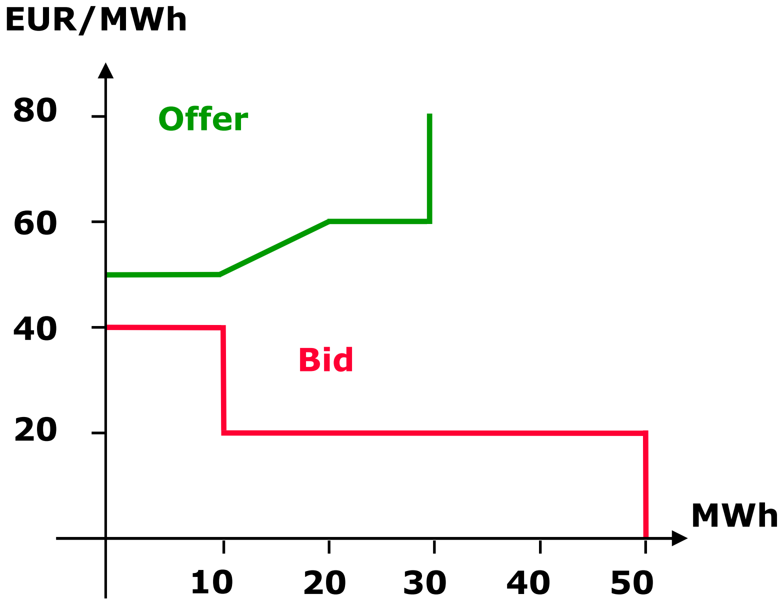

Fig. 6 Bids and offers from one player for the hour 1pm – 2pm of tomorrow.

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 the spot market, 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 between 20 and 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. In this case, the retailer will have a total production of 60 MWh, of which 10 MWh is sold to the exchange.

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.

When the exchange's prices are calculated, the purchase bids are aggregated to a demand curve. The sale offers are aggregated to a supply curve (fig. 7). The exchange price can be read at the point where the two curves intersect, if there's neither market coupling nor market splitting.

Note: precisely at the two curves' intersection point, the exchange's purchase volume is equal to the exchange's sales volume. Without market coupling or market splitting, the exchange needs to arrange the price calculation, so the two volumes are equal (please also refer to chapters 8 and 9).

An exchange price is calculated for each hour of the next day. The spot market is a day-ahead market, as this is trading energy produced and consumed 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).

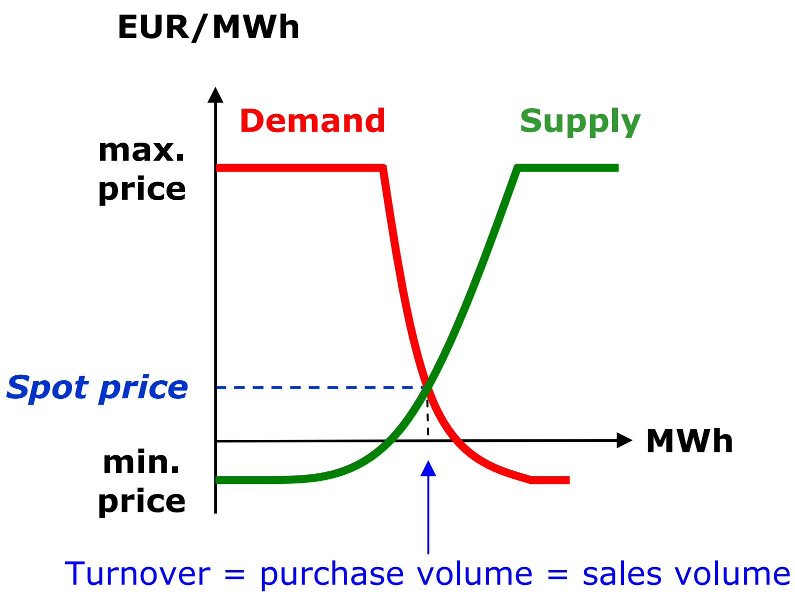

Fig. 7 Spot price calculation when there's neither market coupling nor market splitting

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

At noon, the calculating the day-ahead prices starts. When the calculation is finished, the exchange prices are published. These day-ahead auction prices are called "spot prices". Fig. 8 shows an example of spot prices.

Also, when the calculation is completed, 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 Baltic-Nordic area. The TSOs use this information, when they later calculate the balancing energy for each player.

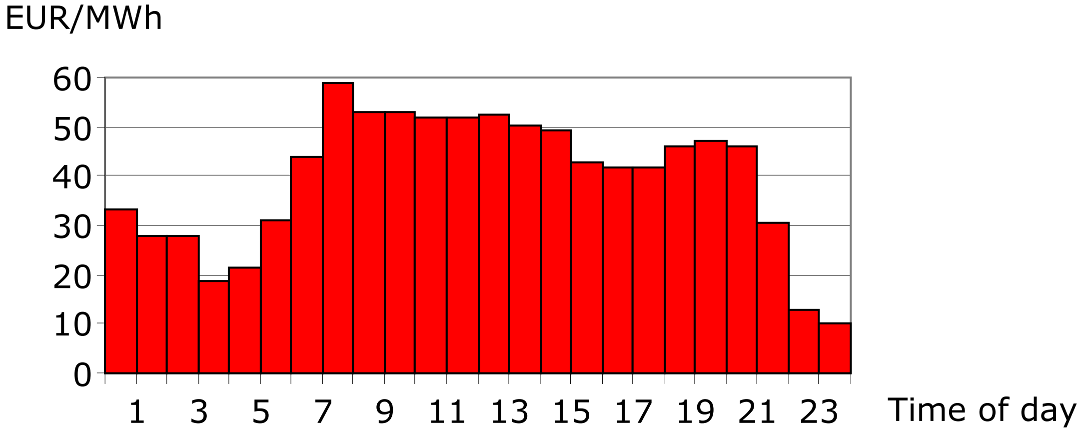

Fig. 8 Spot prices in Eastern Denmark Monday 6 August 2012

As of April 2014, the standard Elspot trading & clearing fee was 0.045 EUR/MWh. The fee is paid by both buyers and sellers[2].

Other European countries also have electricity exchanges operating day-ahead auction markets. In general, such exchange markets are called "spot markets", and the exchanges are called "spot exchanges". Hence, Elspot is an example of a spot market, and Nord Pool Spot is an example of a spot exchange.

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[2] Unfortunately, when we introduce market coupling or market splitting, the spot exchanges become monopolies. Among other things, this has created a lack of cost control: even though the euro inflation is very low, Nord Pool Spot's trading & clearing fee was raised with 20% from 2013 to 2014. Please refer to the PowerPoint presentation *Single spot exchange for the Single Electricity market* and the PDF document *Unbundling of spot exchanges and associated clearing houses*. At *houmollerconsulting.dk*, you can download the documents from the page *Facts and findings*.

7. Price zones

Due to the grid bottlenecks, the Baltic-Nordic area is divided into a number of price zones. A price zone is a geographical area, within which the players can trade electrical energy day-ahead without considering grid bottlenecks. In fig. 2, you see four price zones.

Fig. 9 shows the Baltic-Nordic prize zones as of October 2013.
For example, when a producer in Eastern Denmark (DK2) sends his bids to Nord Pool Spot, he must specify that these bids belong to the price zone DK2.

A spot price is calculated for each price zone for each hour of the following day. For example, fig. 8 showed the 24 spot prices for Eastern Denmark for 6 August 2012.

Naturally, there are often hours, where neighbouring price zones have the same price. Likewise there may also be hours, where the whole Nord Pool Spot area has the same price: for example, during 2005, the whole Nordic area had the same spot price during 32% of the hours (in 2005, Nord Pool Spot did not operate a spot market in the Baltic States).

Fig. 9 The Baltic-Nordic price zones as of October 2013

8. Day-ahead Grid Congestion Management: Market Splitting

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

This day-ahead congestion management is called market splitting.

To explain market splitting let us consider a grid bottleneck with a capacity of 600 MW. We'll consider one, given hour of the following day. Assume the price-calculating computer during the calculation of the spot prices discovers 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 zone whereas the other side will be a high-price zone.

In this case the computer will automatically insert an extra purchase of 600 MWh in the low-price zone and an extra sale of 600 MWh in the high-price zone and then carry on with the price calculation.

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 zone will cause a production surplus of 600 MWh in this zone: in the low-price zone, there are producers who will produce the extra 600 MWh, as they have sold this to the exchange. However, in the low-price zone, there is no corresponding local consumption. Due to the production surplus, electricity must flow out of the low-price zone.

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

Hence, once the computer has inserted the extra purchase in the low-price zone and the extra sale in the high-price zone, the laws of nature will do the rest: the next day, during the hour in question, electricity will flow from the low-price zone into the high-price zone. Please refer to fig. 10.

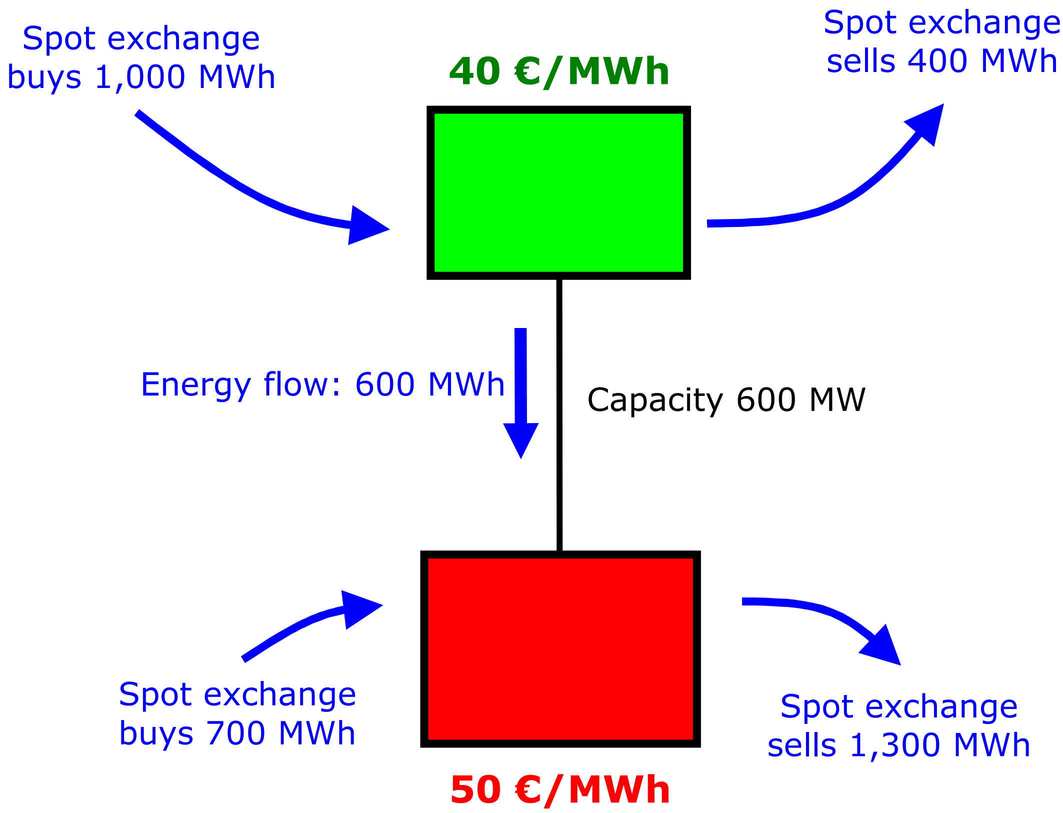

Fig. 10 Implicit auction (market splitting or market coupling). An example for one hour of operation

Naturally, the extra purchase will increase the price in the low-price zone. Likewise, the extra sale will decrease the price in the high-price zone. 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 spot market is used to carry out the day-ahead congestion management on all the interconnectors linking the price zones in the Baltic-Nordic area.

9. Day-ahead Congestion Management: Market Coupling

In case of market splitting, you have the same electricity exchange on the two sides of an interconnector linking two price zones.

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 spot prices realise there is a price difference on the border, extra electricity is bought from the exchange in the low-price zone, and extra electricity is sold to the exchange in the high-price zone. 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 zone towards the high-price zone. Again, please refer to fig. 10.

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

Implicit auction is the common term for market coupling and market splitting.

10. Calculation of the spot prices with market coupling or market splitting

Figure 7 illustrates the spot calculation for a price zone, when there's neither market coupling nor market splitting. For such a price zone, the spot exchange must arrange the spot price calculation, so the exchange's purchase volume equals the exchange's sales volume.

However, with market coupling/splitting the spot exchange must buy extra energy in the low-price zones and sell this extra energy in the high price zones.

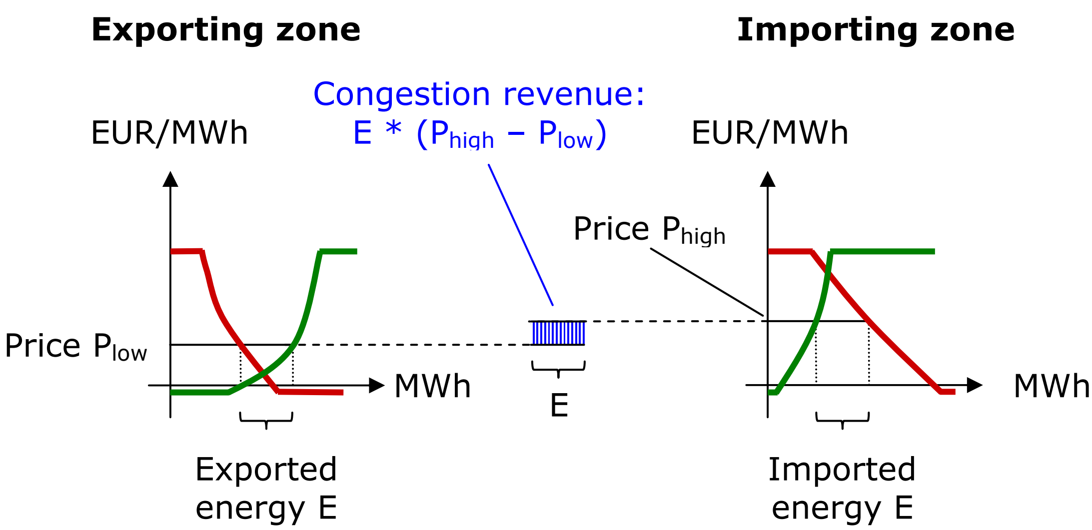

Fig. 11 Spot price calculation when there's implicit auction (market splitting or market coupling)

Fig. 11 illustrates the spot price calculation for a simple example with only two prices zones. As can be seen: in the low-price zone, the exchange sets the spot price higher than the price given by the intersection of the local demand and supply curves. By increasing the price in the low-price zone, the exchange gets a purchase surplus in the low-price zone.

Correspondingly: in the high-price zone, the exchange sets the spot price lower than the price given by the intersection of the local demand and supply curve. By lowering the price in the high-price zone, the exchange gets a sales surplus in the high-price zone.

In this way, the spot exchange reduces the price differences between the zones. If the grid capacity between the two zones is high, the exchange can level out the prices and create a common spot price for the two zones. However, fig. 11 illustrates a case, where the grid capacity is too low for this: there's a spot price difference (P_{high} – P_{low}) between the two zones. This creates an arbitrage revenue, as the exchange is buying the transferred energy E at price P_{low} and selling E at price P_{high}. This arbitrage revenue is called the congestion revenue (or congestion rent).

The spot exchange hands over the congestion revenue to the owners of the cross-border capacity (normally transmission system operators).

11. Cross-border trading[3]

Inside the Nordic area, all capacity on the interconnectors linking the price zones is handled by Nord Pool Spot: only Nord Pool Spot can carry out trading on these interconnectors.

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

Therefore, two Nordic commercial players situated in different price zones cannot trade electricity with each other.

In order to trade with each other, Nordic players in different price zones can use the financial electricity market (fig. 12). The two players can trade the energy with Nord Pool Spot or with a player situated in their own price zone (ie, the

[3] Here, the "border" needs not be a border between two countries. It may be a border between two price zones inside a country.

energy is traded locally). In addition the two players have a settlement in accordance with 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 the spot exchange. Hence, what is interesting for the commercial players is only the price. However, by means of a financial contract, the players can lock in the price.

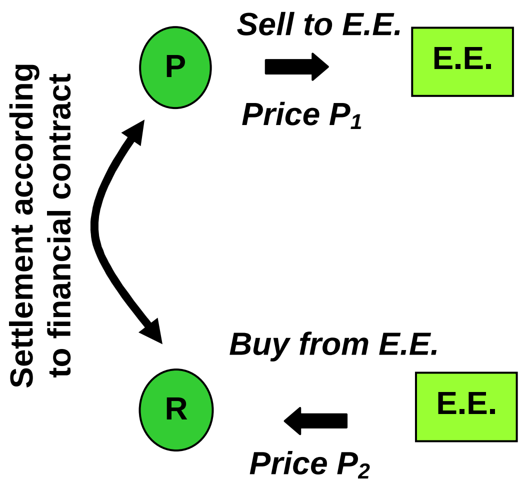

Fig. 12 The capacity on the Nordic grid bottlenecks is given to the E.E. (Electricity Exchange). How can a producer P and a retailer R trade, if they are separated by one or more bottleneck(s)? Answer: They trade the energy with the E.E. or with another local counterpart. Furthermore, they have a financial contract.

12. The financial electricity market

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

Fig. 13 illustrates how a financial contract works. In the example, a retailer and a supplier have entered into a financial 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 given, future month.

The parties have a mutual insurance and a mutual obligation. Suppose the average spot price for the month in question turns out to be 66 EUR/MWh (ie, 1 EUR/MWh higher than the hedge price). A high price at 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 spot price for the month in question turns out to be 63 EUR/MWh (ie, 2 EUR/MWh lower than the hedge price). A low price at the wholesale market is obviously disadvantageous for the supplier. However, in this situation, the retailer will compensate the supplier. The retailer pays the supplier

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

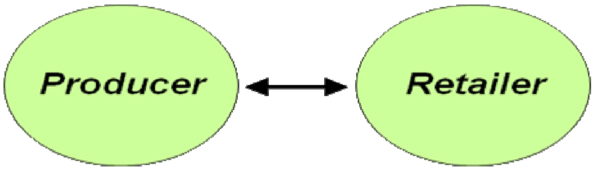

Fig. 13 Producer and retailer sign a financial contract with hedge price 65 EUR/MWh and volume 3,600 MWh: if, for instance, the average spot price in the month concerned turns out to be 66 EUR/MWh: The producer pays the retailer 1 EUR/MWh * 3,600 MWh. If, for instance, the average spot price in the month concerned turns out to be 63 EUR/MWh: The retailer pays the producer 2 EUR/MWh * 3,600 MWh.

The contract is therefore settled by comparing the hedge price of the contract with the average spot price for the period in question. The price difference is multiplied by the contract's volume. 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 the spot exchange (a "price taking" purchase bid). The retailer can notify the spot exchange 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.

Now, the actual spot price is irrelevant for the retailer. 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 other party of the financial contract.

The retailer, therefore, has two trade arrangements: a purchase on the spot market and a financial contract. In total, the two trade arrangements guarantee his net cost for the 3,600 MWh will be 65 EUR/MWh[4].

13. 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. 13). Furthermore, the clearing house guarantees the settlement: the clearing house will ensure 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 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.

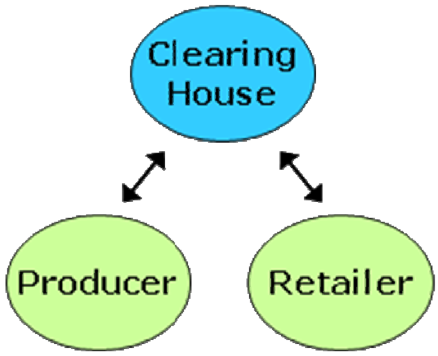

Fig. 14 Clearing

14. Long-term contracts

At the spot market, 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 5 MWh/h to an end user at a price of 67 EUR/MWh for a future month of 30 days (ie, a total sale of 3,600 MWh). The retailer now has to make a corresponding purchase on the wholesale market.

[4] Because the Nordic market has many price zones, the Nordic financial contracts are actually more complicated than this description indicates
(For the technically interested: for the Nordic market, this description fits a case, where the two parties have both a so-called System Price contract and a so-called Electricity Price Area Differential (EPAD) contract with each other).

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

When we arrive at the month in question, the retailer can simply buy the energy from the spot market or from a local supplier.

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

15. The day-ahead price must be reliable

As can be seen: the spot price is used, when the financial contracts are settled. We say the spot price is the underlying reference for the financial contracts.

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

16. Why electricity exchange?

For society, the spot market provides **price transparency**. For example at the internet, everybody can see the wholesale market's day-ahead price.

In addition, the spot price is used as the underlying reference for financial contracts. Via the financial exchanges' quotation of financial contracts, price transparency is also provided for the more distant future. For example, via the financial exchanges, you can see the market players' estimate of next year's electricity prices.

The spot market also provides another service to society: by means of implicit auction, grid bottlenecks are handled 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 ship the commodity in the right direction: towards the high price.

17. Nord Pool Spot in the year 2013

In 2013, the Elspot turnover was 349 TWh.

About 84% of the consumption of electricity in the Baltic-Nordic area was traded via Nord Pool Spot.

The turn-over at Nord Pool Spot’s intra-day market Elbas (not discussed in this article) was 4 TWh.

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