



The Liberalized electricity market

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Houmoller Consulting ApS




- **The trading system.**
- **The spot market.**
- **Transparency.**
- **Surveillance of the market.**
- **Handling of bottlenecks in the grid: market coupling and market splitting.**
- **Please also refer to the article *The Liberalized Electricity Market***
 - ❑ You'll find the article at the sub-page *Facts and findings* at www.houmollerconsulting.dk

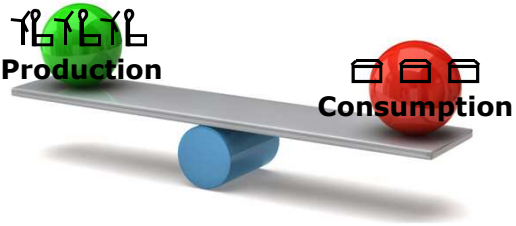
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Day 4

Market economy
The maintenance of the security of supply
The players' roles







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Lecturer Anders Plejdrup Houmøller 

- **Owner and CEO of Houmoller Consulting ApS since 2010**
 - ❑ Please refer to www.houmollerconsulting.dk
- **Worked for the Nordic electricity exchange Nord Pool 1998-2010**
 - ❑ First as Market Manager for Denmark – later as Director of Business Development.
 - ❑ Introduced the electricity exchange in Denmark.
- **Worked as project manager for the Danish Transmission System Operator 1997-1998.**
- **Worked for the Danish power producer Elsam 1993-1996 as head of Elsam's Technology Department.**
- **Worked as project manager in electronics and software companies 1985-1993.**
- **Worked as a high school teacher 1981-1985.**



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Economics

This is the run-up to the following discussion of the electricity market

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Why market economy?

- For commodities like coffee, cotton, electricity, oil, ...
- The idea is to create a **price signal** for the commodity.
- A trustworthy price creates short-term and long-term balance between supply and demand.
- Short-term: balance here and now between supply and demand.
- Long-term: signal to investors.
 - ❑ For example – for electricity – high prices means
 - ✓ For end users: make an extra effort to save electricity.
 - ✓ For investors: invest in more electricity production plants.





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A market

- A market is defined as **a network of contacts between buyers and sellers, who all know the general rules governing the trading.**




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Supply and demand

- **Supply:** the quantity the sellers want to sell at a given price.
- **Demand:** the quantity the buyers want to buy at a given price.

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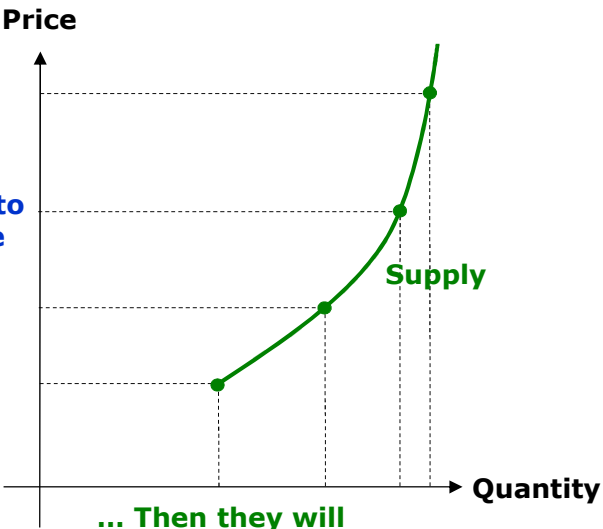
Supply of beef

↑

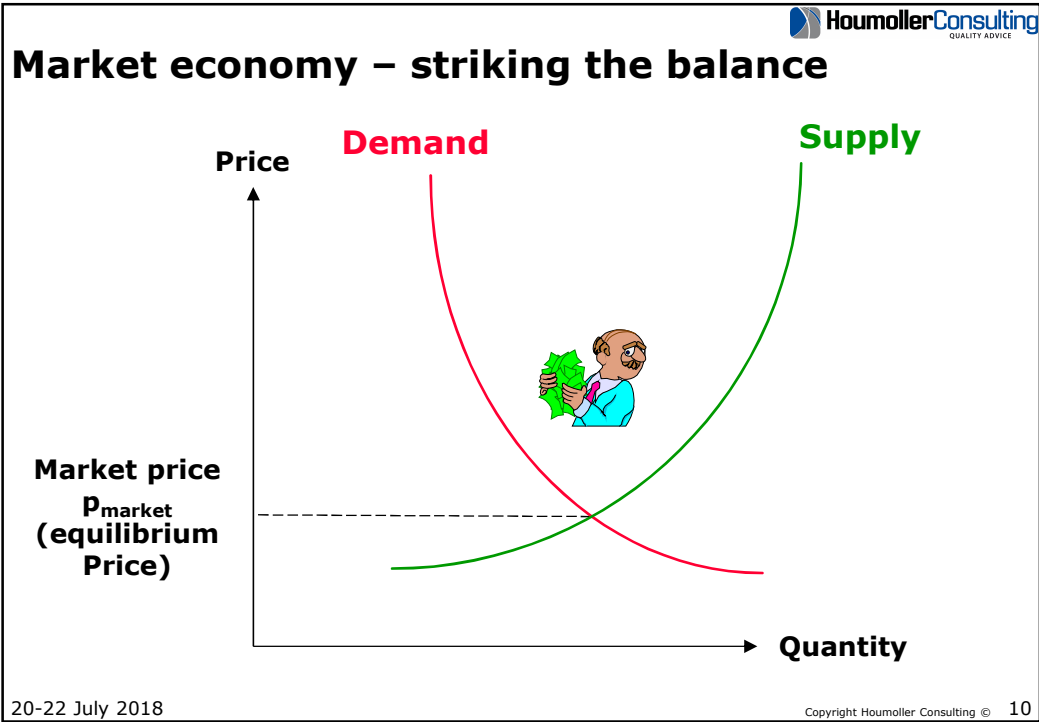
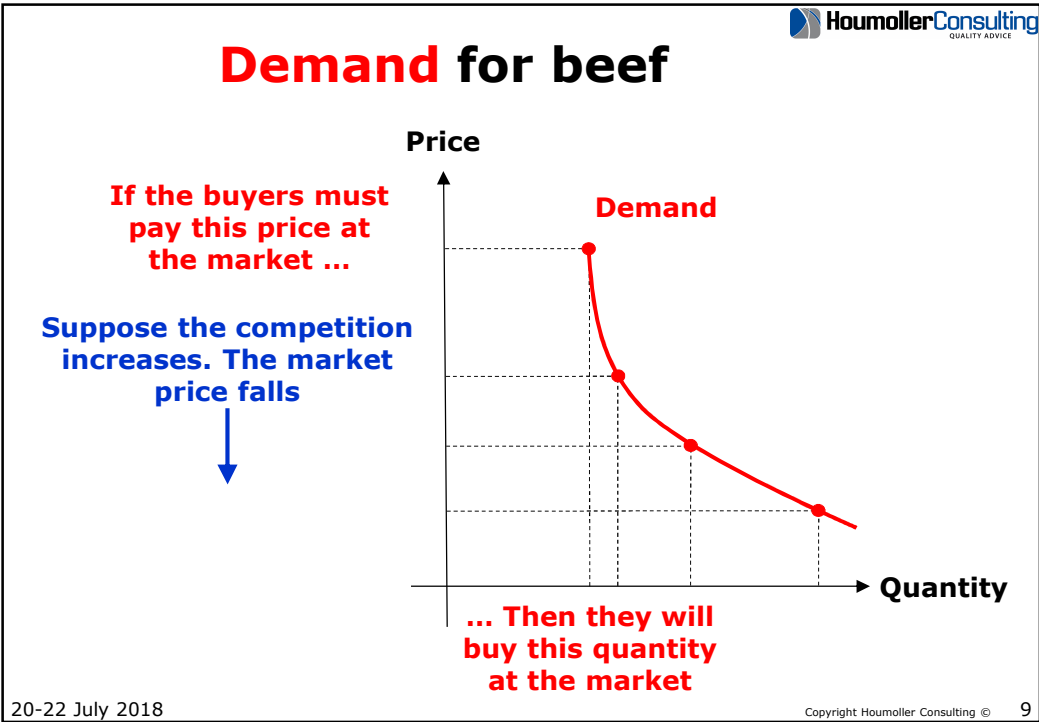
Suppose demand for beef increases. Customers are willing to pay higher prices: the market price goes up

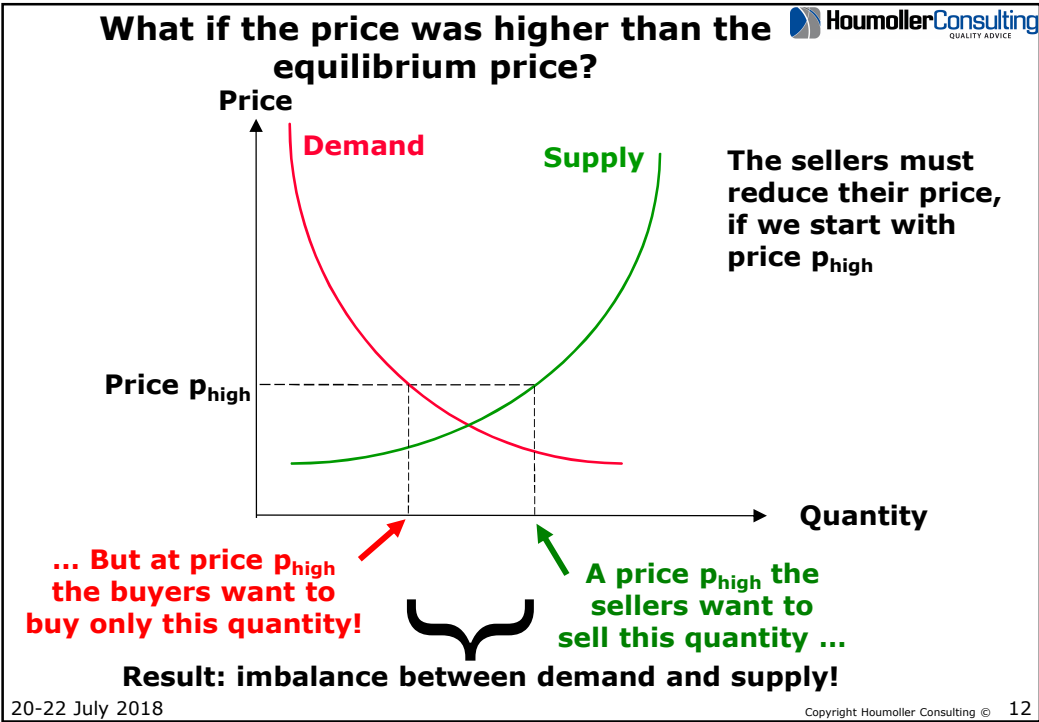
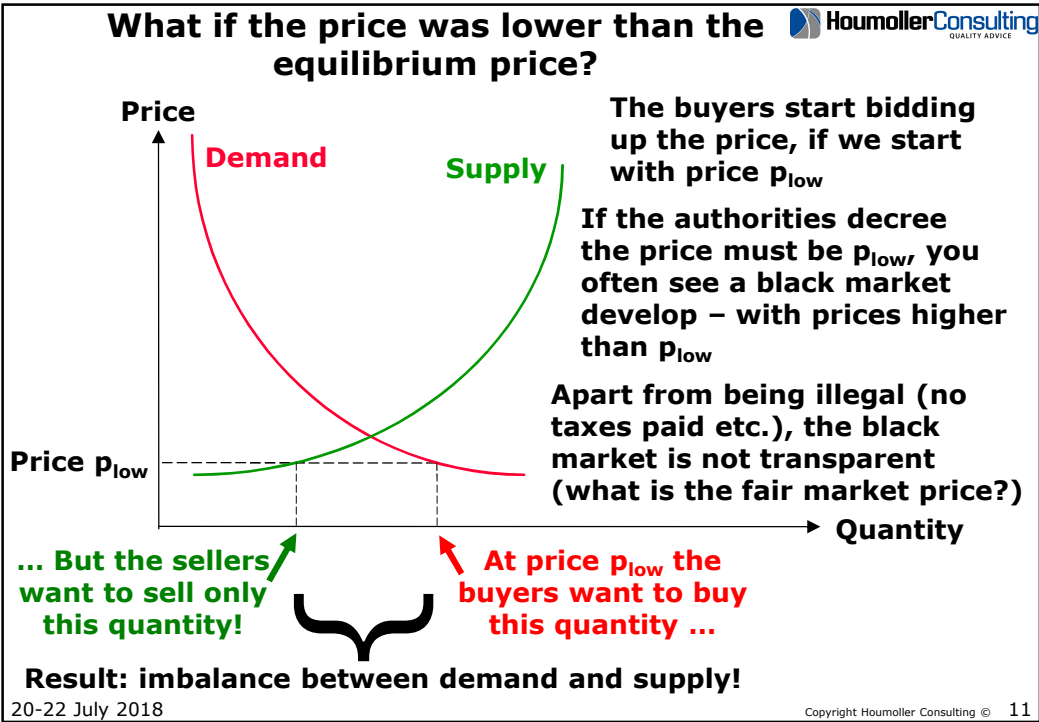
If the producers can get this price at the market ...

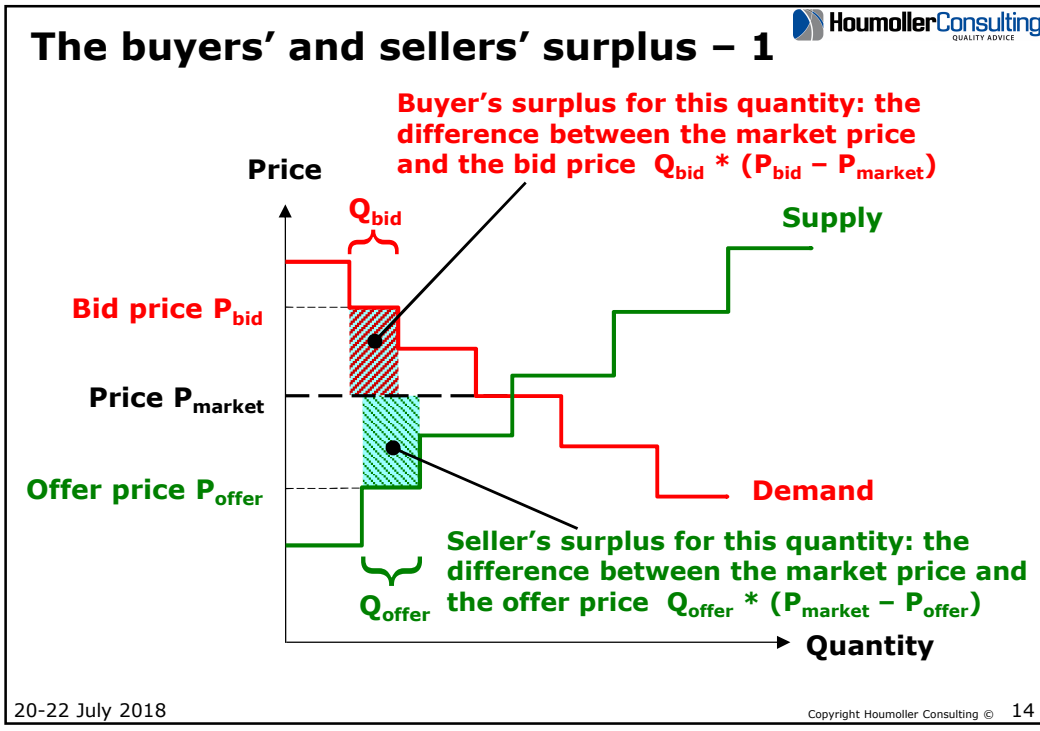
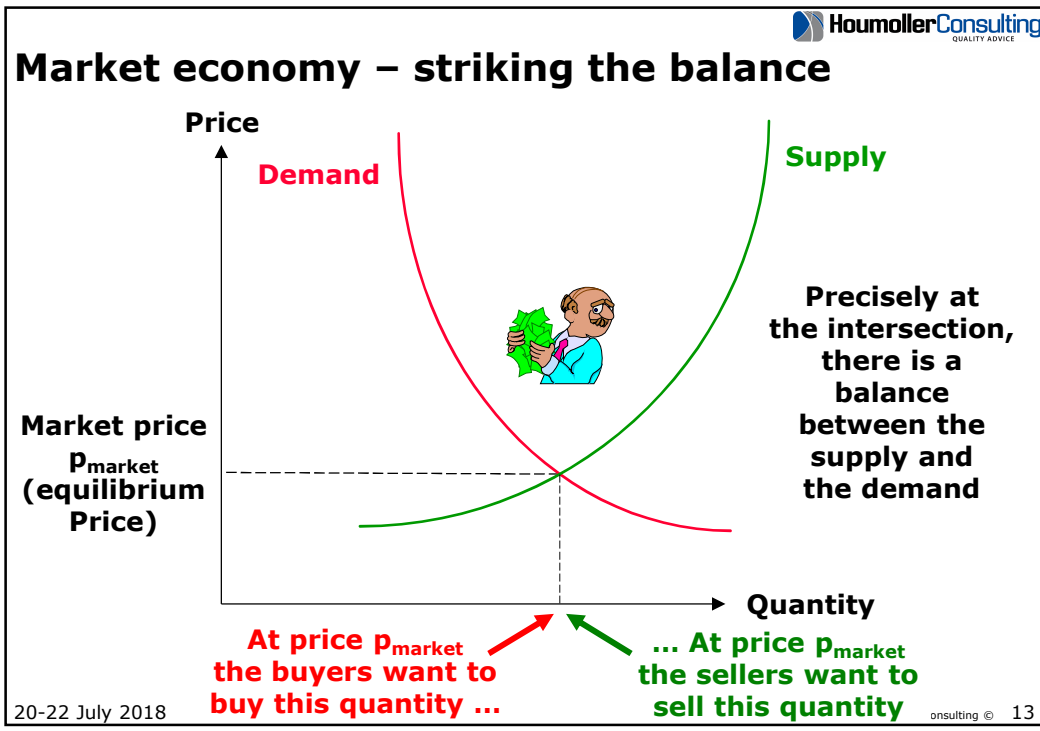
... Then they will supply this quantity to the market

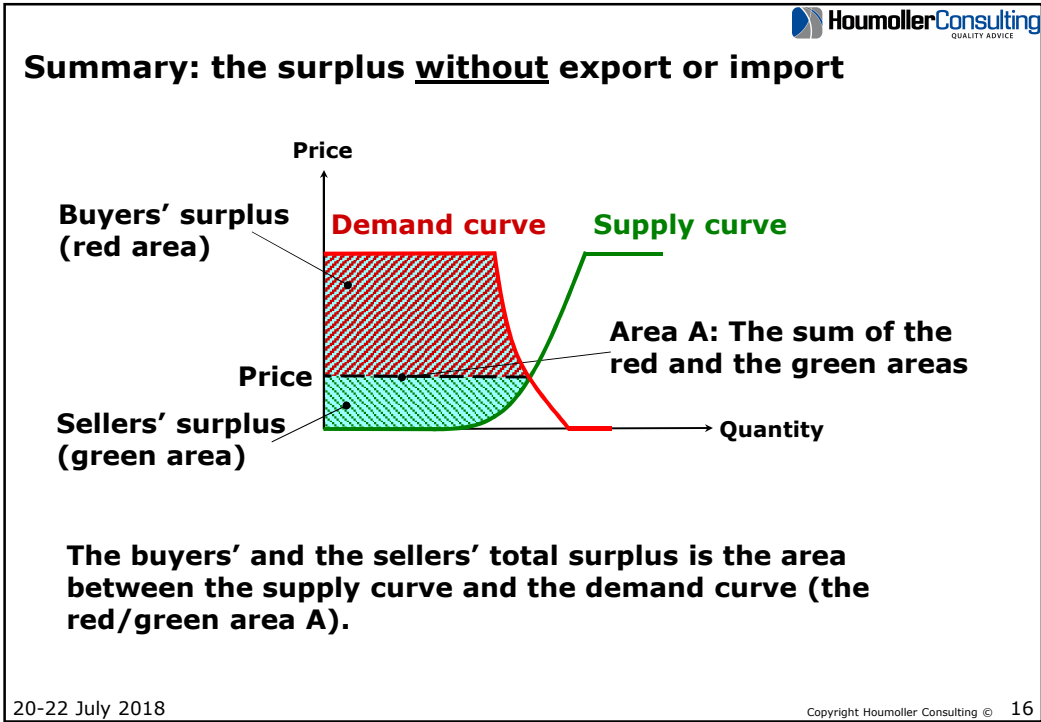
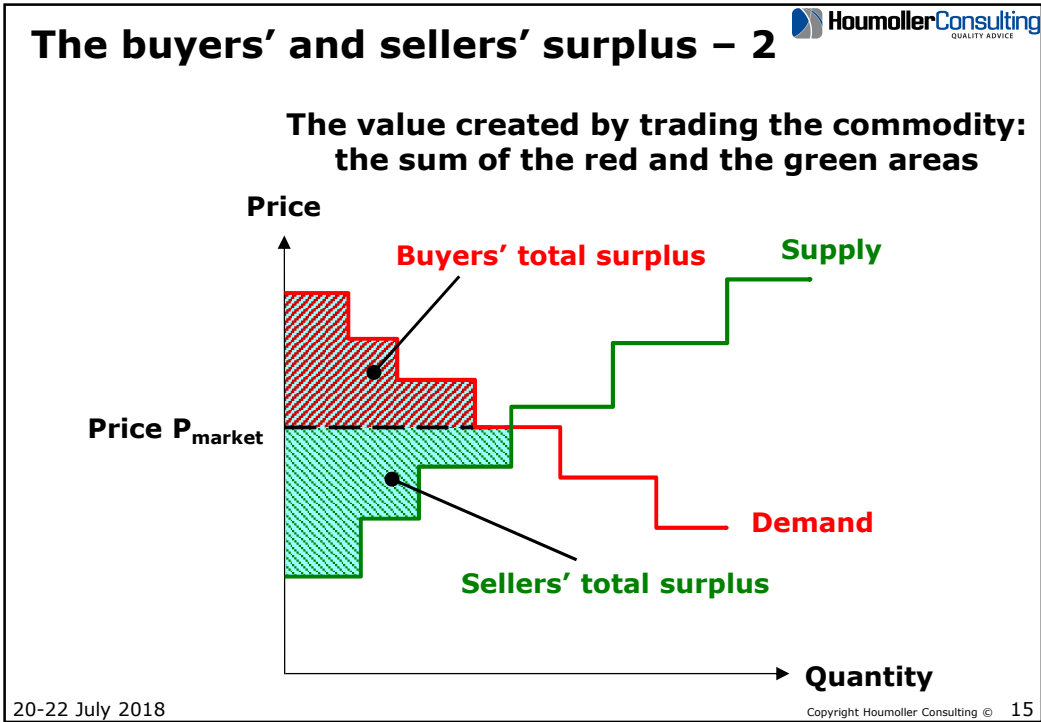


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Marginal production costs – 1

- Assume you build a factory producing mobile telephones.
- The cost of building the factory is **I**
 - ☐ This is the capital cost – also called the investment.
- Assume
 - ☐ **I = \$ 100 mill.**
- After the factory has started producing, the cost of producing one mobile telephone is **c**.
- Assume
 - ☐ **c = \$ 50.**
 - ✓ This is the so-called marginal production cost:
 - The cost of producing one more item, when your factory has been built and is up and running.

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Marginal production costs – 2


- The cost of building the telephone factory is **I = \$ 100 mill.**
- After the factory has started producing, the cost of producing one mobile telephone is **c = \$ 50.**
- Assume the market price for mobile telephones start falling
 - ☐ ***At which price will you stop producing telephones?***
- Assume you can sell your telephones for \$ 51
 - ☐ At this price, you cannot have a return on the investment.
 - ✓ However, you still earn some money – which is better than earning nothing!
- On the other hand: you stop producing, if the price falls to \$ 49.
 - ☐ Otherwise you would loose \$ 1 for each phone produced.
- **Conclusion: you continue to produce and sell, as long as the market price is higher than the marginal production costs!**
- Once the factory has been built, the investment is **sunk cost**
 - ☐ The investment is irrelevant for the decision of whether to produce.

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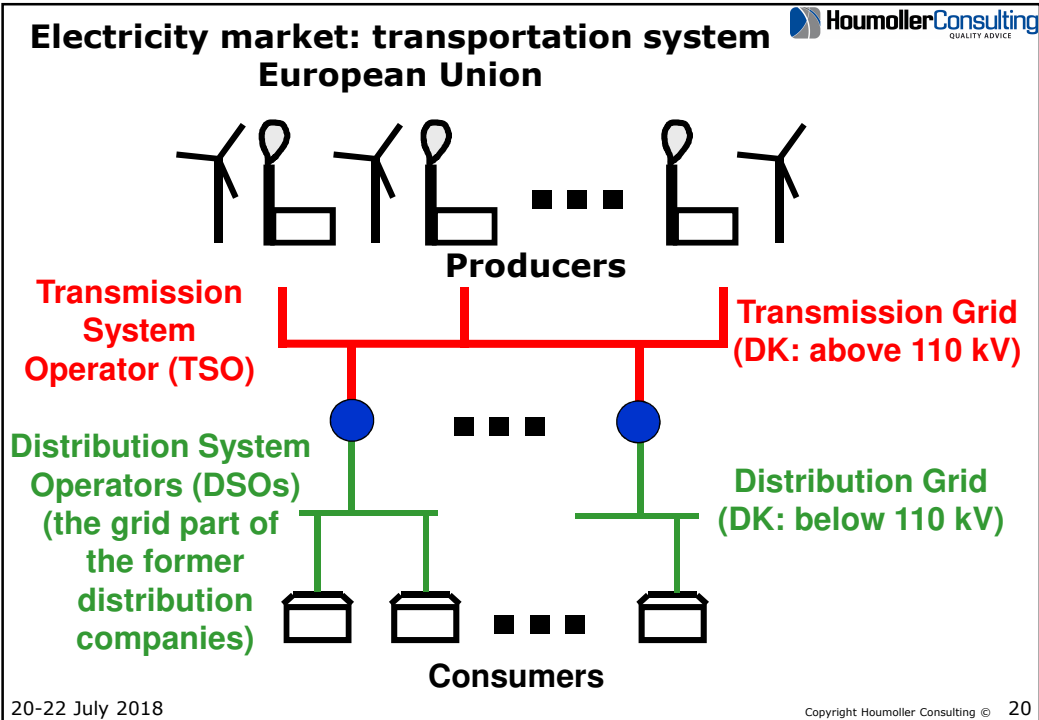
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The electricity market



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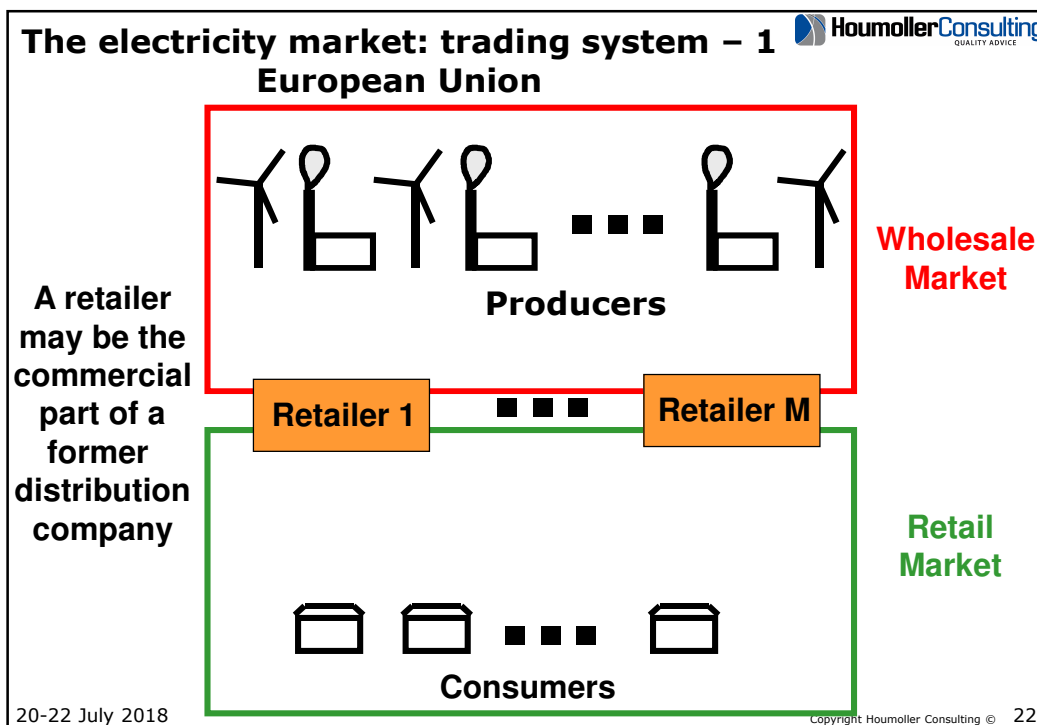


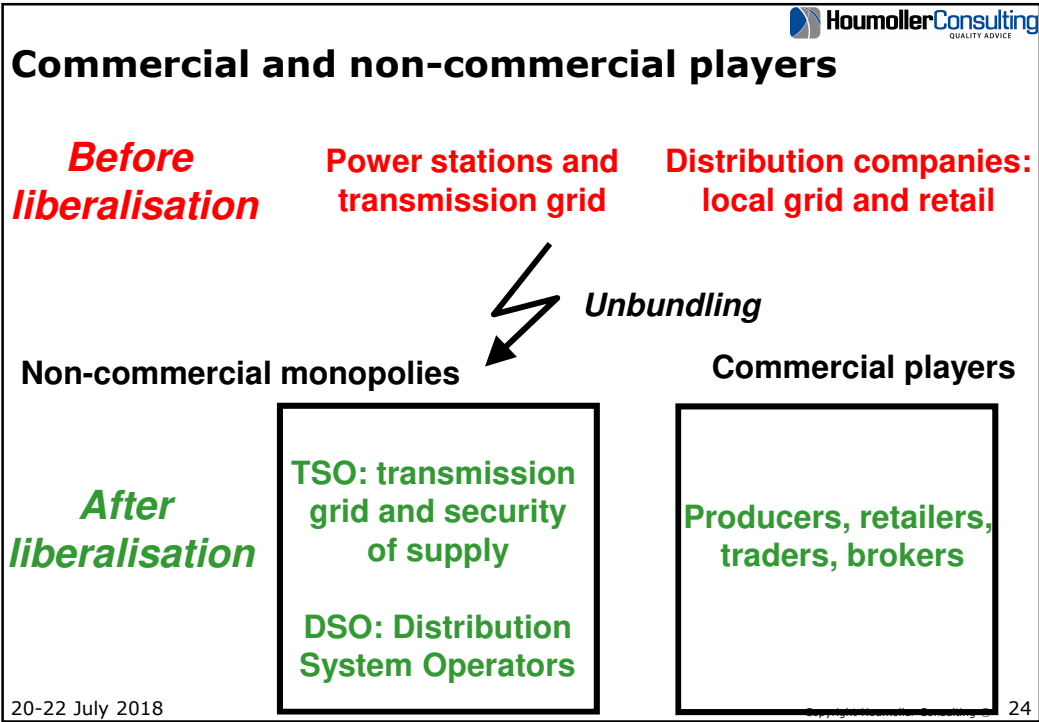
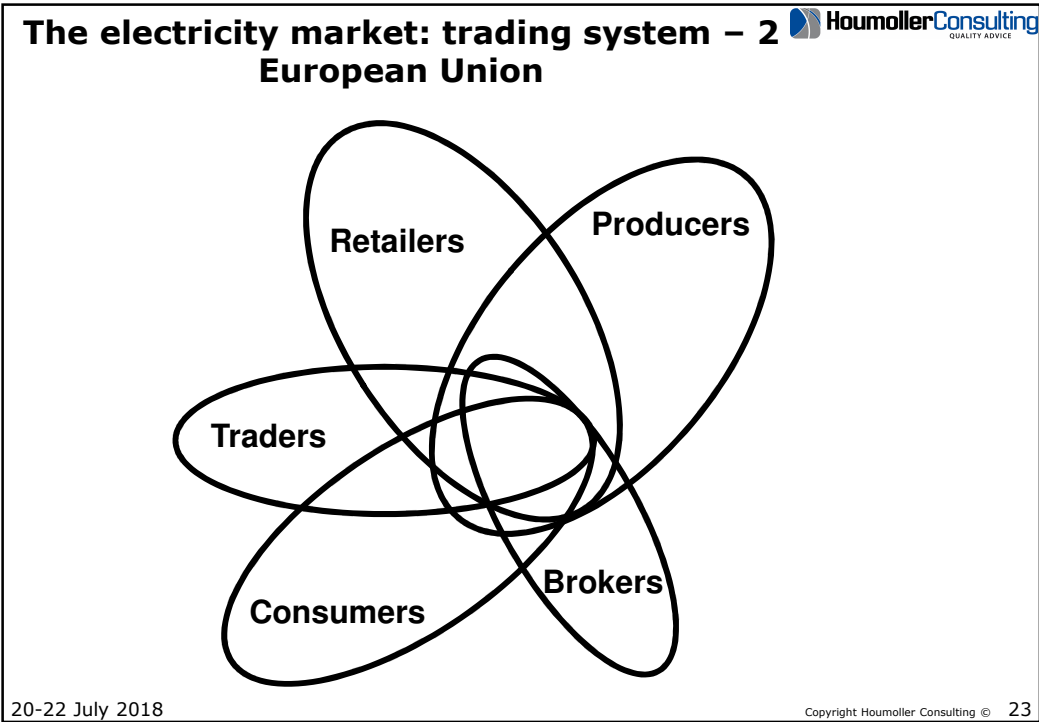
Transmission System Operator (TSO) European Union

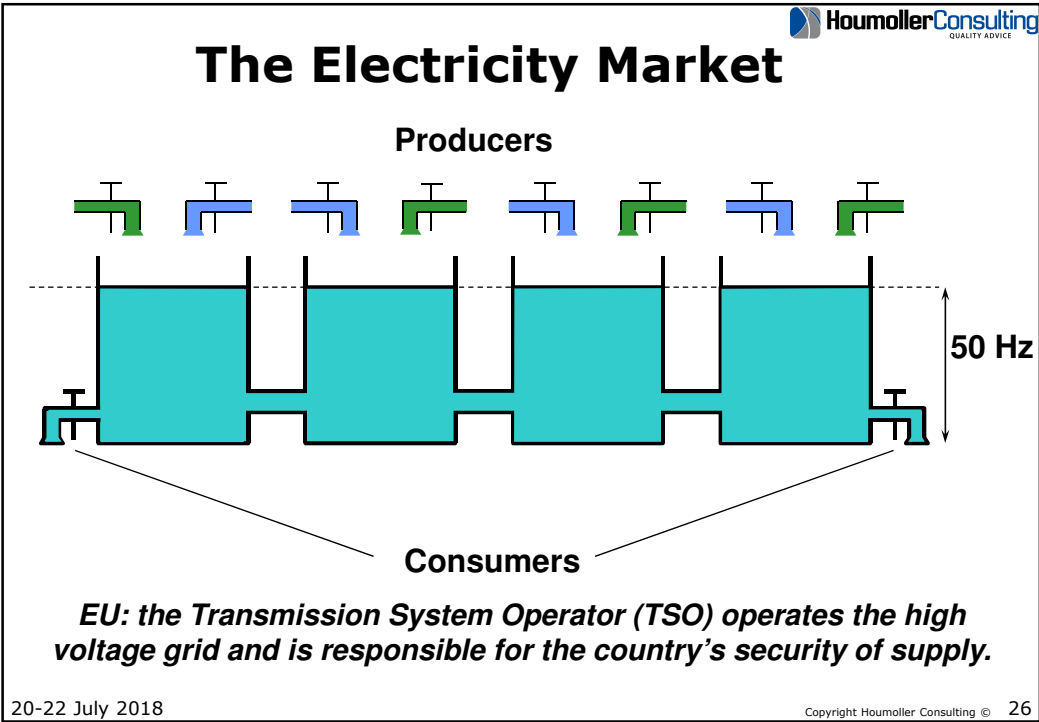
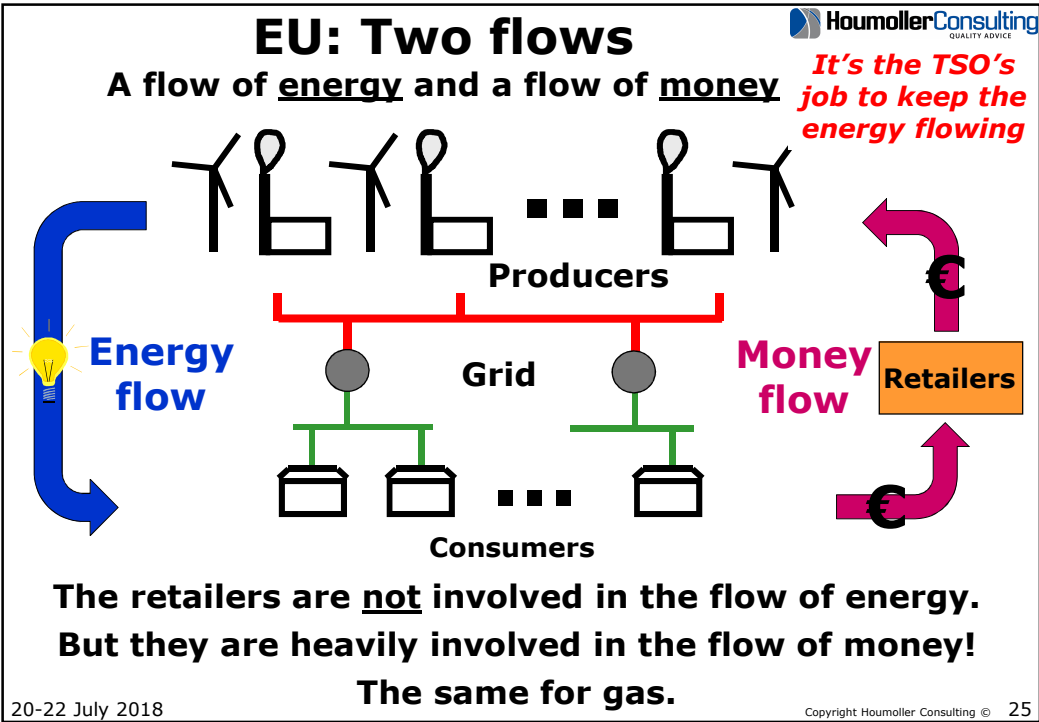
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- The TSO is a non-commercial monopolist.
- In the European Union, each TSO has two tasks:
 - ❑ Maintains the security of supply in the TSO's home country.
 - ❑ Owns and operates the transmission grid (the high-voltage grid)
 - ✓ For example, this means the TSO is responsible for setting the rules for the cross-border trading regime.
 - ❑ Most EU countries have only one TSO.
 - ❑ However, a few EU Member States have more than one TSO (eg, Germany)
 - ✓ For these countries, each TSO operates the high-voltage grid and maintain the security of supply in the TSO's control area.

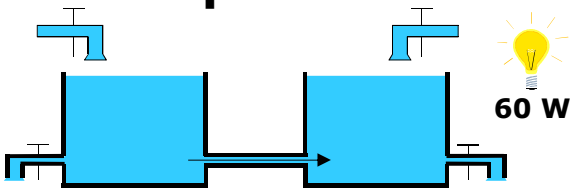
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Concepts and units



Energy consumed during an hour:
 $60\text{ W} * 1\text{ h} = 60\text{ Wh}$

<u>Concept</u>	<u>Explanation</u>	<u>Unit</u>	<u>Water analogy</u>
Power	Flow: how much energy per second?	W (Watt)	Flow: how much water is passing by per second?
Energy	The amount (for example, during an hour)	Wh (Watt-hour)	The amount (for example, during an hour)
Capacity	The ability to change a flow	W (Watt)	The ability to change a flow

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Prefixes


<i>Prefix</i>	<i>Prefix meaning</i>	<i>Examples</i>
k (kilo)	1,000 (thousand)	1 kW = 1,000 W 1 kWh = 1,000 Wh
M (Mega)	1,000,000 (million)	1 MW = 1,000 kW 1 MWh = 1,000 kWh
G (Giga)	1,000,000,000 (billion)	1 GW = 1,000 MW 1 GWh = 1,000 MWh
T (Tera)	1,000,000,000,000 (trillion)	1 TW = 1,000 GW 1 TWh = 1,000 GWh

4000 kWh/year = 4 MWh/year

Consumption Pakistan in 2014 about 87 TWh

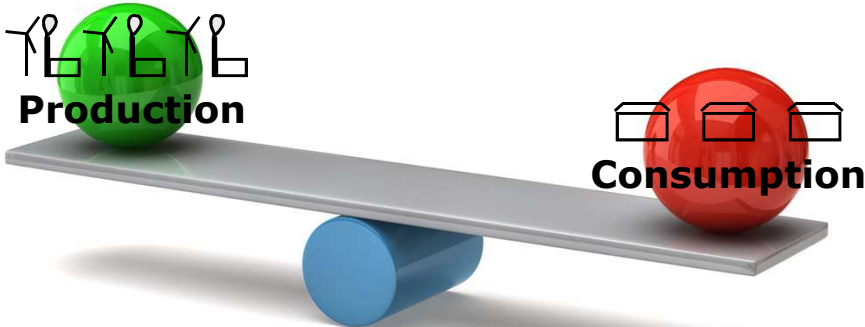
Source: World Bank

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Ancillary services – 1

- We'll now turn our attention to this question:
- **How do the TSOs maintain the security of supply?**
- We'll use the Nordic area as a case of how this can be done
 - ☐ By means of the market.



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Ancillary services – 2

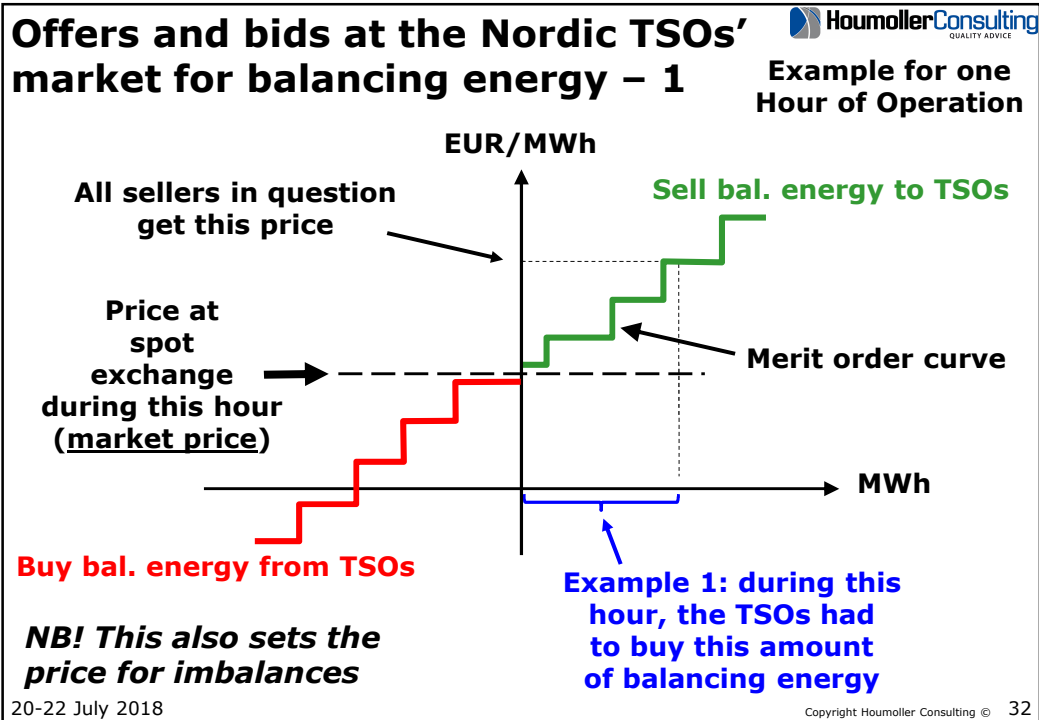
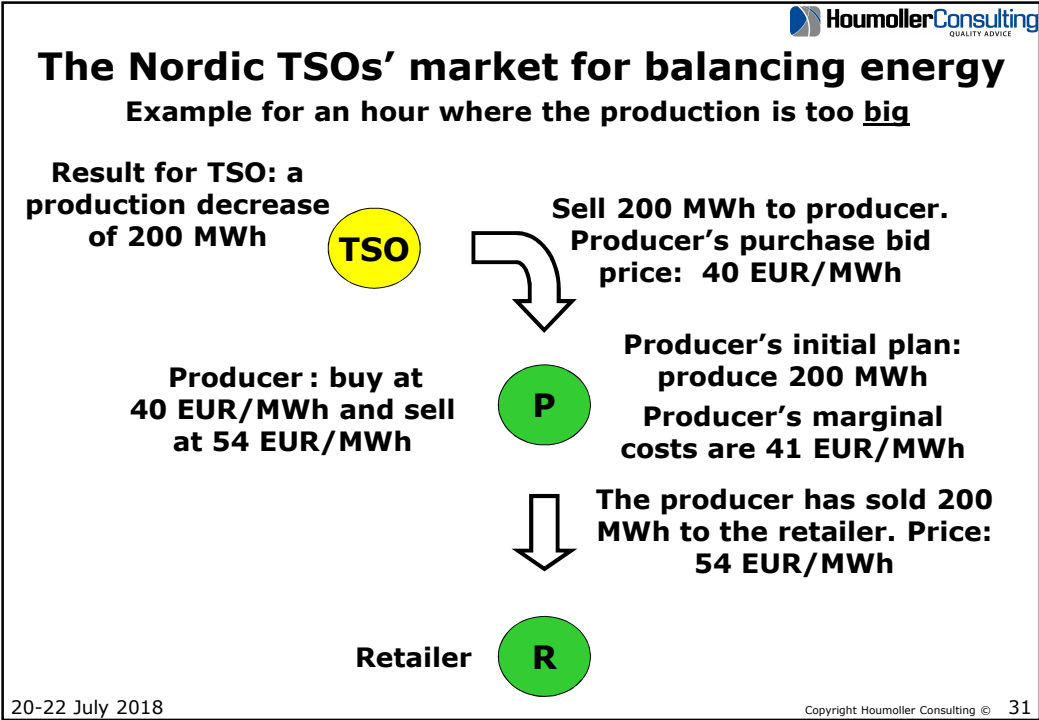
Energy

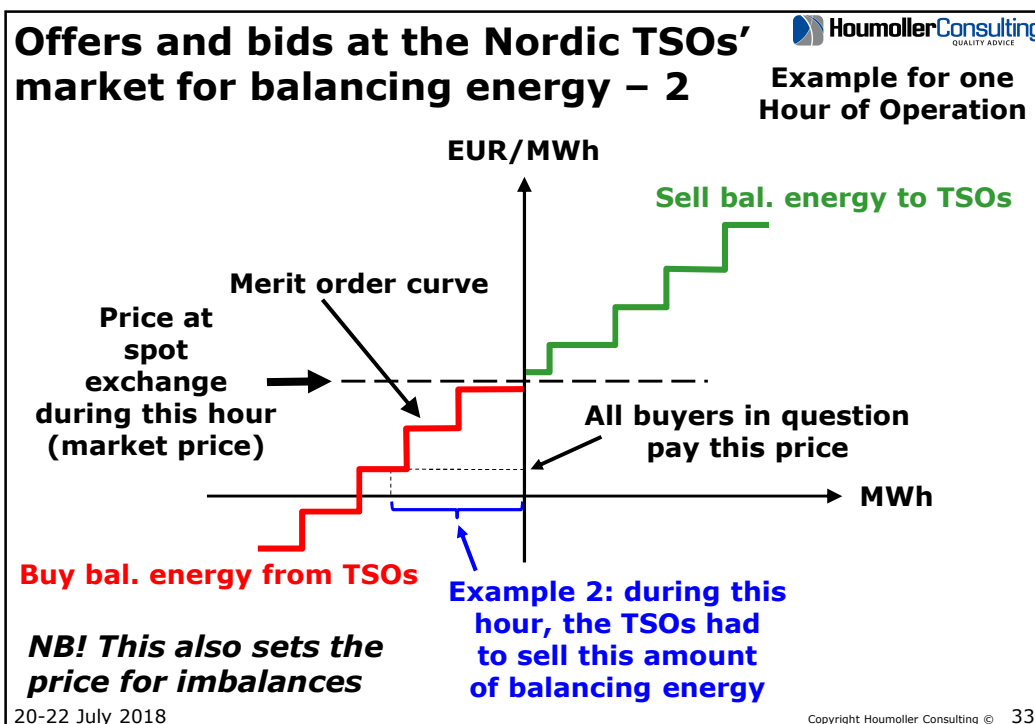
The TSOs' market for balancing energy


Case: the Nordic countries (Denmark, Finland, Norway, Sweden)



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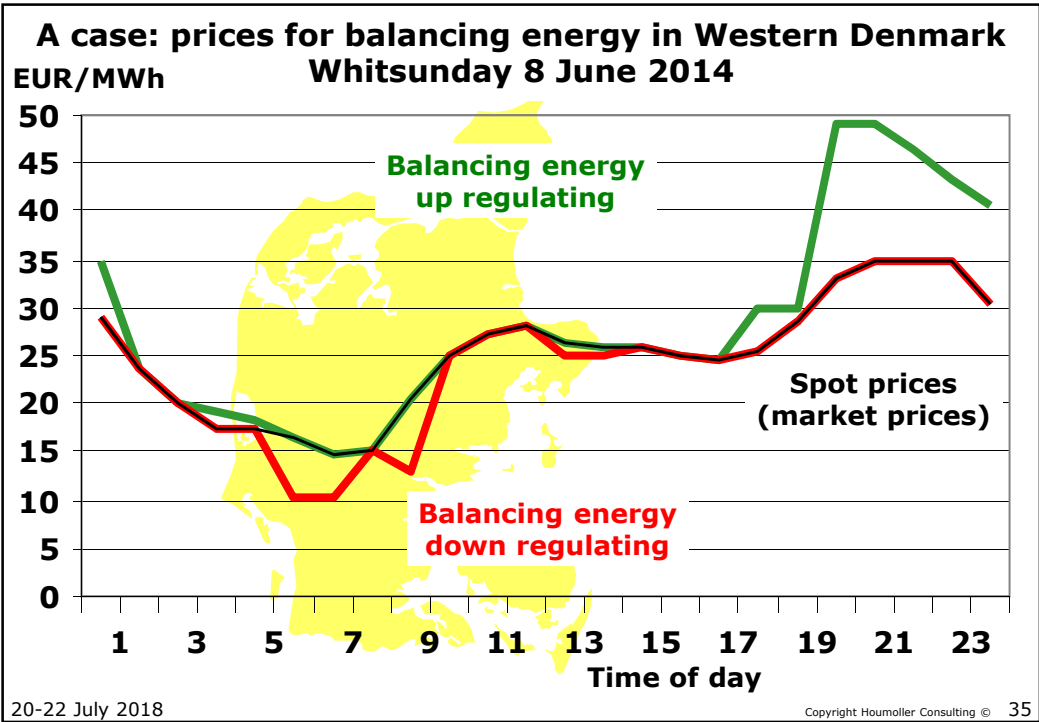




Balancing energy 

- The players at the Nordic market for balancing energy are paid the marginal price
 - ❑ The last player's price sets the price for everyone.
- Marginal pricing gives a *merit order* ranking where
 - ❑ The cheapest among the available, idle facilities are up regulated first.
 - ❑ The most expensive among the running facilities are down regulated first.

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Ancillary services – 3

Capacity

Case: Continental Europe

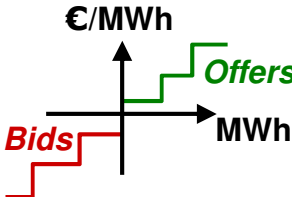
The TSOs' market for balancing capacity

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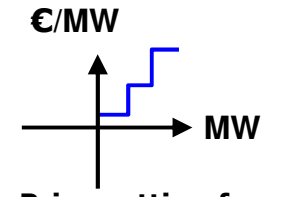
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The TSO's purchase of capacity

- How can the TSO ensure that there are bids and offers at the market for balancing energy?
- Western Denmark as a case: the TSO buys capacity.
- Examples:
 - ❑ A producer who has sold the Danish TSO 20 MW of up balancing capacity for a given hour of the next day must for this hour place an energy offer of 20 MWh volume at the TSO's market.
 - ❑ A producer who has sold the Danish TSO 10 MW down balancing capacity for a given hour of the next day must for this hour place an energy bid of 10 MWh volume at the TSO's market.




Price setting for balancing energy



Price setting for balancing capacity


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The TSO's purchase of balancing capacity and trading of balancing energy

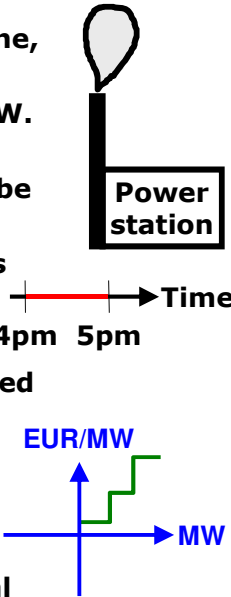
- All players may send bids and offers to the Danish TSO's market for balancing energy.
- However those who have sold capacity to the Danish TSO must send bids and/or offers.
- The Danish TSO buys this capacity day-ahead
 - ❑ During the morning the day before the Day of Operation.
- During the hour of operation (or shortly before) the Danish TSO trades energy, if it's necessary to buy or sell in order to maintain the frequency at 50 Hz.

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Fair pricing of up balancing capacity 

- We'll consider one, given hour of tomorrow and one, given power station.
- The power station in question has capacity 100 MW. The marginal production costs are 35 EUR/MWh.
- For this hour of tomorrow, the power station will be operating (ie, do not consider start-up costs).
- The expected spot price for the hour in question is 40 EUR/MWh.
- Question: *what is the value of 10 MW?*
- Answer: by operating 10 MW, the station's expected profit for this hour is
 $10 \text{ MW} * 1 \text{ h} * (40 - 35) \text{ EUR/MWh} = 50 \text{ EUR}.$
- Hence, a fair capacity price is:
 $50 \text{ EUR}/10 \text{ MW} = 5 \text{ EUR/MW}.$
- This is also the market price, if this is the marginal offer.

Note how the spot market is the starting point for the pricing!



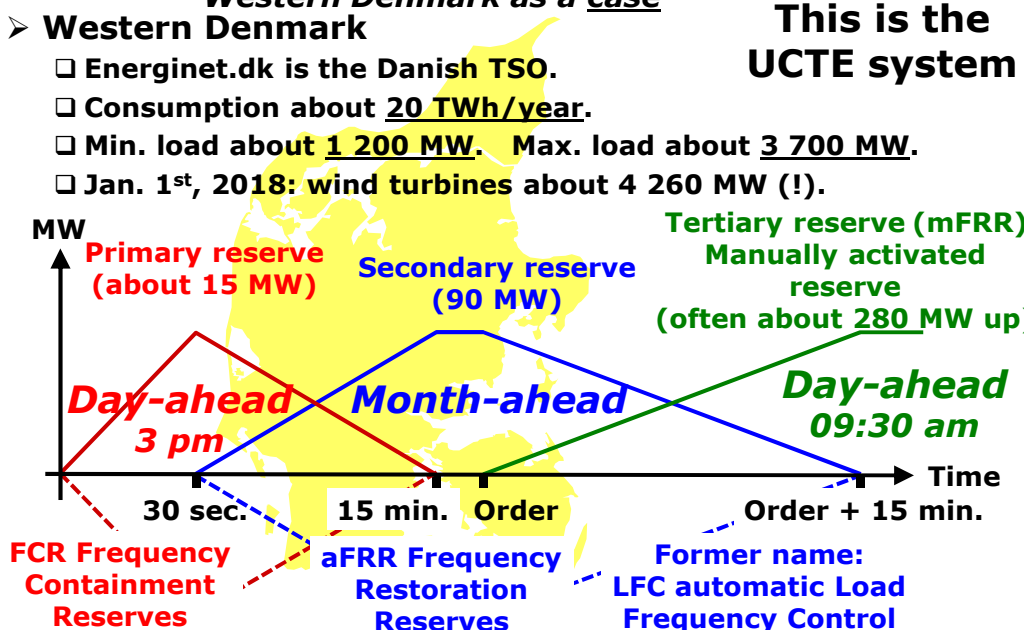
The diagram shows a power station icon and a graph with 'EUR/MW' on the y-axis and 'MW' on the x-axis. A red arrow indicates time from 4pm to 5pm. A green step function graph shows price increasing with capacity.

Capacity bought by the TSO 

Western Denmark as a case

- **Western Denmark**
 - ❑ Energinet.dk is the Danish TSO.
 - ❑ Consumption about 20 TWh/year.
 - ❑ Min. load about 1 200 MW. Max. load about 3 700 MW.
 - ❑ Jan. 1st, 2018: wind turbines about 4 260 MW (!).

This is the UCTE system



The graph shows MW on the y-axis and Time on the x-axis. It features three curves: a red 'Day-ahead 3 pm' curve peaking at 15 MW (Primary reserve), a blue 'Month-ahead' curve peaking at 90 MW (Secondary reserve), and a green 'Day-ahead 09:30 am' curve peaking at 280 MW (Tertiary reserve). Time intervals are marked: 30 sec. for FCR Frequency Containment Reserves, 15 min. Order for aFRR Frequency Restoration Reserves, and Order + 15 min. for Former name: LFC automatic Load Frequency Control.

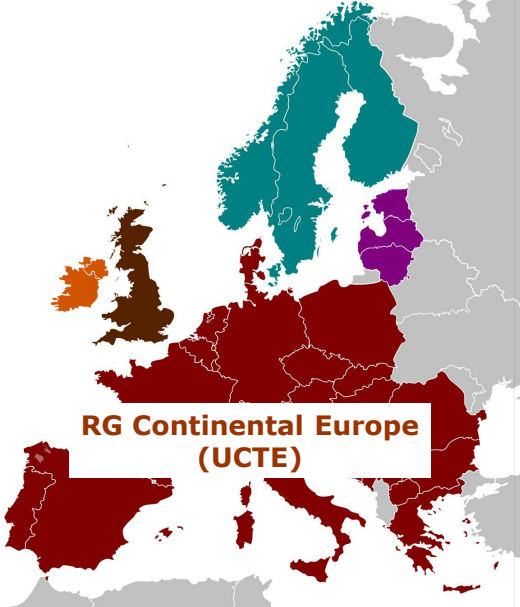
Former name: Union for the Co-ordination of Transmission of Electricity (UCTE). Today RG Continental Europe

Five synchronous grids in EU.

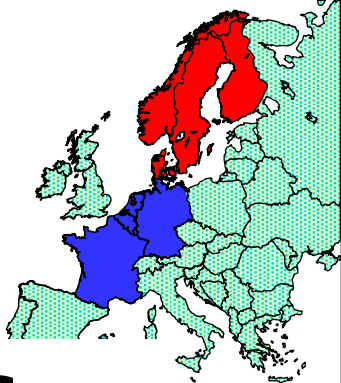
For the trading of electricity, it's of no importance that we have different synchronous areas.

You can trade across DC interconnectors as well as across AC interconnectors

**FCR in UCTE:
A total of 3000 MW**




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Imbalances

The TSO's settlement of imbalances with the market players

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Purchase of energy on the wholesale market

At EU's whole-sale markets, energy is traded per hour (main rule)

Contract no. 1
30 MWh


Contract no.2
70 MWh

}

**Customers' expected
consumption: 100 MWh**

***A retailer's purchase of energy for
the hour 3 p.m. - 4 p.m. July 21st, 2018***

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Imbalances - 1

**Pay supplier
no. 1**

**Pay supplier
no. 2**

Contract no. 1
30 MWh

Contract no. 2
70 MWh

}

**Customers' actual
consumption:
85 MWh.**

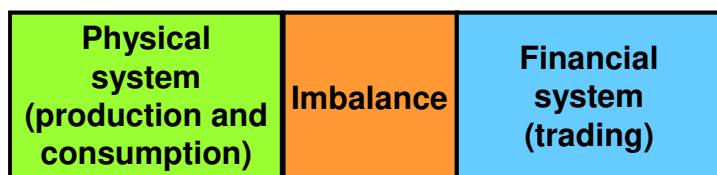
**Imbalance:
15 MWh.
Settle with
Transmission
System Operator (TSO)**

Settling the consumption of energy

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Imbalances - 2

- **Settlement of imbalances is thus the glue between the physical and the financial system:**
 - ❑ For a retailer, settlement of imbalances makes the trading and the consumption balance.
 - ❑ For a producer, settlement of imbalances makes the trading and the production balance.



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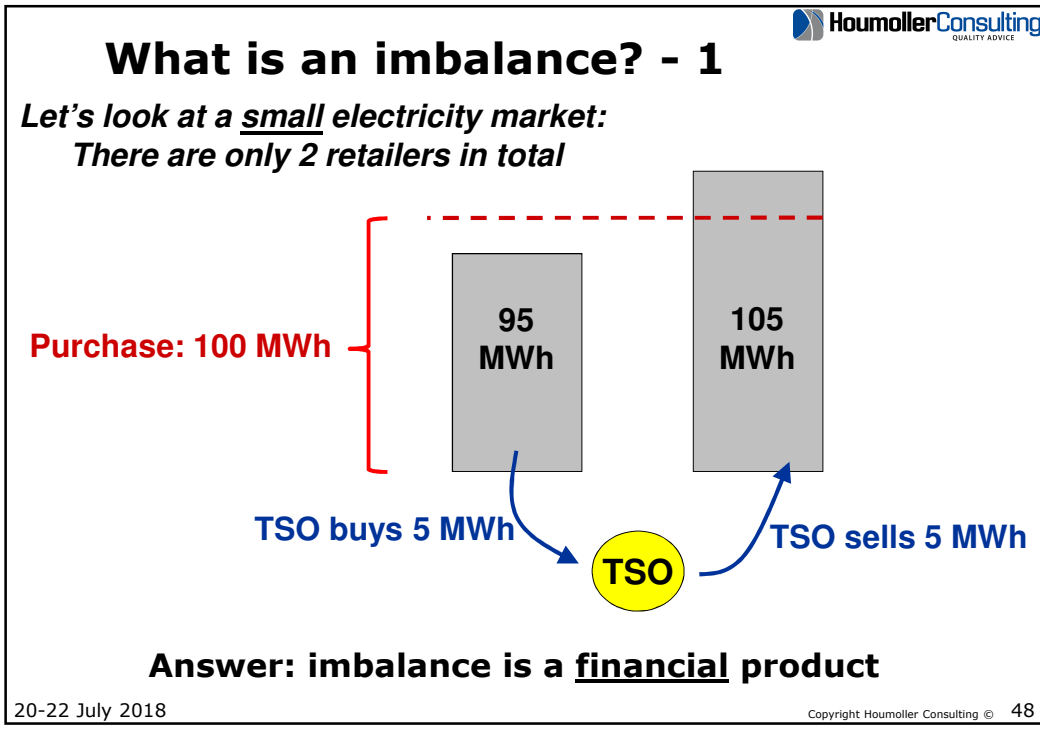
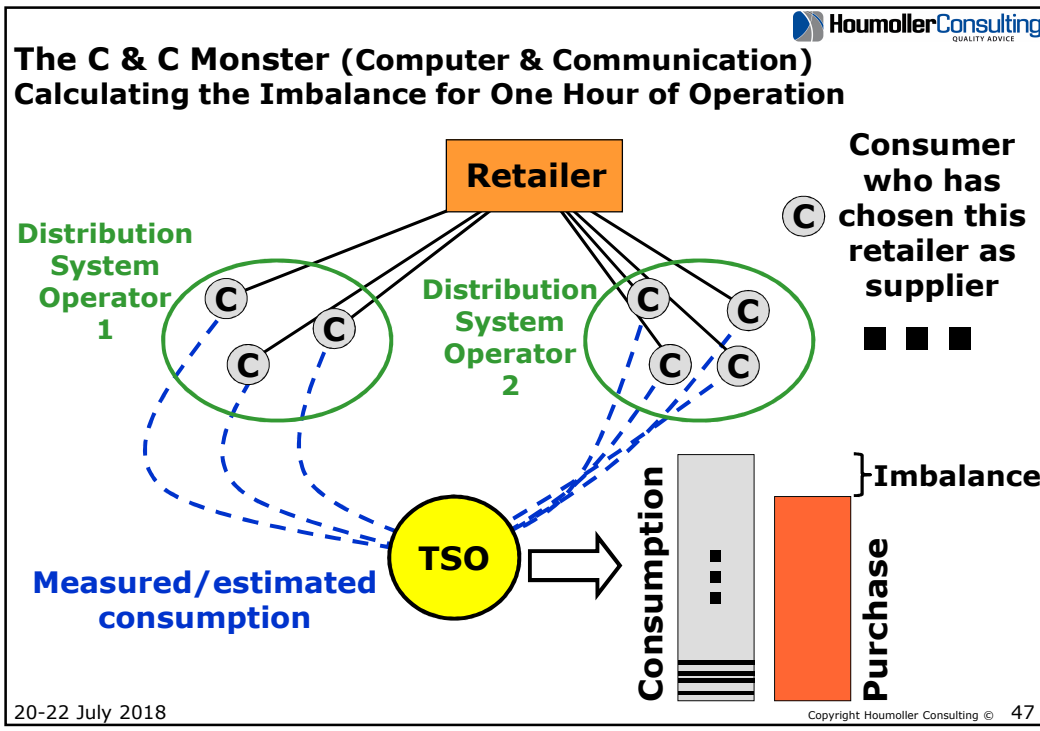
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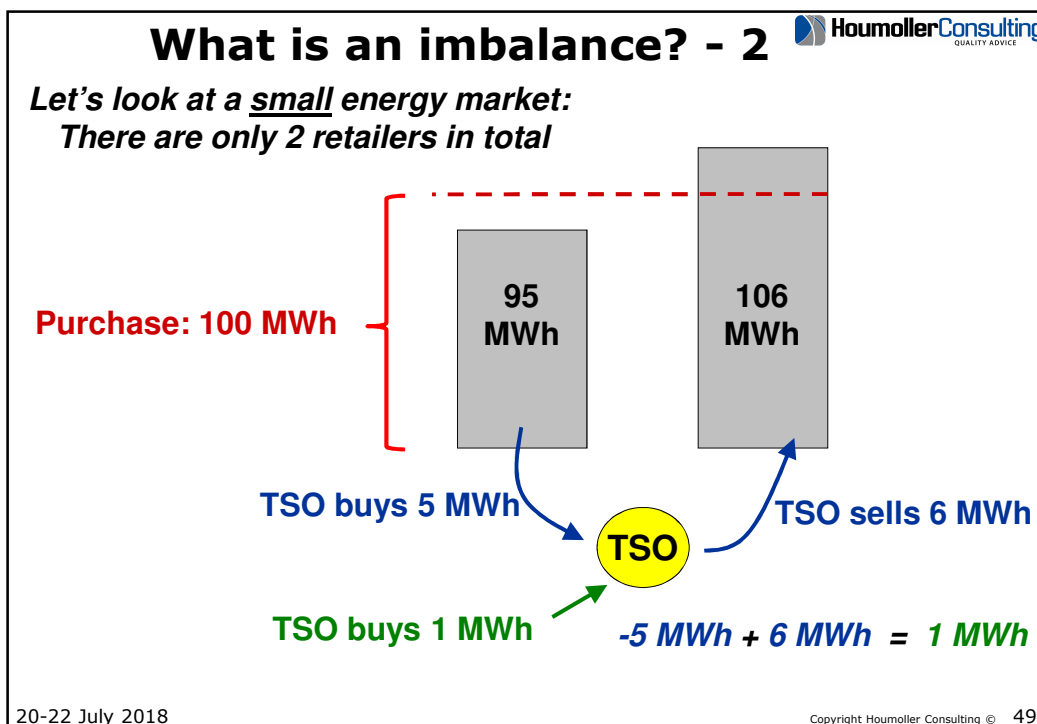
The C & C Monster (Computer & Communication) Calculating the Imbalances

- **For every consumer the consumption during each hour is either measured or estimated.**
 - ❑ For small consumers (e.g. households) the consumption is estimated. Their consumption is not measured every hour.
- **The measurements and the estimates are made by the Distribution System Operators and sent to the TSO.**
- **The TSO uses the measurements and estimates to compute the total consumption for the customers belonging to each retailer.**
- **By comparing with the energy purchased by each retailer the TSO can compute the imbalances.**

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Imbalances - 3

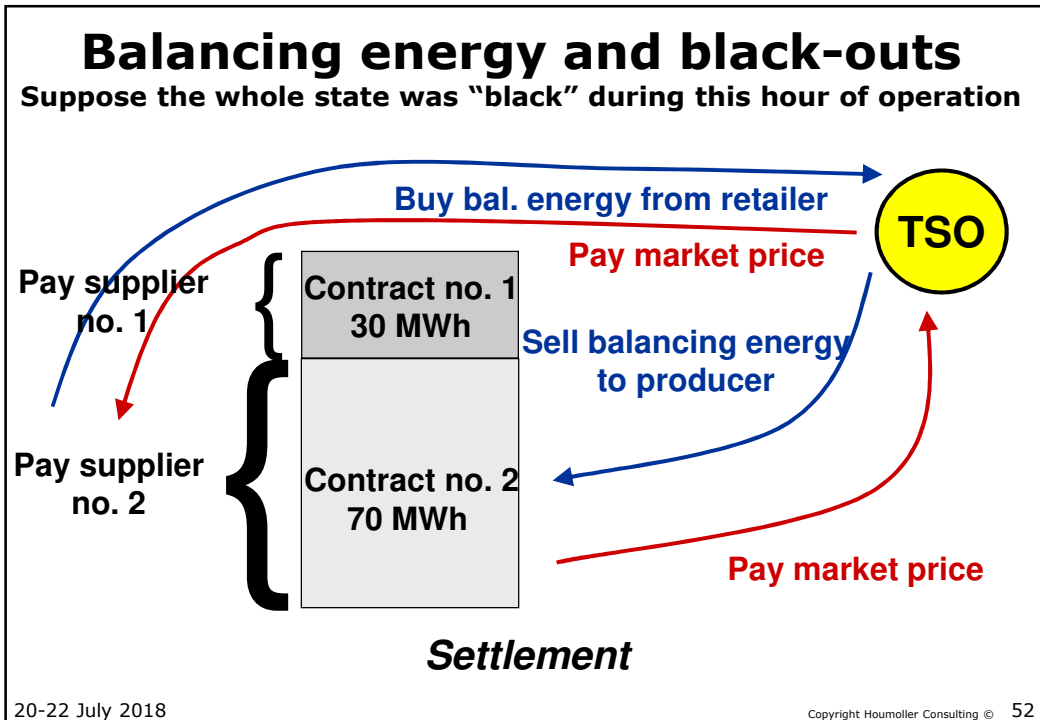
- **What is an imbalance?**
- **It is a financial product**
 - ❑ In contrast: balancing energy is a physical product.
- **If you for one given hour of operation add up all the imbalances, you will get the balancing energy needed during this hour (provided you remember to include the sign in the imbalances):**
 - ❑ $I_1 + I_2 + I_3 + \dots = B$

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Case: settlement of imbalances in DK, FIN and SE (the old system)
For one hour of operation. Gains and losses relative to market price

	<u>Retailer</u>	<u>Producer</u>
Up regulating: price for balancing energy bigger than market price	Bought too little energy: buys at the up regulating price (loss ☹).	Produced too little energy: buys at the up regulating price (loss ☹). Produced too much energy: sells at the market price (neutral ☺).
Down regulating: price for balancing energy lower than market price	Bought too little energy: buys at the market price (neutral ☺). Bought too much energy: sells at the down regulating price (loss ☹).	Produced too little energy: buys at the market price (neutral ☺). Produced too much energy: sells at the down regulating price (loss ☹).

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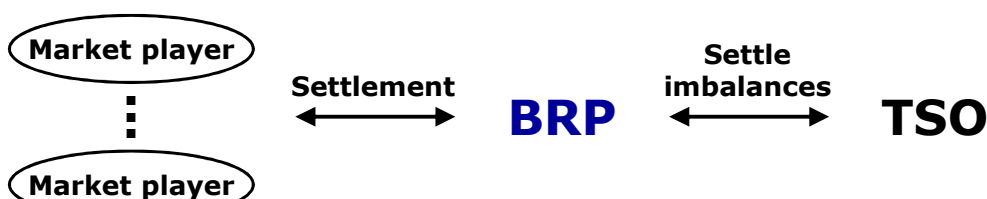
Balancing groups and portfolio management

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BRP Balancing Responsible Party

- **BRP: a player who settles imbalances with the TSO.**
- **If you are a producer, retailer or trader, you can choose to be BRP yourself**
 - ❑ **However, you may also outsource the task of settling imbalances with the TSO.**
- **An organisation can be BRP without being a producer, retailer or trader.**
- **In this case, the organisation is a service provider:**
 - ❑ **As a service for those, who are producers, retailers or traders, the organisation settles their imbalances with the TSO.**



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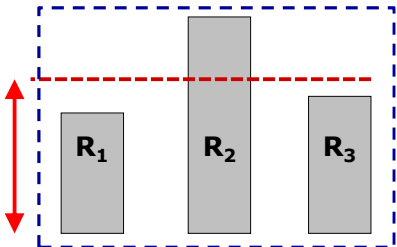
Balancing Group – 1

We consider a given country/imbalance area
Consider three retailers R_1 , R_2 and R_3 , who each are responsible for a portfolio of consumers.
At the outset, they each must settle imbalances with the TSO.
Alternatively, the three may form a Balancing Group.
With the TSO, the Balancing Group will settle the group's total imbalance.


Example for a given hour: for simplicity, assume all three retailers bought 50 MWh for their customers.
The grey columns illustrate the customers' consumption.
For many hours, the team will save money by joining forces in the settlement of imbalances.

Balancing Group

50 MWh

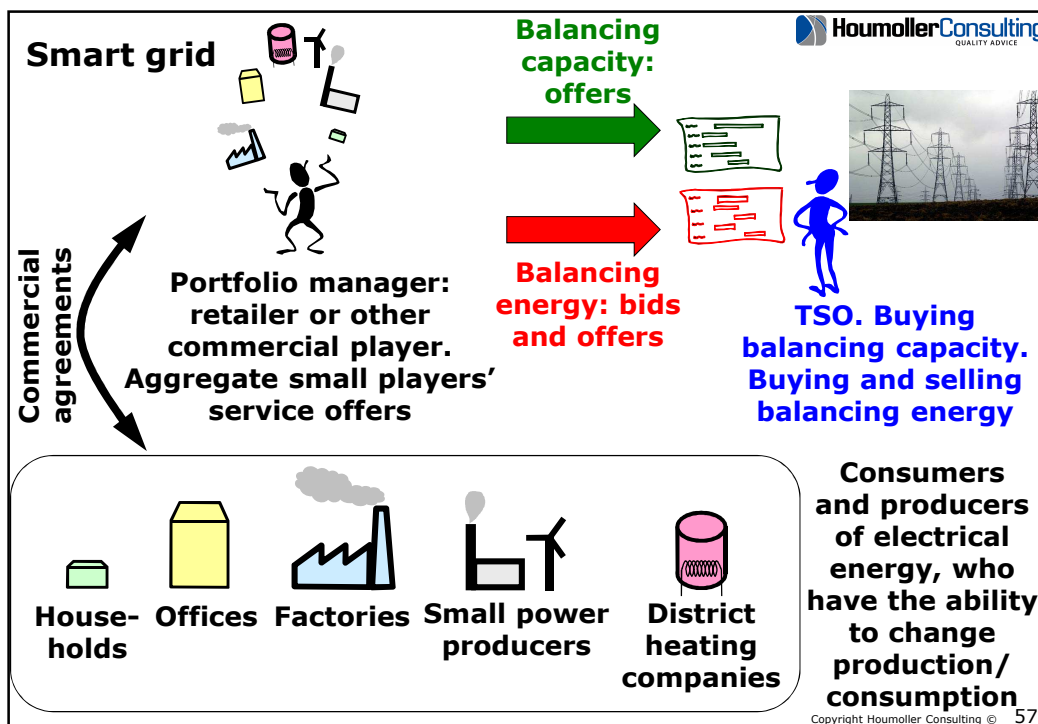


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Portfolio managers offering ancillary services to the TSO

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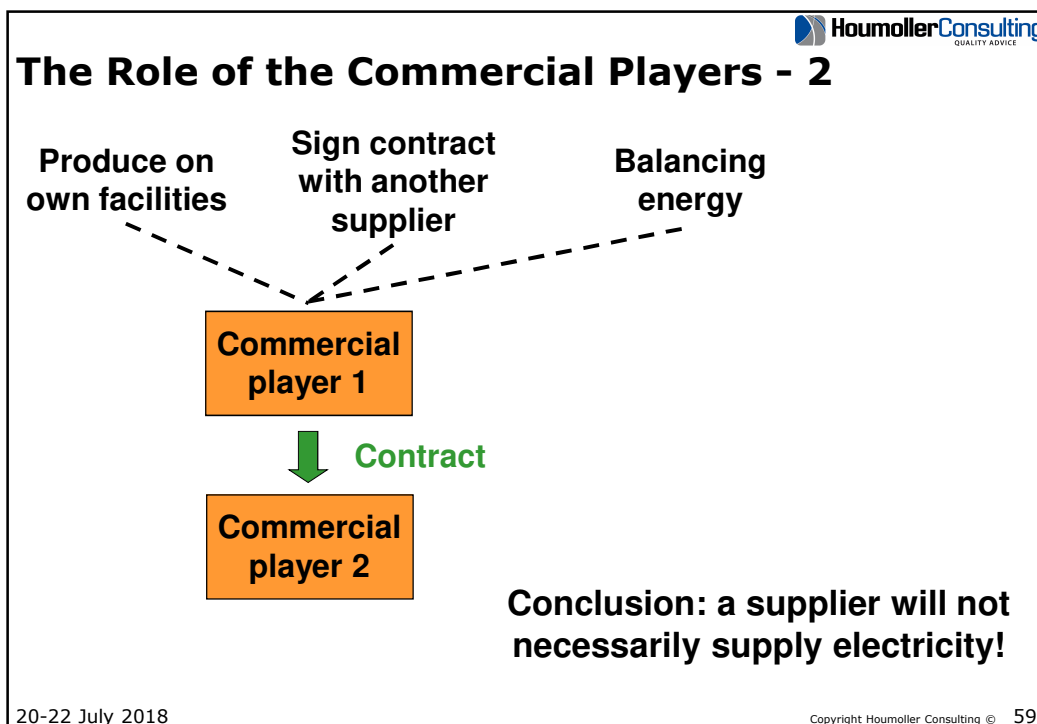
The Role of the Commercial Players - 1


- **The Transmission System Operator (TSO) has (together with the Distribution System Operator) responsibility for:**
 - ❑ The security of supply.
 - ❑ That the consumer actually gets the commodity.
- **A commercial player needs not produce electricity even if he has signed a contract which states that he will "supply".**

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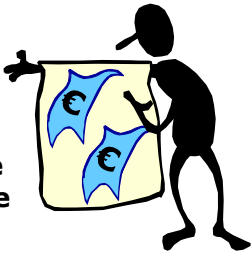
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The Role of the Commercial Players - 3

- The commercial players do not supply security of supply.
- The commercial players will not necessarily supply electricity.
- What do the commercial players supply to the consumers and each other?
- They supply **prices** (and the corresponding bills).
- Thus, the commercial players supply **financial services**.
 - ❑ Naturally, because the financial system is the only thing that is changed, when we liberalise the electricity market.





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The players' roles – 1 European Union

- **The Transmission System Operator (TSO).**
- **As discussed previously – the TSO:**
 - ❑ **Owns and operates the transmission grid**
 - ✓ **The high voltage grid.**
 - ❑ **Maintain the country's security of supply**
 - ✓ **Trade balancing energy and balancing capacity with market players and neighbouring TSOs.**
 - ❑ **Settles the market players' imbalances.**
 - ❑ **Sets many of the rules for the whole-sale market**
 - ✓ **And get the rules approved by the regulator.**





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The players' roles – 2 European Union


- **The Distribution System Operator (DSO).**
- **As discussed Wednesday – the DSO:**
 - ❑ **Owns and operates the distribution grid (low voltage grid).**
 - ❑ **Measures the consumption of consumers connected to the distribution grid (i.e. most consumers).**
 - ❑ **Measures the production of producers connected to the distribution grid (the small producers).**




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The Energy Regulator – 1






Regulator’s role: surveille the electricity supply business



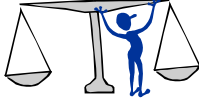
A strong legal foundation for the regulator’s work



Key words for the regulator:


Impartiality/ neutrality.

Trust.





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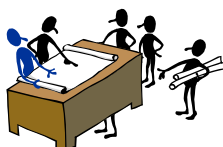


The Energy Regulator – 2

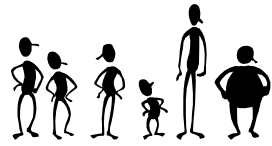





It is of crucial importance the regulator establishes a well-functioning co-operation with the stakeholders



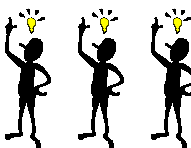
Examples of stakeholders: consumers, producers, traders, transmission system operator(s), distribution companies.



Public consultation is one way of having this co-operation.



Public consultation is also *crowd-sourcing* (i.e. use the knowledge in the whole industry)



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Division of work



- **Normally, the regulator will not set the rules governing the electricity supply industry**
 - ❑ **For comparison: the courts do not set the rules they use when passing judgements.**
- **For example: normally, the regulator does not set tariffs and standards.**
- **The regulator approves tariffs and standards, for example.**
- **Normally, the law governing the electricity supply business is mostly a framework**
 - ❑ **The TSO fills in the framework by drafting rules for the electricity market.**
 - ❑ **The regulator approves or rejects the rules proposed by the TSO.**
 - ❑ **If the regulator would write the rules filling in the law's framework**
 - ✓ **In the next step, the regulator would approve rules written by the regulator...**

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Team exercise




- **Can Pakistan establish a market-based system for ancillary services?**
- **If "yes" – how?**
- **The team exercise will run until 4:15pm**
 - ❑ **Coffee break during team exercise.**
- **From 4:15pm to 5pm, we'll have presentations and discussions of the teams' work.**
- **The teams may produce PowerPoint slides or write on flip-charts.**



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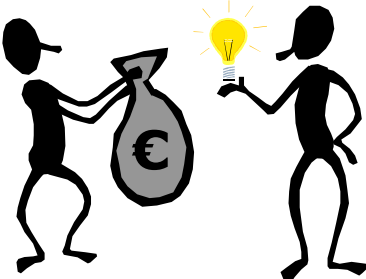
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Day 5

Saturday 21 July

**Trading electrical energy at the whole-sale market
Trading with an electricity exchange**



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The day-ahead dispatch plans

- At 3pm the producers must send the TSO their preliminary production plans for the next day.
- The bilateral trading plus the exchange trading provides the producers with their production plans
 - ❑ For each hour of tomorrow, each producer must produce the amount of energy, the producer has managed to sell.
- Therefore, the market is used as a tool, which provides the dispatch plans for the next day.

Producer

Sale for tomorrow **→** Production plan for tomorrow

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The liberalisation process

Denmark as a case


- **Denmark:**
 - ❑ **1997:** those consumers, who have a consumption of 100 GWh/year or higher, were granted free choice of electricity supplier (were granted eligibility).
 - ❑ **April 1, 2000:** those consumers, who have a consumption of 10 GWh/year or higher, were granted eligibility.
 - ❑ **January 1, 2001:** those consumers, who have a consumption of 1 GWh/year or higher, were granted eligibility.
 - ❑ **January 1, 2003:** all consumers were granted eligibility.
- **Similar methods were used in Norway, Sweden and Finland**
 - ❑ **Also in these three countries all consumers are eligible.**
- **All consumers in the European Union should be eligible.**

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The Effect of Free consumers

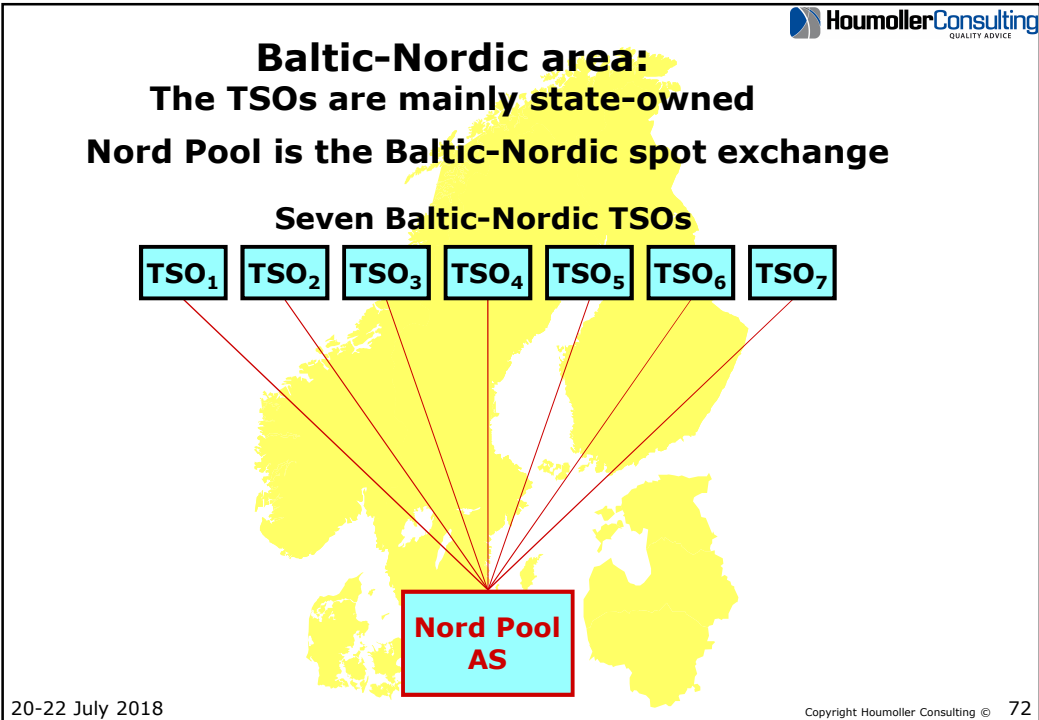
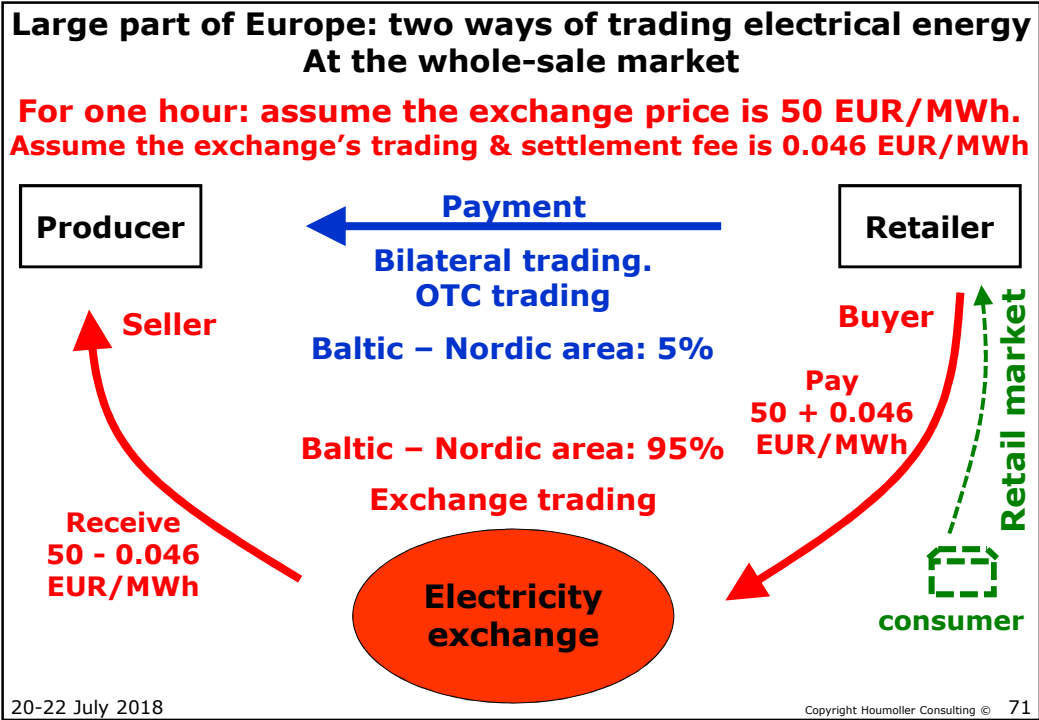
- **At least some consumers must be granted a free choice of supplier.**
- **This makes the retailers worry about prices (and services).**



```

graph LR
    P[Producer] --> R[Retailer]
    R --> C[Free consumer]
    C --> R
    R --> P
  
```

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Two of the spot exchanges in Europe Nord Pool and EPEX Spot

- **Nord Pool** is an exchange, where the players can trade electrical energy **day-ahead** and **intra-day**.
- In 2017, about 95% of the electricity consumed in the Baltic-Nordic area was traded with Nord Pool.
- **Elsport** is Nord Pool's day-ahead auction market.
- **XBid** is the intra-day market (a common European system).
- Turn-over in 2017:
 - ❑ **Elsport** **394 TWh (Baltic-Nordic area)**
 - ❑ **Intraday** **7 TWh (Baltic-Nordic and Germany)**
- -----
- **EPEX Spot**: the same as Nord Pool.
- **Spot turn-over 2017 in Continental Europe: 413 TWh.**
- **Intra-day turn-over in Continental Europe: 56 TWh**
 - ❑ **Germany and Austria: 47 TWh.**

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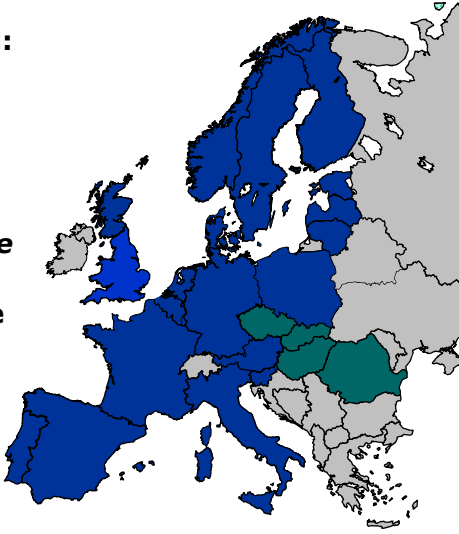
Spot trading and market coupling

- The spot market.
- Handling of bottlenecks in the grid: market coupling and market splitting.
- Please also refer to the article *The Liberalized Electricity Market* and the PowerPoint presentation *Single spot exchange for the Single Electricity Market*
 - ❑ You'll find the documents at the sub-page *Facts and findings* at www.houmollerconsulting.dk

We'll discuss the European spot market as it currently works in the blue and green areas.


Indian Energy Exchange operates a spot market working the same way.

Further, the Turkish spot market works as described at the following slides.



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The spot markets in EU

Day-ahead markets for electrical energy 

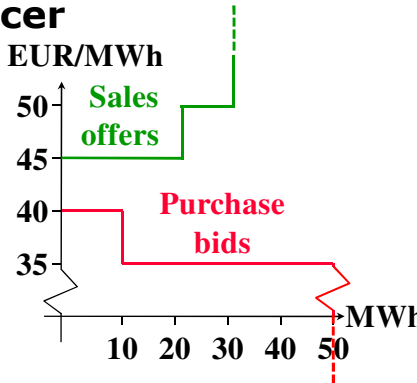
- This is where electrical energy is traded day-ahead.
- Bids and offers must be sent to the spot exchange at the latest 12 o'clock the day before the Day of Operation – gate closure time is 12 o'clock CET (Central European Time).
- At 12 o'clock CET the computation starts: by matching the bids and the offers for every hour of the following day, a spot price for each hour the following day is calculated.
- Normally, the prices for the following day are published around 1 p.m. CET (i.e., it's day-ahead prices).
- **EPEX Spot is Europe's biggest spot exchange.**
- **Baltic-Nordic area: Elspot is the name of Nord Pool's spot market**
 - ❑ Other European spot exchanges have other names for their spot markets (DAM Day-Ahead Market).
- **Note: in the USA, the term "spot market" does not mean the day-ahead market.**

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Example of spot bids for one hour of the next day from a producer

MPC: Marginal Production Costs EUR/MWh

- In this example, the producer has 4 production units:
 - ❑ U1: 40 MW, MPC 35 EUR/MWh
 - ❑ U2: 10 MW, MPC 40 EUR/MWh
 - ❑ U3: 20 MW, MPC 45 EUR/MWh
 - ❑ U4: 10 MW, MPC 50 EUR/MWh
- For this hour of the next day, the producer has sold 50 MWh bilaterally.
- Therefore, at the outset, for this hour of tomorrow, the producer will run the units U1 and U2
 - ❑ Thereby producing 50 MWh at costs 35 EUR/MWh and 40 EUR/MWh.



Purchase bids and sales offers from the producer for the hour 1 p.m. - 2 p.m. of the next day

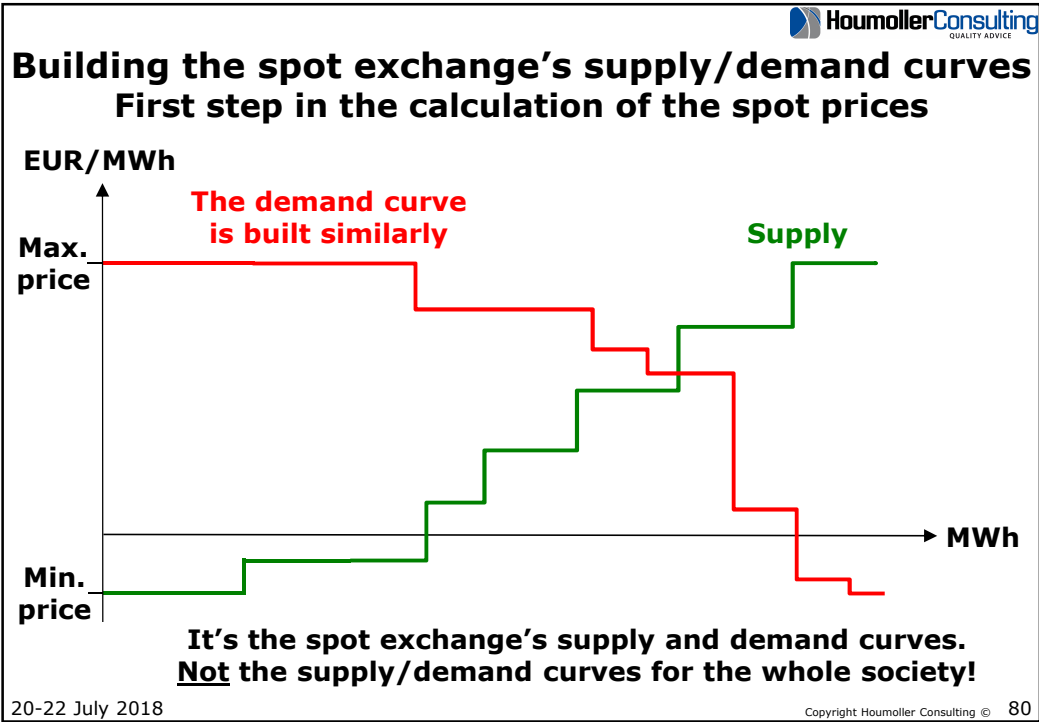
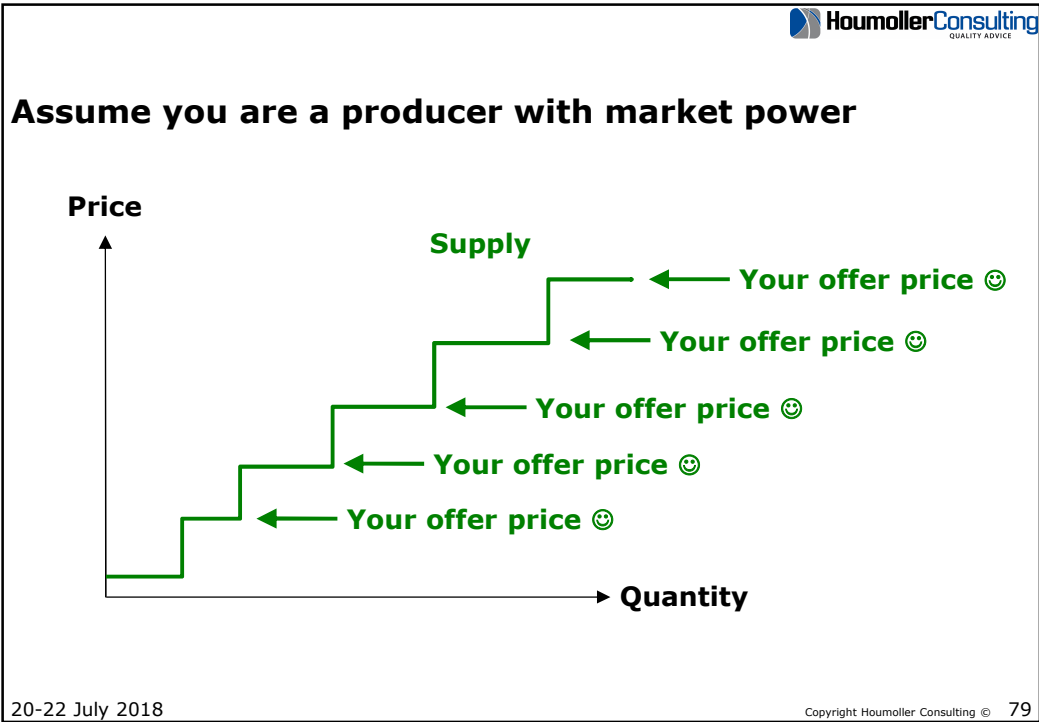
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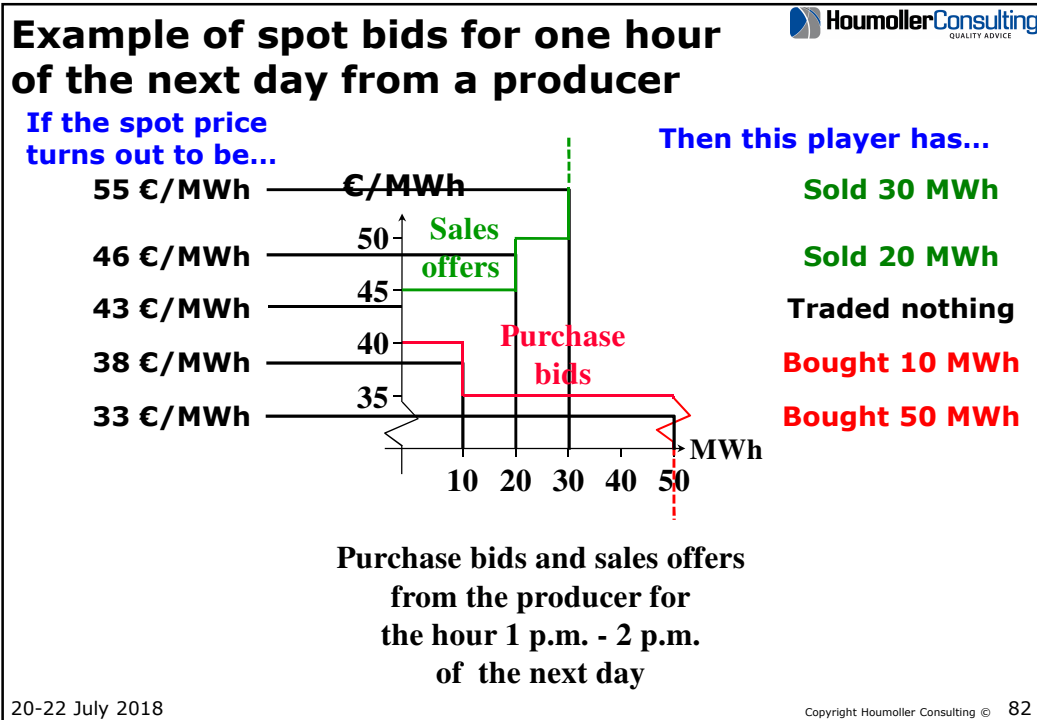
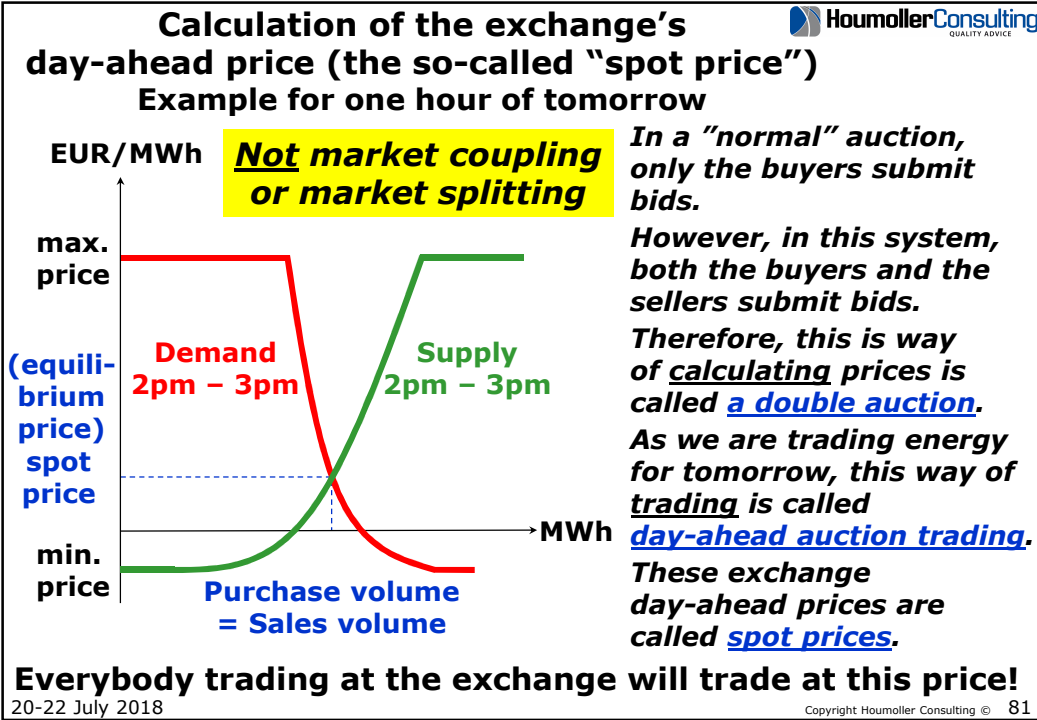
Market power

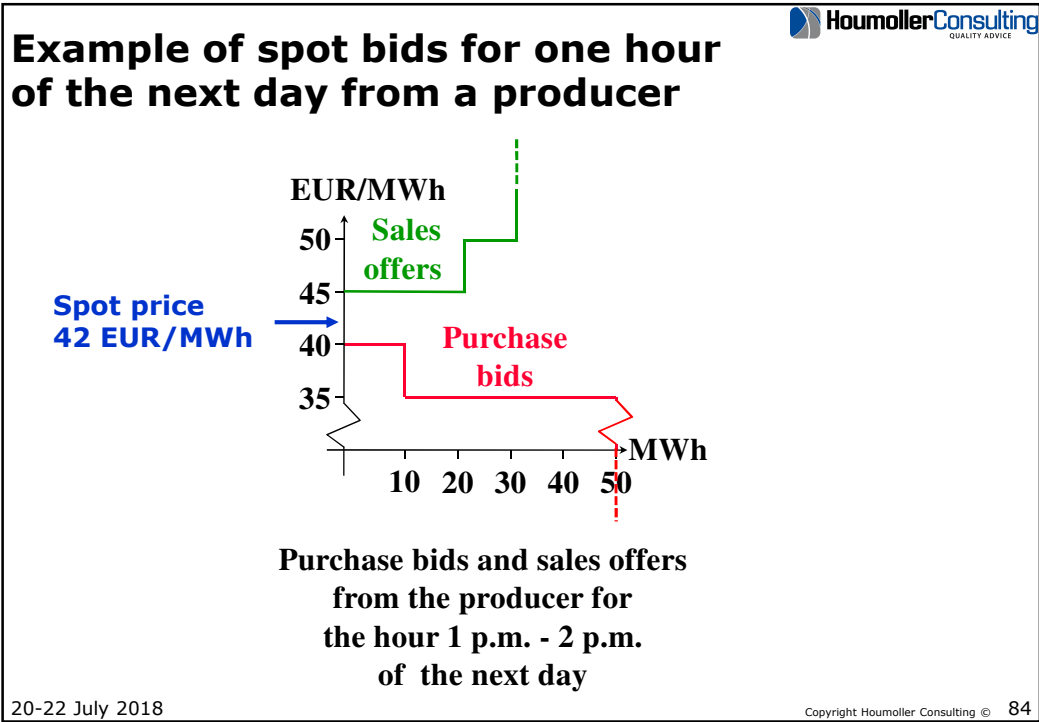
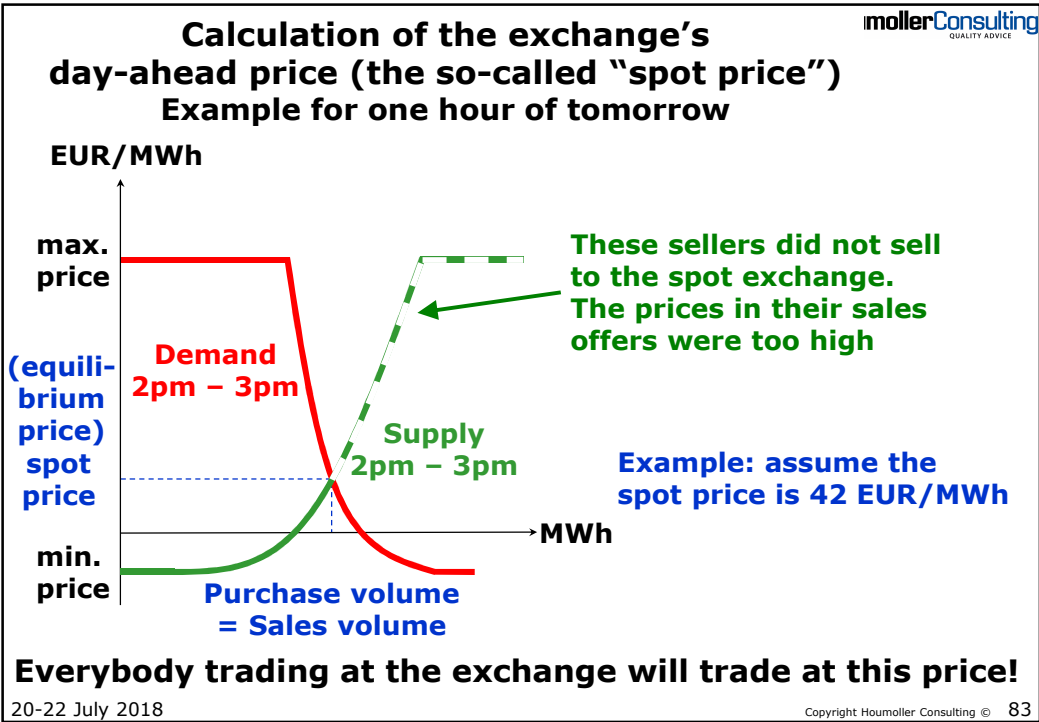
- **As can be seen from the previous slide on bidding at the spot exchange:**
- **A market player must bid using his marginal production costs as bid prices.**
- **However, if a player has market power, the player may bid using other prices**
 - ❑ **Therefore, bidding with prices deviating from the marginal production costs will indicate abuse of market power**
 - ✓ **The authorities must surveille the market in order to check for this.**

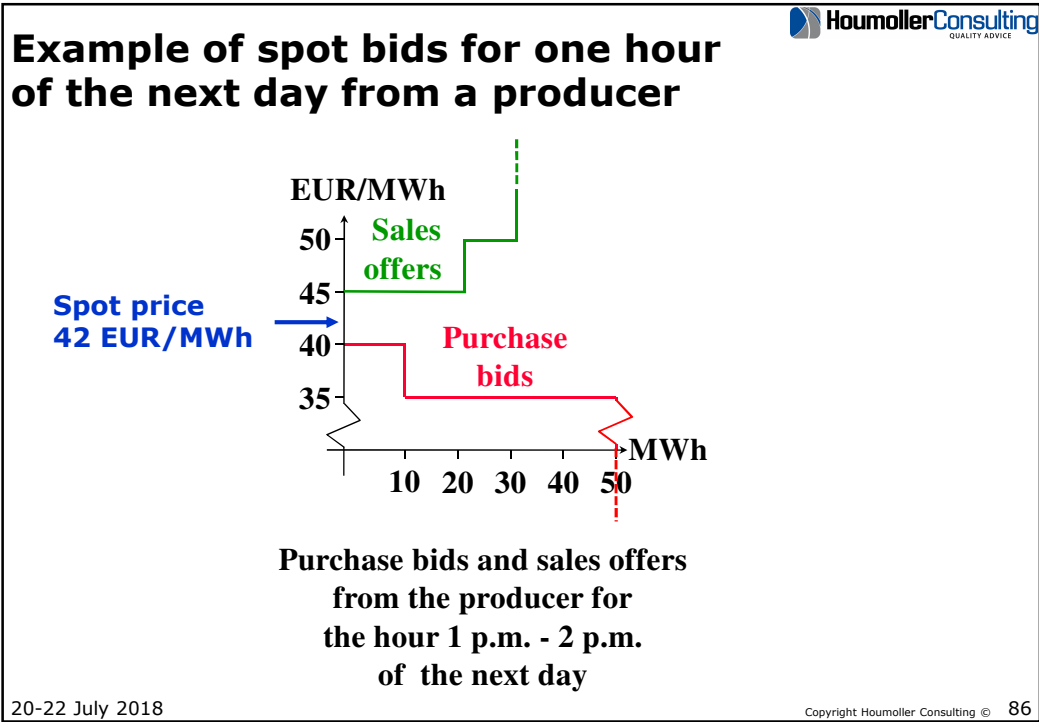
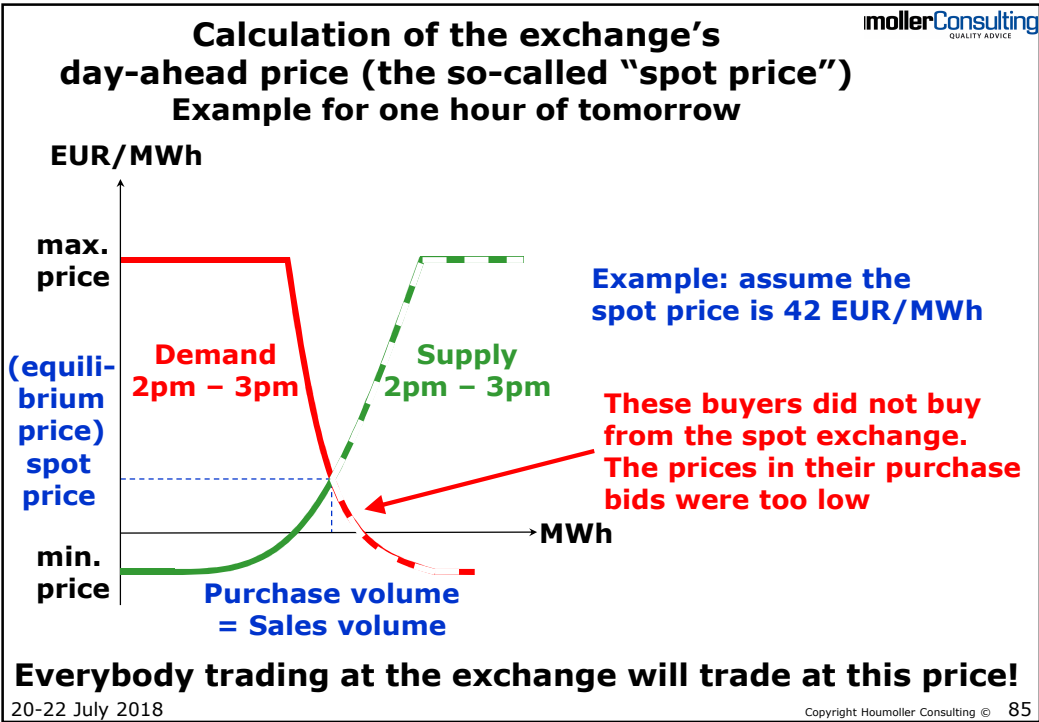
Producer's consideration

- **Assume you are a producer of electricity.**
- **Under what circumstance could you consider to have an offer price at the spot exchange higher than your marginal production costs?**









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The Electricity Market

Question: among the producers – who are selling?

Answer: the competitive producers.
Those who have marginal production costs at or below the market price!

Producers

Consumers

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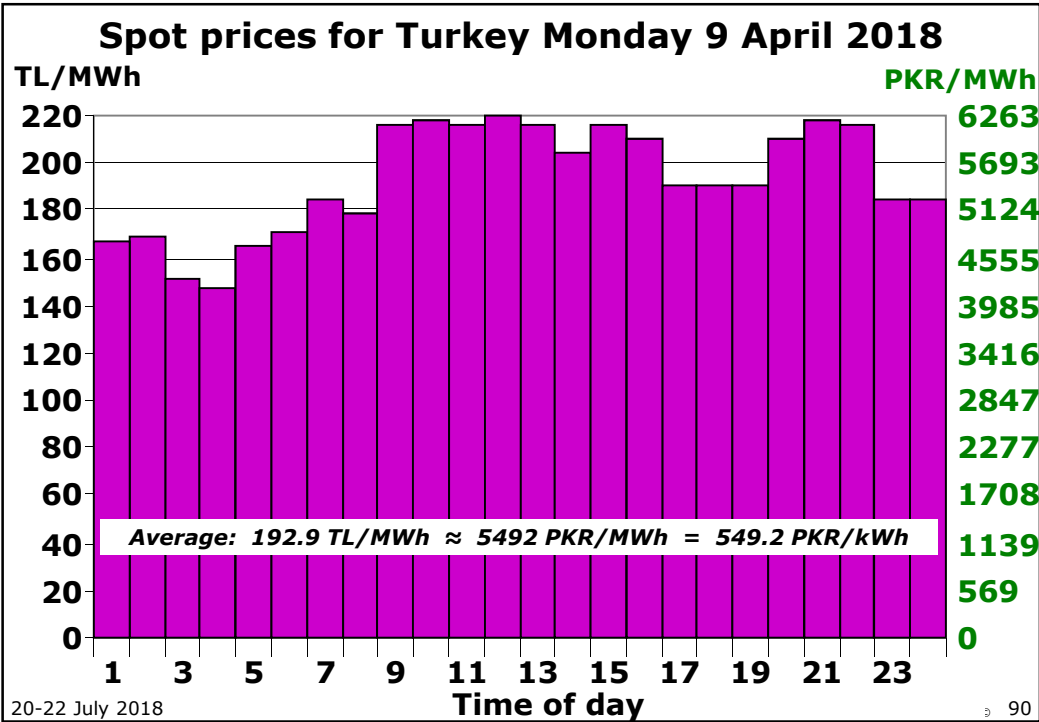
Calculation of the exchange's day-ahead price (the so-called "spot price")

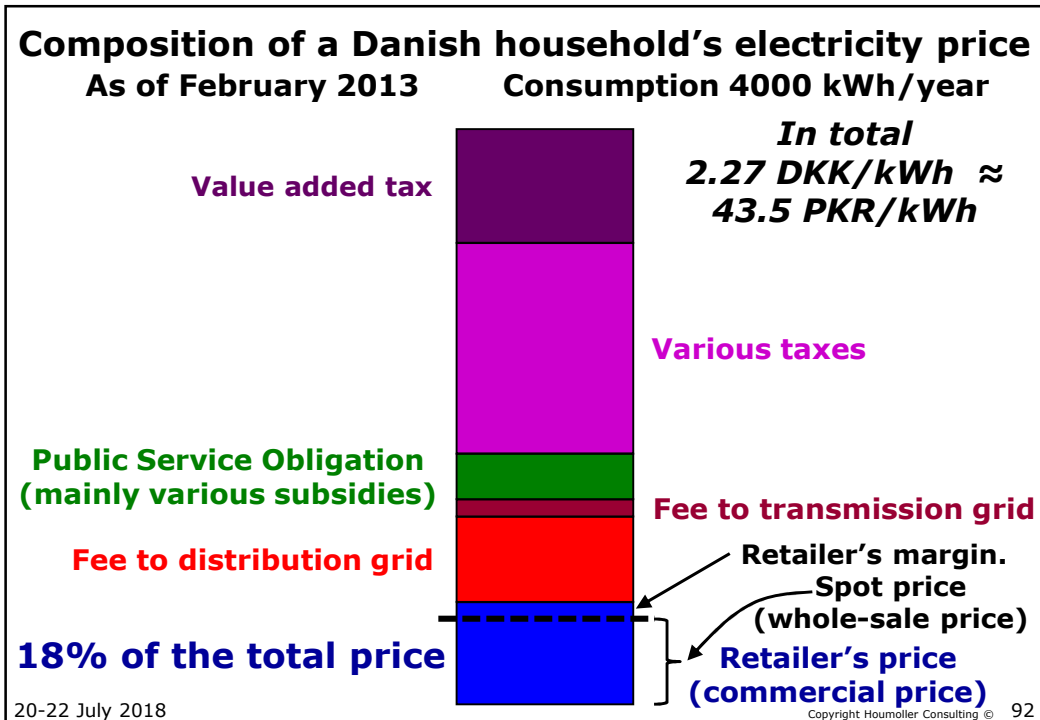
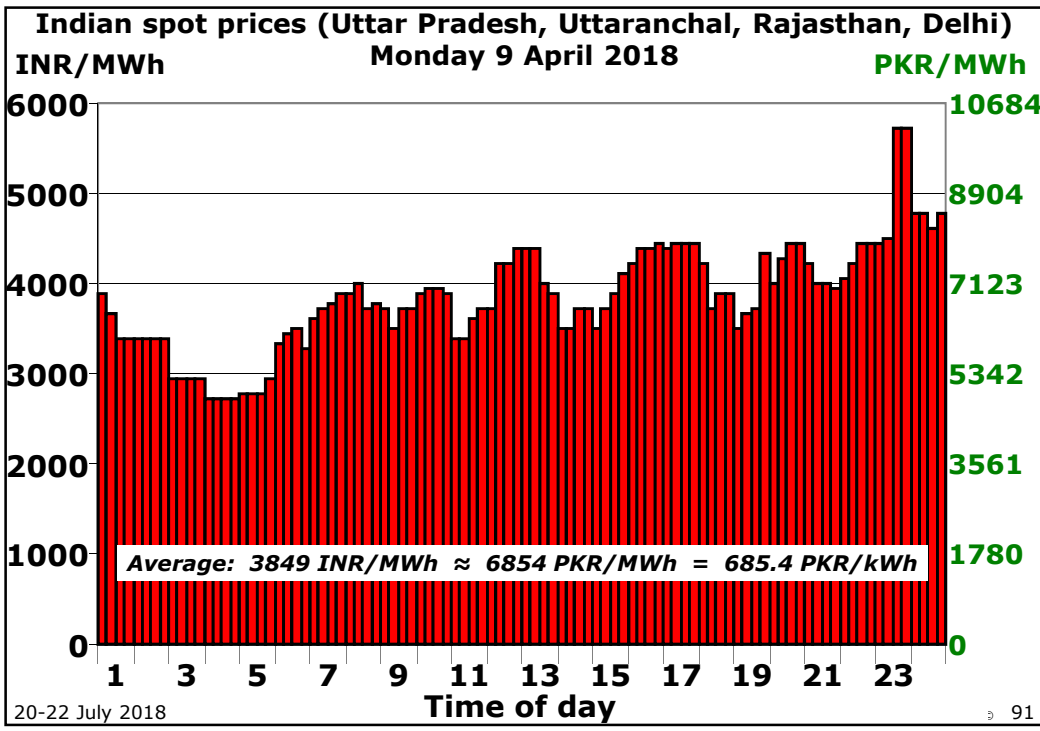
Example for one hour of tomorrow


EUR/MWh

Everybody trading at the exchange will trade at this price!

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European terminology For electricity exchanges

- In many European countries, we have spot markets
 - ❑ A spot market is a market operated by an electricity exchange, where:
 - ✓ The players can trade electrical energy for tomorrow
 - ie, the players trade day-ahead.
 - ✓ The prices at the spot exchange are calculated by a method called *double auction*.
- An electricity exchange operating a spot market is called a spot exchange.
- The spot exchange's prices are called spot prices
 - ❑ Hence, spot prices are day-ahead whole-sale prices for electricity set by a spot exchange.

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Price for the captive consumers

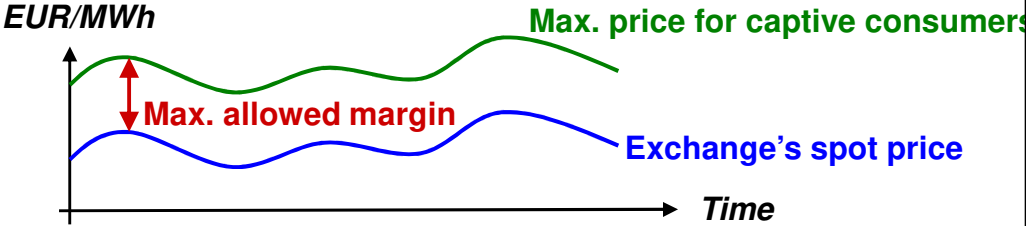
Who can not freely choose a retailer

- During the liberalization's start phase, the small consumers will be captive customers.
- What should be their price for electricity?
- The answer is easy, if you have an electricity exchange with a trustworthy price:
 - ❑ The regulator can set the captive customers' max. price to:

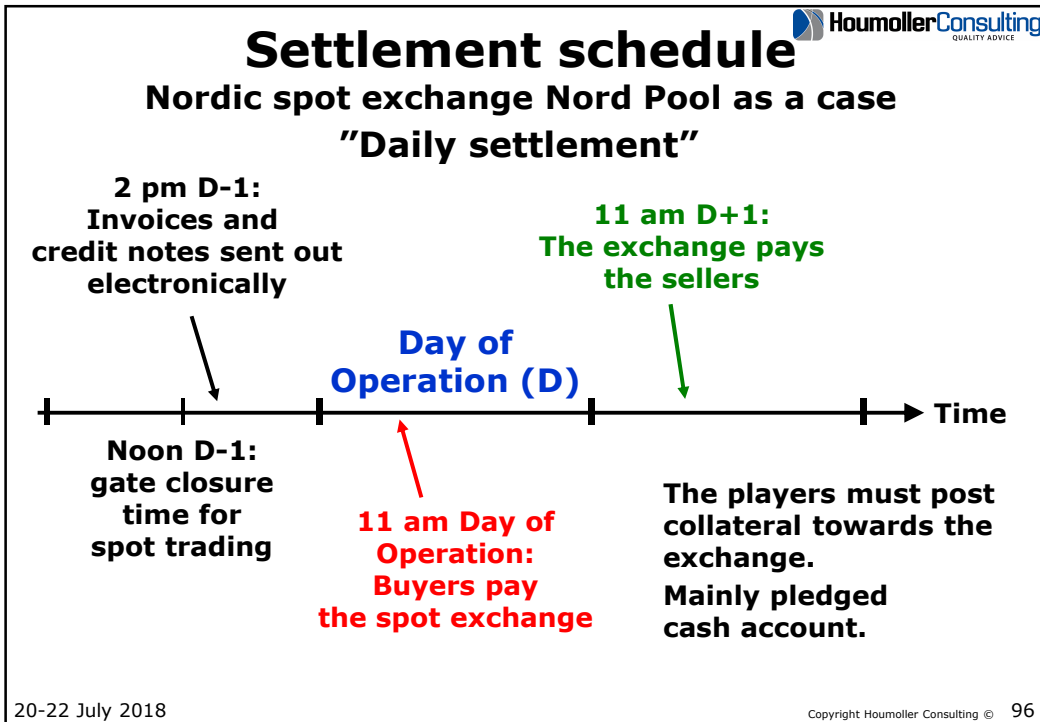
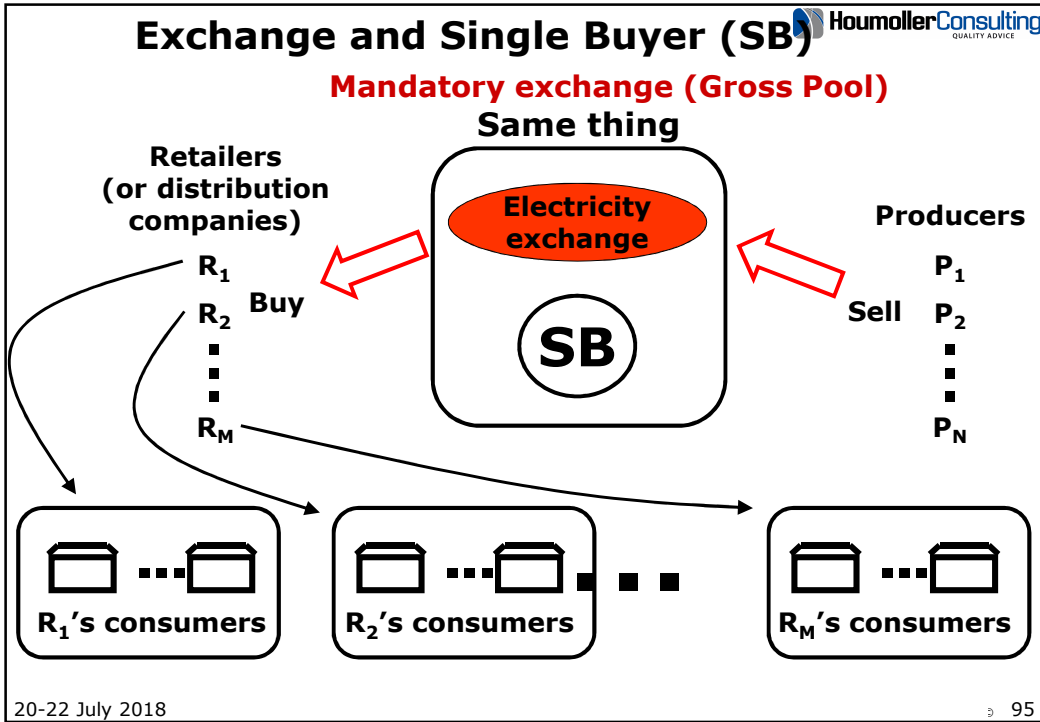
$$(\text{Spot price at the exchange}) + (\text{max. allowed margin}).$$

Note: this can also be the price for consumers, who not actively has chosen a commercial supplier.



In practice, you'll need to regulate their electricity price.




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The players' roles European Union

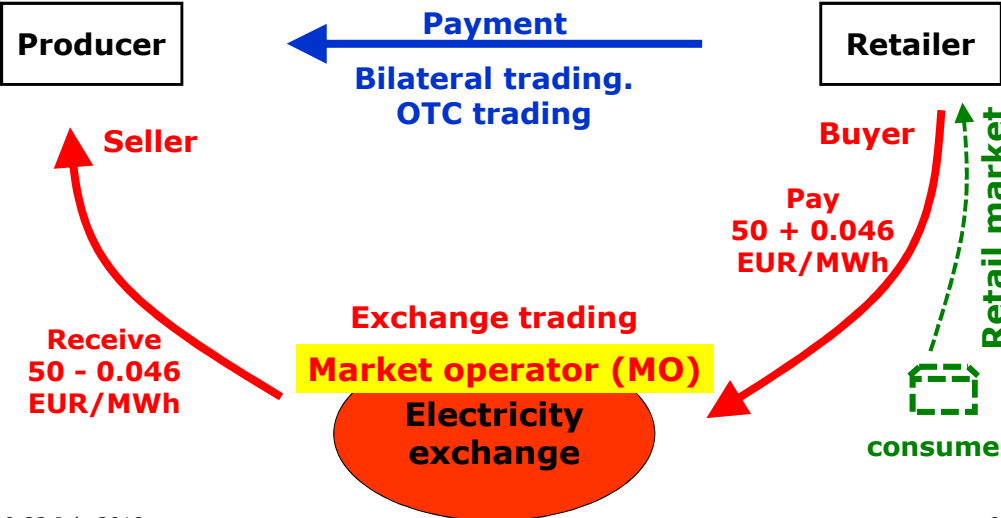
- **The Market Operator (MO).**
- **Operates markets where the commercial players can buy and sell electrical energy.**



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Large part of Europe: two ways of trading electrical energy At the whole-sale market

For one hour: assume the exchange price is 50 EUR/MWh.
Assume the exchange's trading & settlement fee is 0.046 EUR/MWh



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**Exchange trading
Versus bilateral trading**

➤ **Exchange trading:**

- ❑ The exchange takes care of settlement
 - ✓ Buyer pays exchange and exchange pays seller.
- ❑ Trading is anonymous
 - ✓ For both buyer and seller: the exchange is the counterpart.

**Clearing
exchange takes
care of settlement
and guarantees
settlement.**

Bilateral trading: not anonymous and seller has counterparty risk

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**The Market Operator – 1
European Union**

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➤ **The Market Operator is a trader**

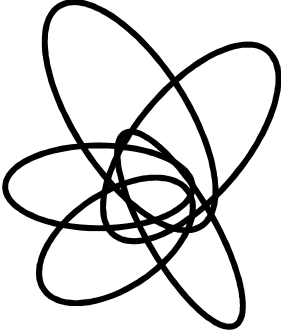
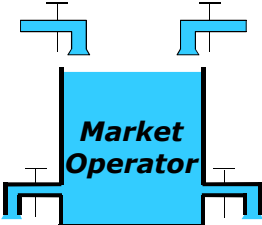
- ❑ For every Hour of Operation
 - ✓ The Market Operator is buying and selling the same amount of energy.

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The Market Operator – 2 European Union

- **The Market Operator has the same relation to the TSO as other traders.**
- **For example – Market Operator must:**
 - Report all trading to the TSO.
 - Settle imbalances with the TSO
 - ✓ In case Market Operator makes a mistake, so the purchase volume and the sales volume are not the same.



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Price-taking spot bids

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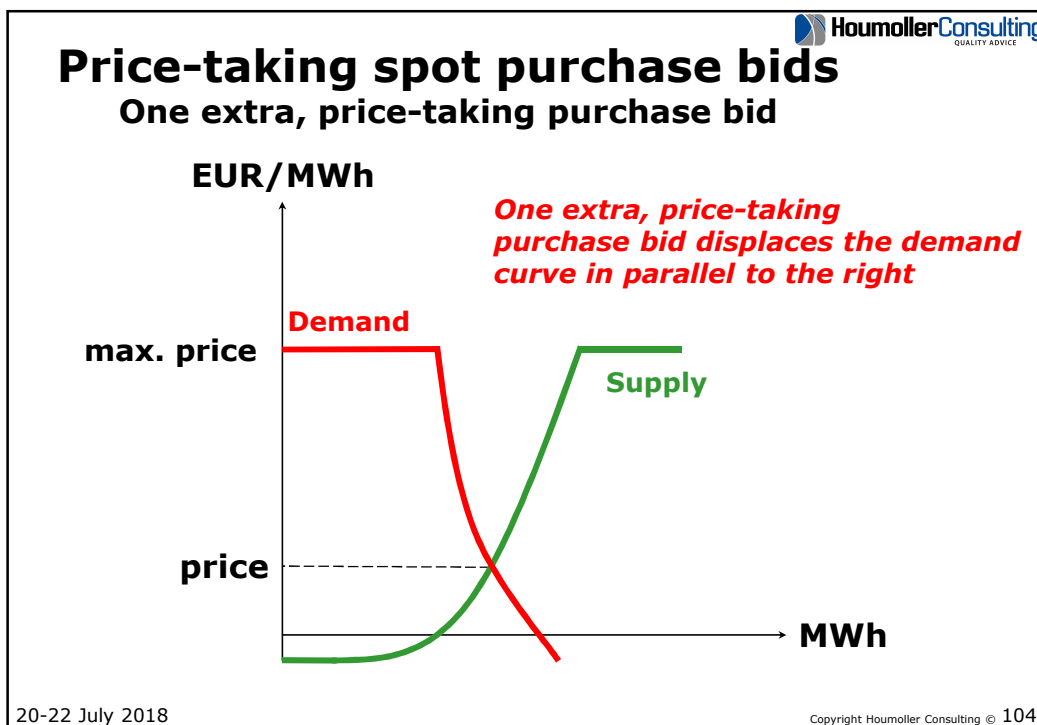
Price-taking spot bids

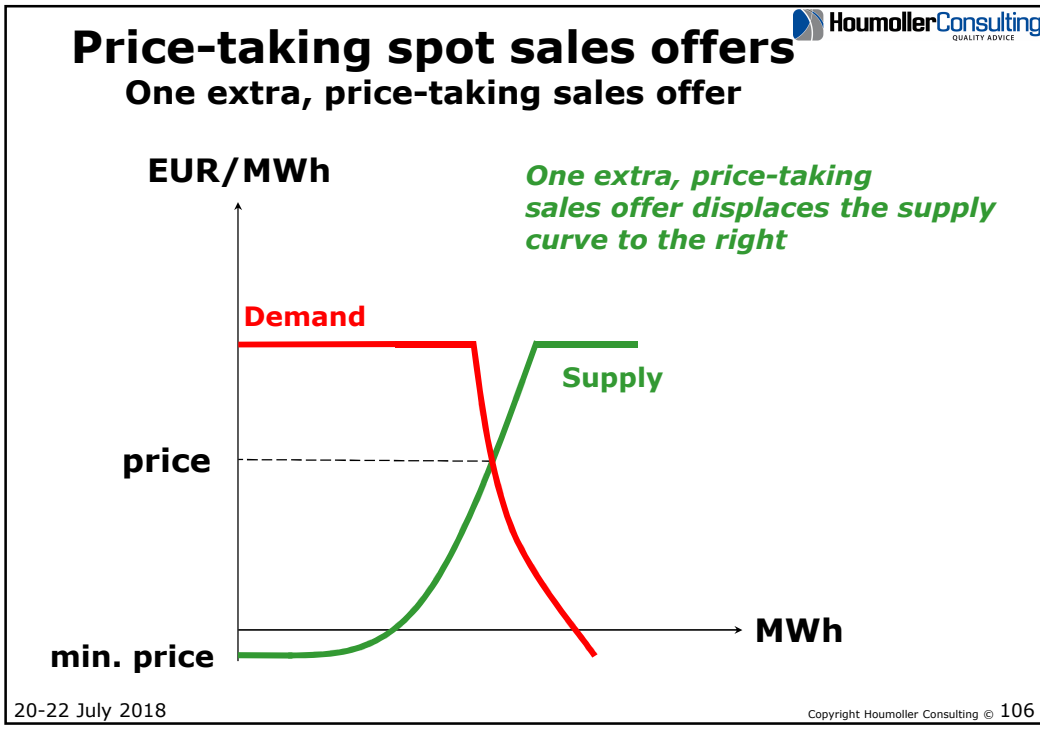
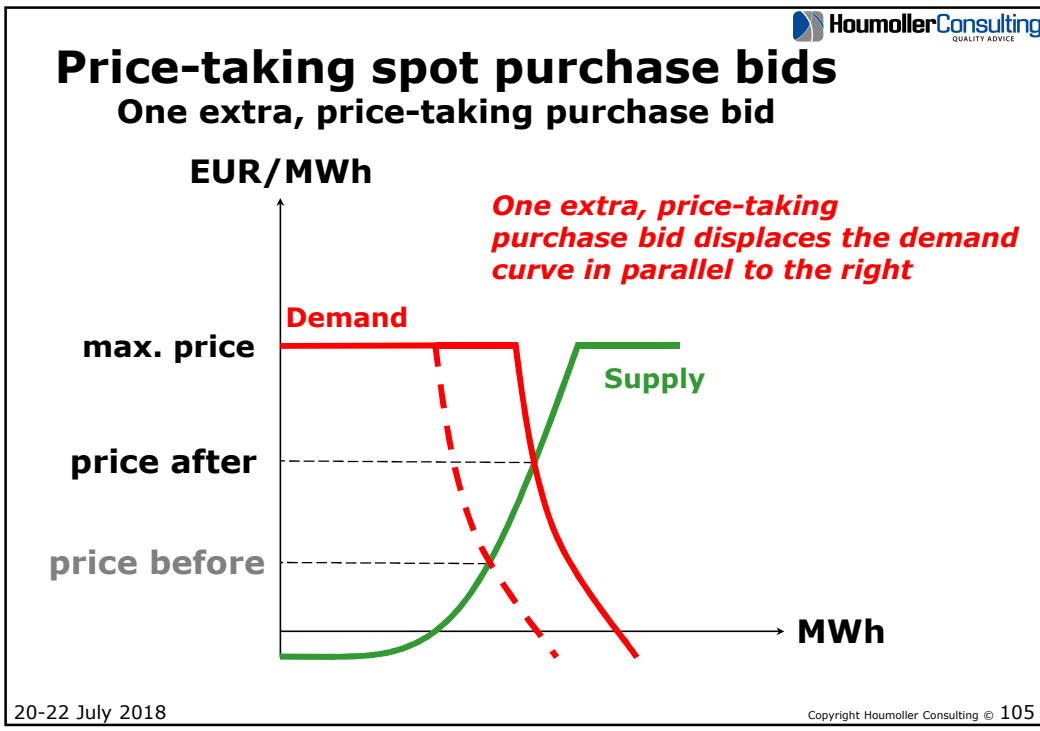
For a given hour of tomorrow

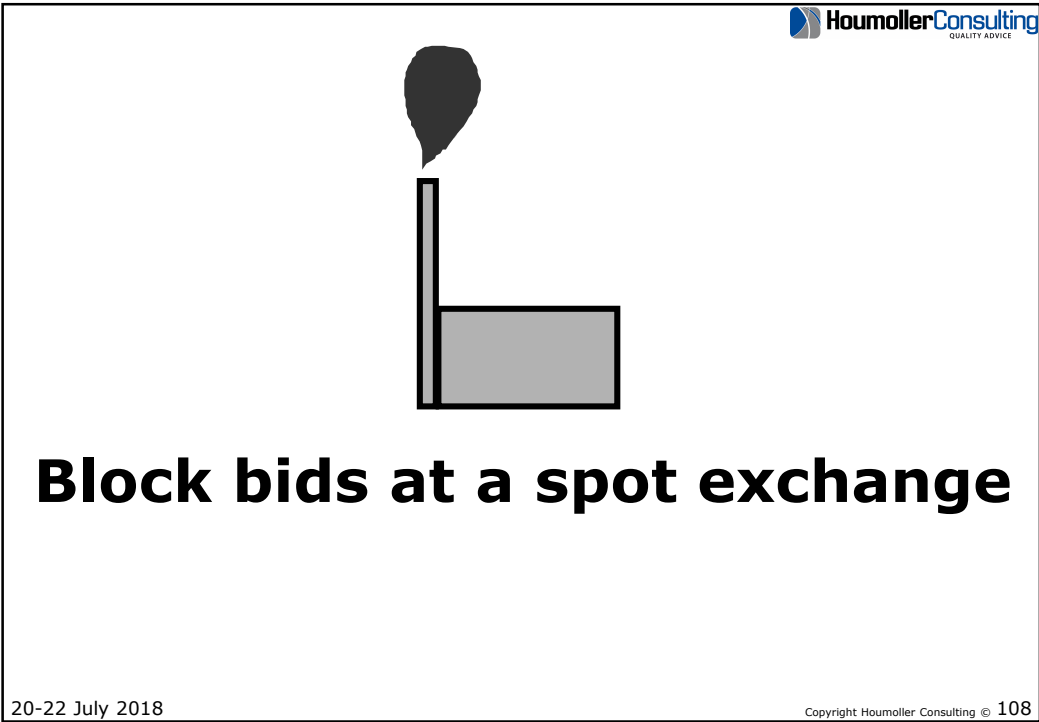
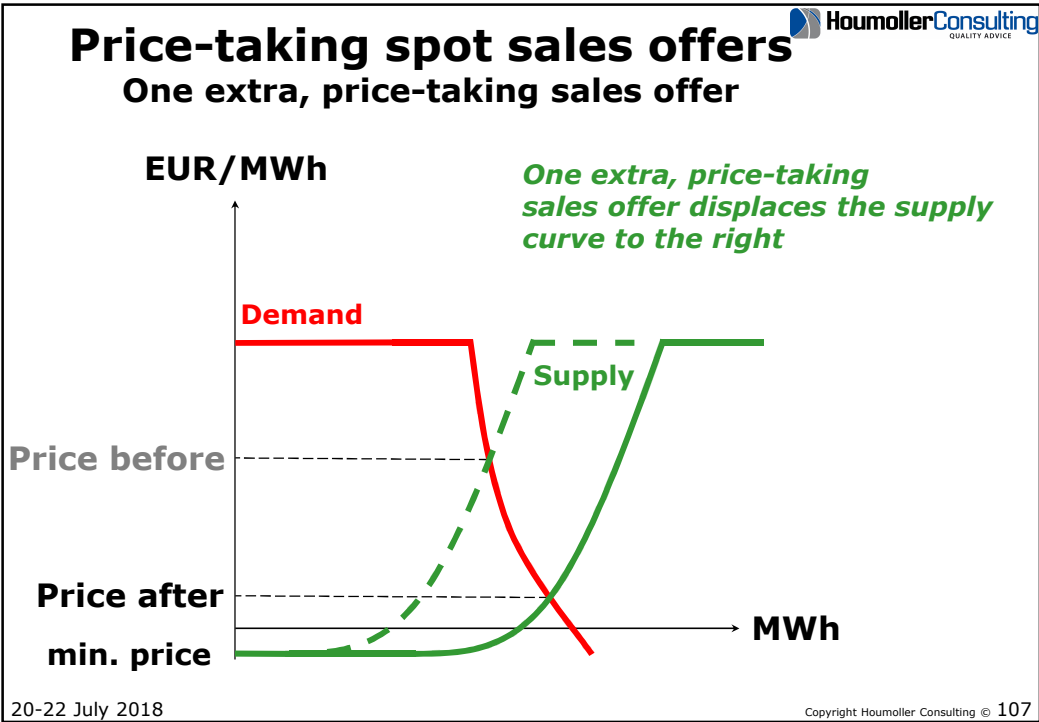
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- **A price-taking purchase bid:**
 - ❑ *"I'll buy – even at the maximum price"*
 - ✓ Currently 3,000 EUR/MWh.
- **A price-taking sales offer:**
 - ❑ *"I'll sell – even at the minimum price"*
 - ✓ Currently -500 EUR/MWh.
- **Price-taking bids: The common term for price-taking purchase bids and price-taking sales offers.**
- **The effect of price-taking bids on the day-ahead price:**
 - ❑ A price-taking **purchase bid** displaces the **demand curve** in parallel to the right (thereby increasing the price).
 - ❑ A price-taking **sales offer** displaces the **supply curve** in parallel to the right (thereby lowering the price).

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Block bids – 1



- An example of a block sales offer:
 - ❑ *“Tomorrow, to the power exchange, I’ll sell 200 MWh per hour during the hours from 7 am to 3 pm, if the exchange’s average price is at least 50 EUR/MWh”*
 - ✓ Therefore, the production facility’s start-up costs are distributed over the eight hours from 7 am to 3 pm.
 - ✓ The block’s offer price = (the facility’s marginal production costs) + (the facility’s start-up costs distributed over eight hours).
- In the calculation of the spot prices: for each of the eight hours from 7 am to 3 pm, the 200 MWh are inserted as a price-taking sales offer
 - ❑ ie, an offer where the seller is willing to sell 200 MWh even at the minimum price.
 - ❑ Because: during a single hour, the seller is actually willing to sell at the minimum price
 - ✓ Only the average price during the eight hours is of interest for the seller.

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Block bids – 2



- An example of a block sales offer:
 - ❑ *“Tomorrow, to the power exchange, I’ll sell 200 MWh per hour during the hours from 7 am to 3 pm, if the exchange’s average price is at least 50 EUR/MWh”*
- Everything is OK, if the price calculation yields an average price for the eight hours of 50 EUR/MWh or higher.
- Otherwise the block is rejected, and the price calculation is repeated without the block sales offer.
- Problem: with the block rejected, the price calculation may yield an average price for the eight hours higher than 50 EUR/MWh!
 - ❑ However: you can’t fix this by re-inserting the block offer in the price calculation...
 - ❑ Hence, this gives a PRB – Paradoxically Rejected block Bid.

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Block bids – 3

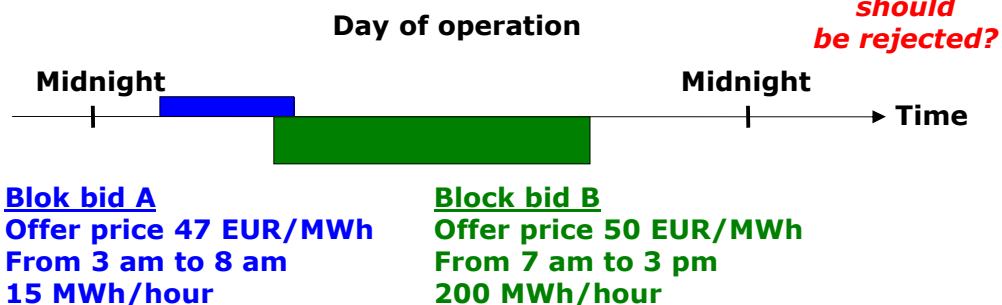
- **An example of a block purchase bid:**
 - ❑ *Tomorrow, from the power exchange, I'll buy 100 MWh per hour during the hours from 1 pm to 11 pm, if the exchange's average price is at most 45 EUR/MWh during the ten hours.*
- **In the calculation of the spot prices: for each of the ten hours from 1 pm to 11 pm, the 100 MWh are inserted as a price-taking purchase bid**
 - ❑ **ie, a purchase bid where the buyer is willing to buy 100 MWh even at the maximum price.**
 - ❑ **Because: during a single hour, the buyer is actually willing to pay the maximum price**
 - ✓ **Only the average price during the ten hours is of interest for the buyer.**
- **"Block bids" is the common term for block sales offers and block purchase bids.**

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How to select the block bids to be included in the exchange trading?

- **Every day, at each exchange, there are lots of block bids.**
- **How to select the block bids, which will be included in the spot trading?**
- **Example – two competing block sales offers, where a one hour overlap creates a situation, where only one bid can be included in the trading:**



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It's all about selecting the block bids!  QUALITY ADVICE

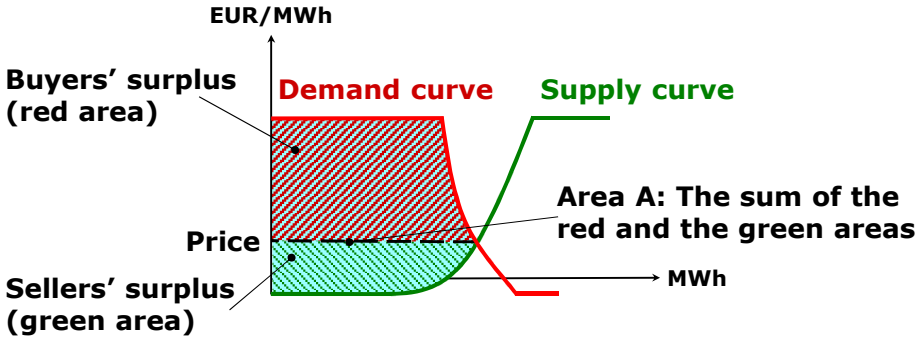
When the spot prices are calculated

- **If there were no block bids, there would be only one solution to the spot price calculation**
 - ❑ ie, only one set of valid spot prices per price zone and only one set of valid day-ahead plans for the cross-border energy flows.
- **A "valid solution" is a solution fulfilling all the requirements**
 - ❑ For each hour for each price zone: the spot purchase price is equal to the spot sale price.
 - ❑ For each hour for each interconnector: the day-ahead plan for the cross-border energy flow must not exceed the interconnector's capacity.
 - ❑ An so on...
- **With block bids: there are millions (perhaps billions) of valid solutions!**
- **Therefore: with block bids, you need a criterion for selecting the preferred solution among all the valid solutions!**

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The traders' surplus  QUALITY ADVICE

One hour one price zone. No import or export of energy



EUR/MWh

Buyers' surplus (red area)

Demand curve

Supply curve

Price

Sellers' surplus (green area)

Area A: The sum of the red and the green areas

MWh

For one hour for one price zone: the buyers' and the sellers' total surplus from the spot trading is the area between the exchange's supply curve and the exchange's demand curve (the red/green area A).

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XBid

A continuous trading system

The diagram shows a computer screen representing an order book. It features a light blue background with a central white area. On the left, there are several green rectangular boxes representing sell orders, with the top one labeled 'Sale: A MWh X EUR/MWh'. On the right, there are several red rectangular boxes representing buy orders, with the top one labeled 'Buy: B MWh Y EUR/MWh'. The vertical distance between the top sell order and the top buy order is labeled 'Spread {'. Above the sell orders are 'Other sale offers' and below the buy orders are 'Other purchase bids'. To the right of the screen, the text reads 'Computer screen' and 'This is an example for one future hour of operation for one price zone'. The Hougoller Consulting logo is in the top right corner.

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XBid features in the Nordic countries

- **Main rule: in the Baltic-Nordic countries, XBid trading for the next day opens at 2pm**
 - ☐ You can trade down to one hour before the hour of operation

The diagram features a yellow map of the Nordic region in the background. Below it is a horizontal timeline labeled 'Time' with an arrow pointing right. Key events are marked with vertical lines: '12 spot gate closure' (black), '2pm XBid trading for the next day opens' (blue), 'Midnight' (black), 'You can trade until 10am' (green), 'Next day' (blue), 'hour of operation: 11am-12' (red), and another 'Midnight' (black). The Hougoller Consulting logo is in the top right corner.

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Electricity exchange and spot exchange sulting ITY ADVICE

- **Electricity exchange:** here the players can trade electrical energy **day-ahead** and **intra-day**
 - ❑ Baltic-Nordic area: both markets are operated by Nord Pool.
 - ❑ Baltic-Nordic area: Nord Pool's names of the two markets are
 - ✓ **Elsport (day-ahead auction market).**
 - ✓ **XBid (intra-day market – continuous trading).**
 - ❑ In other European countries, the electricity exchanges have other names for their **day-ahead auction market.**
- **Spot exchange:** that part of the electricity exchange, where the exchange offers day-ahead auction trading.

Electricity exchange {

Spot exchange: the exchange's day-ahead auction market	Big turn-over
Intra-day market	← Small turn-over

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EU: time line for trading electrical energy

Day of Operation:
The day where the electrical energy is produced and consumed.

Hour of Operation:
The hour where the electrical energy is produced and consumed.

Long-term contracts (physical and financial):
Some days ahead, week-ahead, month-ahead, year/years ahead

Day-ahead trading →

Intra-day trading → Trading balancing energy with TSO

D - 1 **Day of Operation (D)**

Midnight
Noon D-1:
gate closure
time for spot
trading
Midnight
Hour of
Operation
Midnight

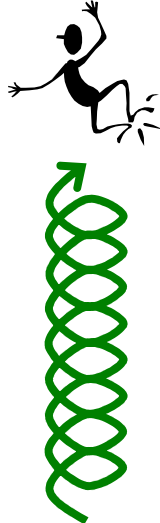
Time →

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The importance of exchange liquidity – 1

- **A necessary condition for reliable exchange prices is high liquidity**
 - ❑ **Among other things, high liquidity implies individual players' decision to buy or sell will not affect the exchange's prices.**
- **The virtuous circle where liquidity creates liquidity:**
 - ❑ **High liquidity → Reliable exchange prices → Players feel confident trading at the exchange → More players choose to trade at the exchange → exchange's liquidity increases.**

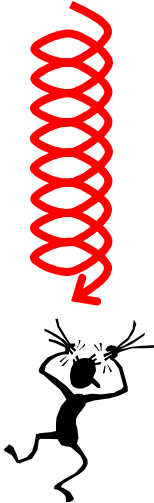


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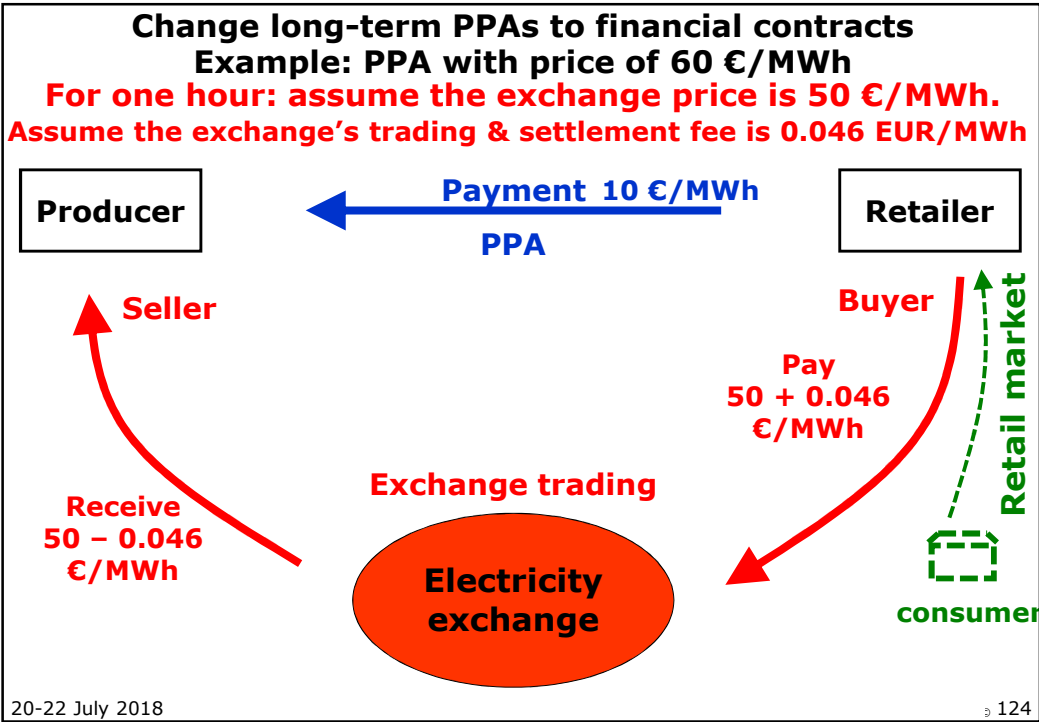
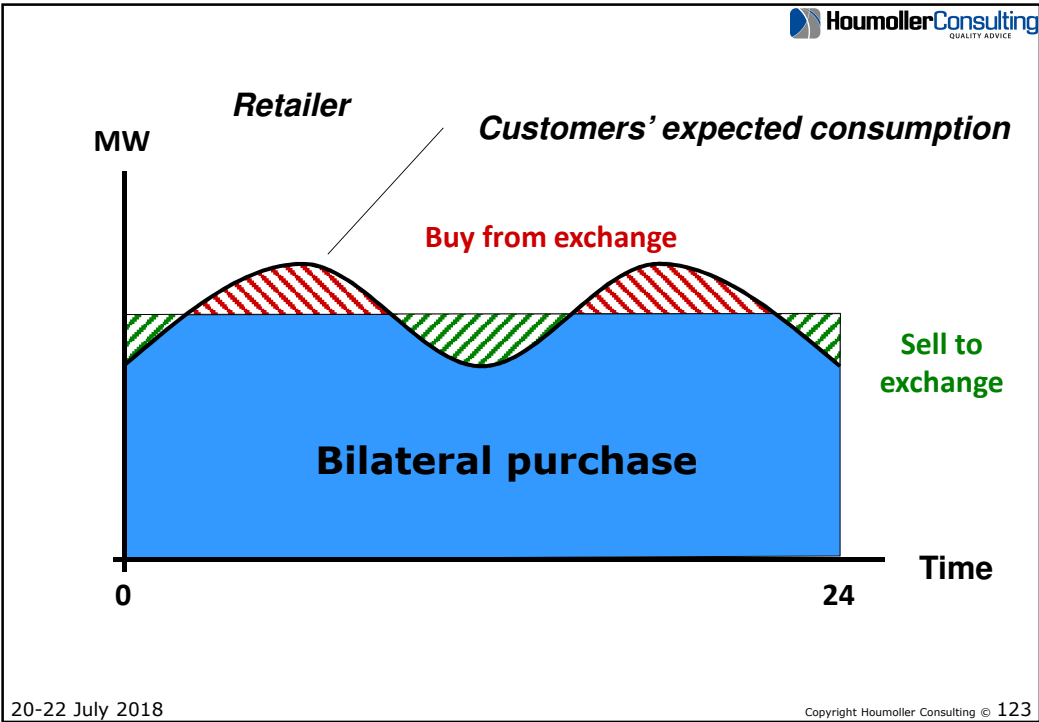
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The importance of exchange liquidity – 2

- **Without high exchange liquidity, a few players' decision to trade can change the exchange prices a lot – thereby creating volatility unrelated to the market situation.**
- **In turn, this brings about a feeling the exchange is a casino best avoided by sane players**
 - ❑ **This is the vicious circle, where lack of liquidity creates lack of liquidity.**



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Two types of exchange trading

Price discovery: the process of determining the market price of a commodity through the interactions of buyers and sellers.

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Exchange trading continuous trading versus spot trading (double auction)

Continuous trading: exchange trading system for stocks, derivatives and most commodities

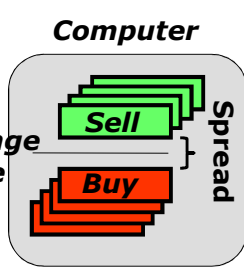
Every trading day: the exchange price is continuously changed during the period where the exchange is open for trading.

If it's electronic trading: you trade by clicking at a purchase bid or a sale offer.

Double auction: the dominant way of day-ahead trading at electricity exchanges in Europe

All the exchange's day-ahead liquidity is concentrated just before 12 o'clock the day before the Day of Operation.

The exchange prices for the next day are set once and for all by the calculation carried out just after 12 o'clock.



Computer

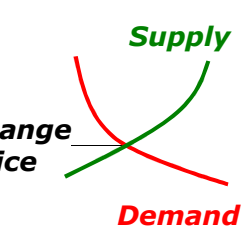
Exchange price

Spread

Sell

Buy

Exchange price



Supply

Demand

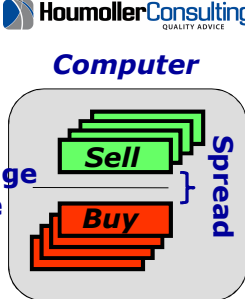
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Exchange with continuous trading

A market maker

- **Market maker:** a player who voluntarily submits both sale offers and purchase bids to the exchange.
- The market maker has agreed with the exchange:
 - ❑ A certain minimum volume for both the sale offers and the purchase bids.
 - ❑ A maximum allowed spread.
- If a market maker during a trading day sells and buys the same volume, the market maker's profit is:
 - ❑ $\text{spread} * (\text{traded volume})$
- If the exchange has one or more market makers you can always
 - ❑ Buy and sell at the exchange.
 - ❑ Set the exchange's price for the commodity traded at the exchange.

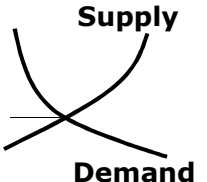


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Strengths and weaknesses

- **Continuous trading**
 - ❑ **Robust towards low liquidity**
 - ✓ If there's a market maker, there's always an exchange price – even if there's no exchange trading!
 - ✓ **Less secure price discovery**
 - At which time do we have the right price for tomorrow?
 - The closing price is normally used.
 - ✓ **More difficult/expensive for the market players.**
- **Double auction (spot trading)**
 - ❑ **Very good price discovery**
 - ✓ All the exchange's day-ahead liquidity is concentrated at 12 o'clock.
 - ❑ **Easy/inexpensive for the players.**
 - ❑ **Very vulnerable towards low liquidity**
 - ✓ **What if there's no intersection?**
 - Danish gas exchange as a case.





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Team exercise

- **How to establish exchange trading of electricity in Pakistan?**
- **The team exercise will run until 4:15pm**
 - ☐ **Coffee break during team exercise.**
- **From 4:15pm to 5pm, we'll have presentations and discussions of the teams' work.**
- **The teams may produce PowerPoint slides or write on flip-charts.**



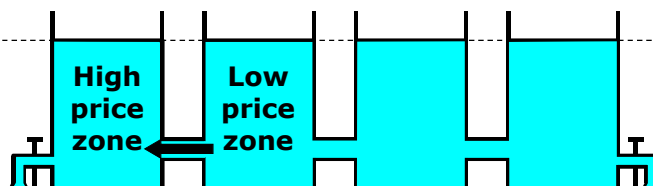
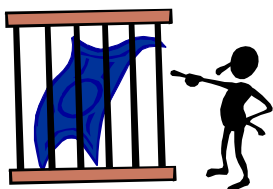
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Day 6

Sunday 22 July

Risk management
Market coupling
Subsidy systems for renewables



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Risk management

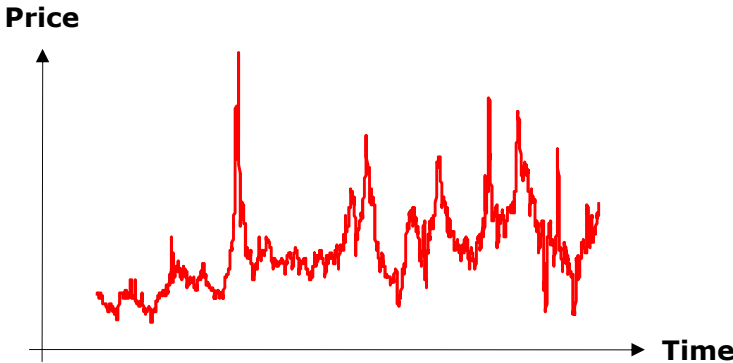


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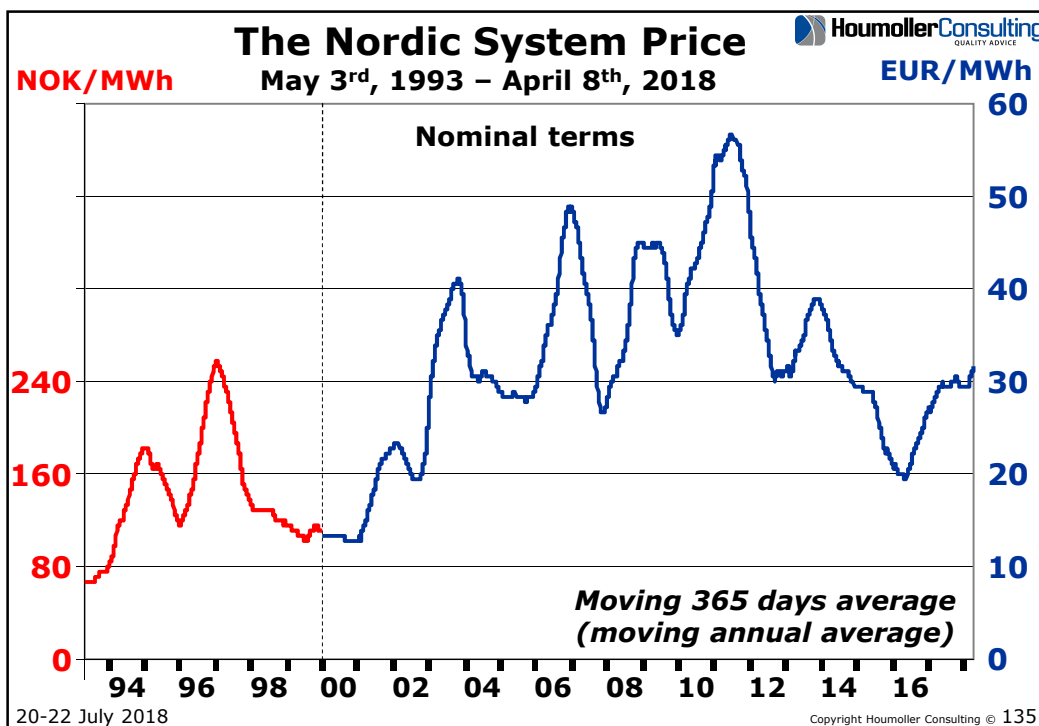
Price volatility


Case: Nordic market



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Price hedging  **Getting rid of risk**

- **A case: message from the French power producer Engie 8 March 2018**
 - ❑ Engie's hedging of European power production.
- **For this year, Engie had hedged 92% of the expected power production in Europe**
 - ❑ Average hedging price 34 €/MWh ≈ 4847 PKR/MWh.
- **For 2019, Engie had hedged 61% of the expected power production in Europe**
 - ❑ Average hedging price 36 €/MWh ≈ 5132 PKR/MWh.
- **For 2020, Engie had hedged 21% of the expected power production in Europe**
 - ❑ Average hedging price 39 €/MWh ≈ 5560 PKR/MWh.

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Making money at the market for long-term contracts By taking risk

- We'll consider a country, which has a spot exchange.
- You enter into a long-term contract:
 - ❑ Assume you sell 10 MWh/h of electricity for next year at a price of 50 €/MWh
 - ✓ $10 \text{ MWh/h} * 24 \text{ h} * 365 = 87,600 \text{ MWh}$.
- To fulfil you contract, you need electricity.
- Therefore, every day, from the spot exchange, you buy 10 MWh/h.
- Assume the average spot price at the exchange turns out to be 45 €/MWh.
- Your profit:
 - ❑ $10 \text{ MWh} * (50 - 45) \text{ €/MWh} * 24 * 365 = 438,000 \text{ €}$.


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The market for long-term contracts has two types of players!


- Price hedging: long-term contracts can be used to get rid of risk.
- Speculation/trading: long-term contracts can be used to take risk (in the hope of gaining a profit).
- Some of these long-term contracts are called "derivatives".
- You have long-term contracts/derivatives on all sorts of markets.
- Cases: at the following slide, you'll have information on the results of trading long-term contracts on other markets than the electricity market.

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The Derivatives Disasters Club


The following examples are not from the electricity market



➤	Year where the losses became public and approximate loss (losses in prices as of 2007)	Billion \$
➤ Morgan Stanley <small>Howie Hubler</small>	2008 Credit default swaps	8.7
➤ Société Générale <small>Jérôme Kerviel</small>	2008 European index futures	7.0
➤ Amaranth Advisors <small>Brian Hunter</small>	2006 Gas futures	6.7
➤ Long Term Cap. Mang. <small>Meriwether</small>	1998 Interest rate & equity deriv.	5.9
➤ JPMorgan Chase <small>Bruno Iksil</small>	2012 Credit default swaps	5.8
➤ Sumitomo <small>Yasuo Hamanaka</small>	1996 Cobber futures	3.5
➤ Aracruz <small>Zagury og Sotero</small>	2008 FX options	2.4
➤ Orange County <small>Robert Citron</small>	1994 Leveraged bond investments	2.4
➤ Metalgesellschaft <small>Schimmelbusch</small>	1993 Oil futures	2.3
➤ Barings <small>Nick Leeson</small>	1995 Nikkei futures	1.8

Source http://en.wikipedia.org/wiki/List_of_trading_losses


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The long-term electricity market Summary

This market has two types of players!

Price hedging: long-term contracts can be used to get rid of risk

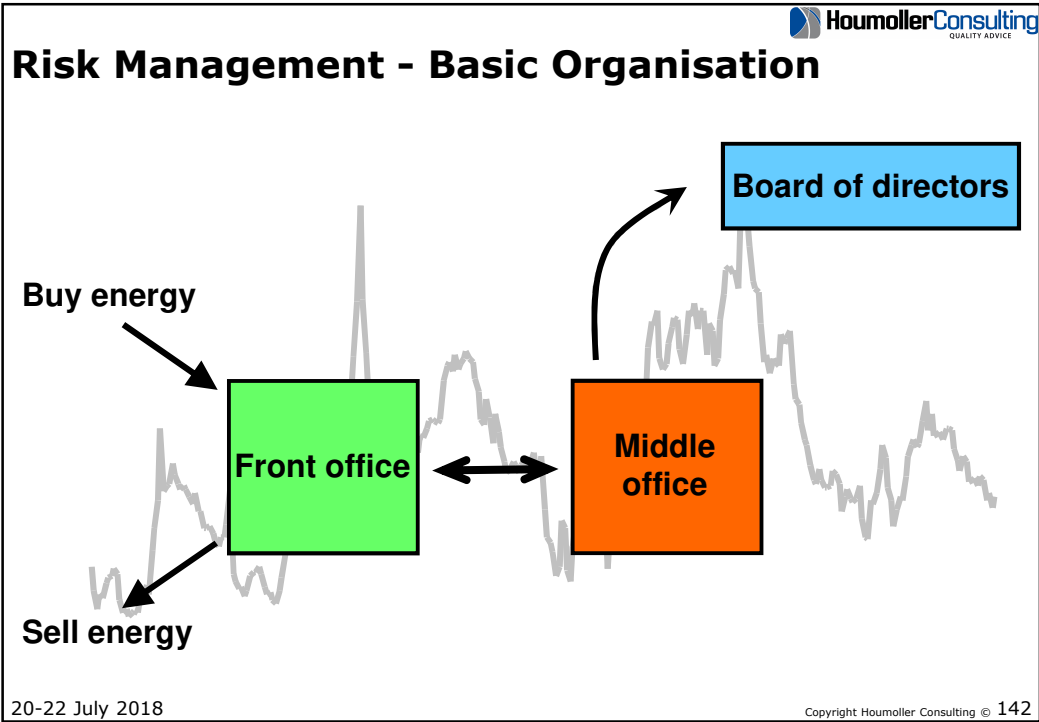
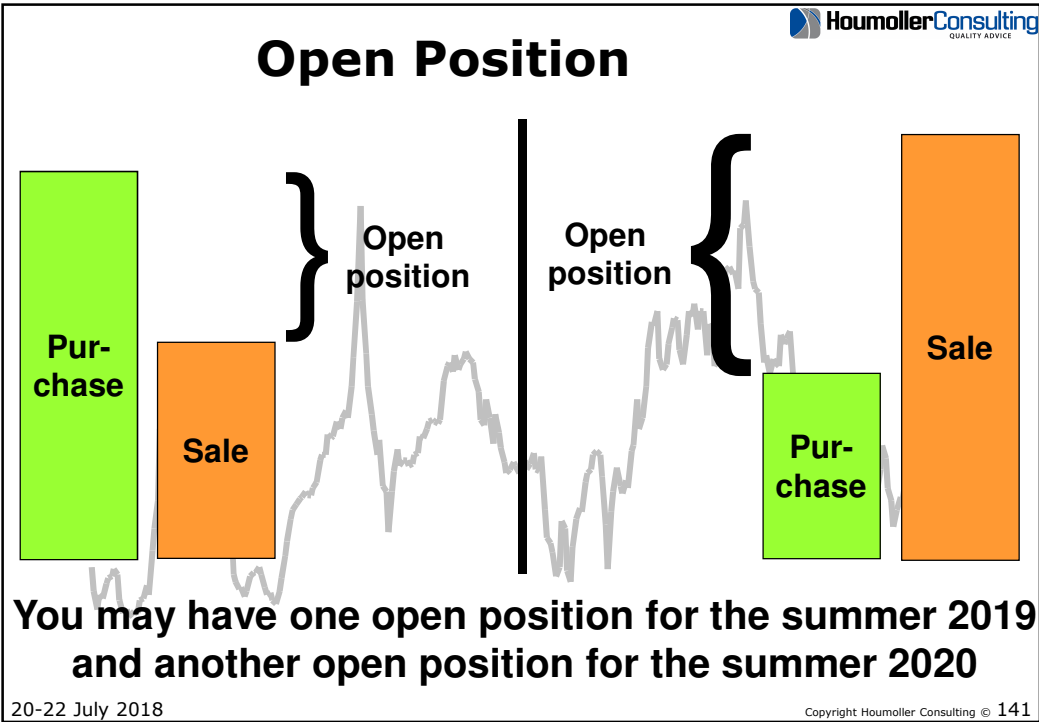



Speculation/trading: long-term contracts can be used to take risk (in the hope of gaining a profit).

At the long-term market you trade risk

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Electricity companies

Characteristics – electricity companies

- **Important industry for the society.**
- **Influence on the environment when producing.**
- **Very investment incentive industry.**
- **Volatile prices of electricity.**
- **Volatile prices of fuel.**



Risk management is very important in the electricity supply business.



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What to get from good Risk Management

- **A Risk Management Policy that is aligned with the strategy of the company**
- **Risk Management Policy that try to cover all the business processes in the company**
- **The important risks are mapped, and the acceptable risk are approved by management**
- **There is a periodically report to management showing the actual level of the risks**
- **No one can commit the company on their own. There will always be controls**
- **Assets and liabilities are taken in the books at market values**
- **All the assets and liabilities are registered in the books**
- **Better focus on the business and better profit.**



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Important business processes in the commercial companies




Production ↔ Trading ↔ Customer sales

<ul style="list-style-type: none"> - Business strategy - Risk management - Investment planning - Production planning - Sourcing of fuel - Logistics - Sale of electricity (PPA) 	<ul style="list-style-type: none"> - Business strategy - Risk management - Handling credits - Market analyses - Trading activities - Special contracts (PPA/PSA) 	<ul style="list-style-type: none"> - Business strategy - Risk management - Consumption prognoses - Customer management - Handling credits - Buying of electricity (PSA)
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Risks in a commercial electricity company



	Production	Trading	Customer sales
Regulatory	High risk	Low risk	Medium risk
Natural disasters	High risk	Low risk	Low risk
Environment	High risk	Low risk	Low risk
Marketprices	Medium risk	High risk	Medium risk
Financial	High risk	High risk	Low risk
Credit	Medium risk	High risk	High risk
Breakdowns, production	High risk	Low risk	Medium risk
Breakdowns, net	Medium risk	Medium risk	Medium risk
Sourcing of fuel	Medium risk	Low risk	Low risk
Customers leaving	Medium risk	Medium risk	High risk
Competences (people)	Medium risk	High risk	Medium risk
Systems (IT)	Medium risk	Medium risk	Medium risk

	High risk
	Medium risk
	Low risk

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Payments and risk sharing

Payments and risk sharing

- Capacity payment (MW)
- Energy payment (MWh)
- Incentive payments

- Payments linked to end customer prices
- Payments linked to customer consumption
- Periods linked to customer contract periods



Production

↔

Trading

↔

Customer sales

→

End customers


(PPA)

(PSA)

- Regulatory
- Natural disasters
- Environment
- Financial
- Breakdowns, production

- Marketprices
- Financial
- Credit
- Competences (people)

- Credit
- Customers leaving



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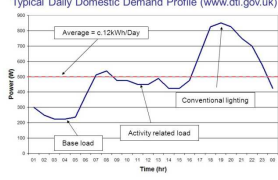
Trading perspective End Customers

End Customers

- Highly predictable consumption, except for some large industrial customers
- There is a risk of variation in the volumes
- There is a risk of variations in consumption profile
- There is a risk that customers do not pay their bills
- There is at risk that customers leaves

Typical Domestic Electrical Load

Typical Daily Domestic Demand Profile (www.dti.gov.uk)



Consumption is not sensitive to the price of electricity

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Risk Management policy – market related risks



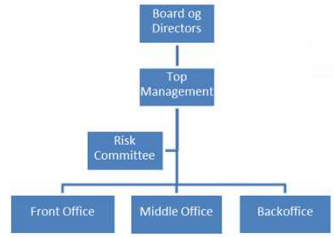
The risk management policy has to be anchored at the top level of the company (Board of Directors). The policy need to cover the following issues

- Governance
- Book structure
- Exposure in the market
- Handling of credits
- Powers of attorney
- Reporting
- Violations of the risk policy
- Implementation of the policy

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Governance



Front Office:

- Production prognoses
- Consumption prognosis
- Optimization of production
- Day ahead plan
- Spot and intraday trading
- Sales of system services
- Hedging
- Purchase of fuel
- Storage Optimization

Tasks differs depending of the structure of the company.

Middle Office:


- Monitoring of Risk Exposure in Front Office and check that they operate within mandates and limits
- Reporting of deviations
- Reporting of risks and results (P&L reporting), including the use of credit limits
- Ensure that internal controls are set up and followed
- Maintain counterparty list and assign and follow up on credit limits
- Test and validate risk models

Back Office:

- Control and administrate all transactions that are made by Front Office
- Settlement of trades
- Handling of collateral

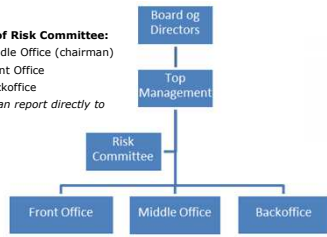
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Governance

Members of Risk Committee:
 Head of Middle Office (chairman)
 Head of Front Office
 Head of Backoffice
Chairman can report directly to the Board



Board of Directors:

- Approves the overall risk policy


Delegated to the Risk Committee

- Which markets and trading platforms is it allowed to trade on
- Which products must be traded
- Risk mandates for Traders in Front Office
- Which counterparties is it allowed to trade with and with which credit limits

Risk Committee:


- Monitor the risk and ensure that risk policy and instructions are respected.
- Report to the Board if mandates or limits are exceeded
- Ensure that any break of mandates or limits are corrected within a deadline set by the Risk Committee
- Ensure compliance with the rules on market behavior in the electricity market, including avoiding insider trading
- Ensure that updated business procedures and instructions are in place

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Deciding on book structure

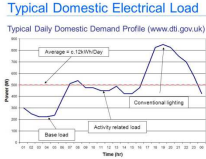
Production



Trading



End Customer Sales



Hedging book – Production technology 1

Hedging book – Production technology 2

→

Internal trades between books will be made


Trading – ex. market making

Hedging book – End Customers

Hedging book – End Customers (larger industrial companies)


Clear economical results can be made for the individual books.

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Exposure in the market - Production


Production



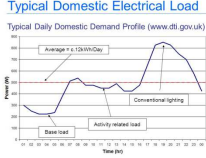
Hedging



Trading



End Customer Sales



Hedging book - Production

5 years

Responsibility of Risk Committee

5 years to 30 years

Strategic issue -responsibility of Top Management

The Risk Committee has to decide on a policy for hedging. The policy normally have to include the following elements


- More hedging the closer you are to the present (more in year one than in year 5)
- More hedging with high electricity prices at the market

The Traders will have to stick to the policy for hedging within limits decided by the Risk Committee.

It is recommended to get approval in the Board of Directors of the overall elements in the policy of hedging.


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Exposure in the market – Trading

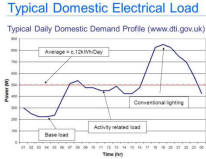
Production



Trading



End Customer Sales



Trading

5 years

Responsibility of Risk Committee


The Risk Committee can allow trading in a separate trading books. The reason for allowing such books is

- Market making tasks, where the trading entity is obliged to offer prices to the market (to secure liquidity)
- Keeping the traders on track with the market, so that they are up to date when they have to do hedging
- Introduce competition between traders and hopefully secure extra earnings to the company

The Traders will have to stick to trading limits decided by the Risk Committee.


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Exposure in the market – End Customer Sales

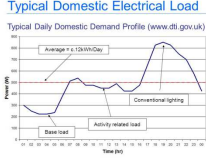
Production



Trading



Hedging



Hedging book – End Customers

5 years

Responsibility of Risk Committee

5 years to 30 years

Strategic issue - responsibility of Top Management (long term contracts with large industrial consumers)


The Risk Committee has to decide on a policy for hedging. The policy normally have to include the following elements

- Hedging period has to be the same as the duration of End Customer contracts
- The profile of the hedging has to be close to the profile of the consumption by the End Customers


The Traders will have to stick to the policy for hedging within limits decided by the Risk Committee.

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Governance - organization



Front Office – Short term Trading

- Optimization of production
- Day ahead plan
- Spot and intraday trading
- Sales of system services

Front Office – Middle/Long term Trading

- Production prognoses
- Optimization of production
- Hedging
- Purchase of fuel
- Storage Optimization
- Sales of system services

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Actions – Trading and risk management setup

Start a more simple setup – advanced setup later

<ul style="list-style-type: none"> - Position in the market - Structure of the company - Investment planning - Mergers or sale of plants? 	<ul style="list-style-type: none"> - Deciding on risk management policy - Designing the organization - Having the right people onboard 	<ul style="list-style-type: none"> - Build instructions and procedures - Hire and train people - Build/buy IT systems - Framework agreements with trading partners 	<ul style="list-style-type: none"> - Hedging activities - Short term trading - Market analyses - Controlling and reporting
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Getting the right people on board is important. Technical skills will still be needed, but also new people with financial skills will be needed.

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Cross-border trading of electricity

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Price zones

The Baltic-Nordic area as a case


Normally, there are not the same spot prices in the Baltic-Nordic area.
Normally, there are high-price zones and low-price zones.
Lithuania, Latvia, Estonia and Finland each constitute one price zone.
Denmark is divided into two price zones.
Sweden is divided into four price zones.
Norway can be split into a number of price zones
Currently, Norway is split into five price zones.
It's the Norwegian TSO who decides the Norwegian price zones.

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Indian price zones

The Indian spot prices previously shown were from the price zone N2


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Price zone – definition

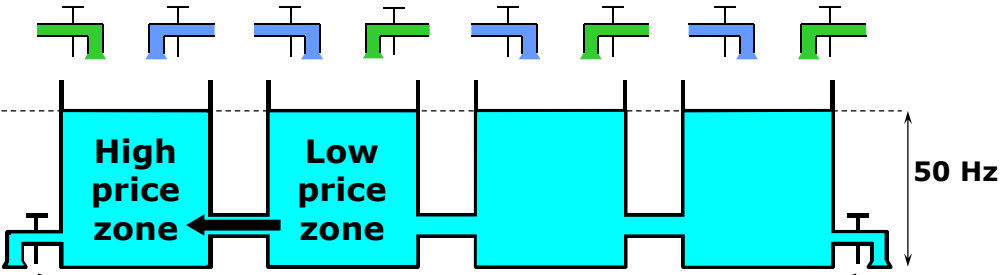
- **A price zone is a geographical area, within which the market players can trade electrical energy day-ahead without considering grid bottlenecks.**
- **As a consequence: for a given hour of operation and a given price zone, a spot exchange will calculate one spot price for the whole zone**
 - **Hence the name “price zone”.**

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How to couple energy markets together

Producers



High price zone **Low price zone**

consumers

A good grid congestion management system will ensure the energy flows towards the high price zone!

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Market coupling (implicit auctions)

A day-ahead grid congestion management system:

The day-ahead plans for the cross-border energy flows are calculated using the purchase bids and sales offers sent by the market players to the electricity exchanges

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Terminology: market splitting and market coupling

- **Market splitting:** When **one** electricity exchange manages the cross-border energy flows in its own area
 - Example: the Baltic-Nordic area where its done by Nord Pool.
- **Market coupling:** When **two** electricity exchanges manage the cross-border energy flow at a border where two exchanges meet
 - Example: the coupling between Germany and the Baltic-Nordic area.
- **Implicit auction** is the common term for market splitting and market coupling.

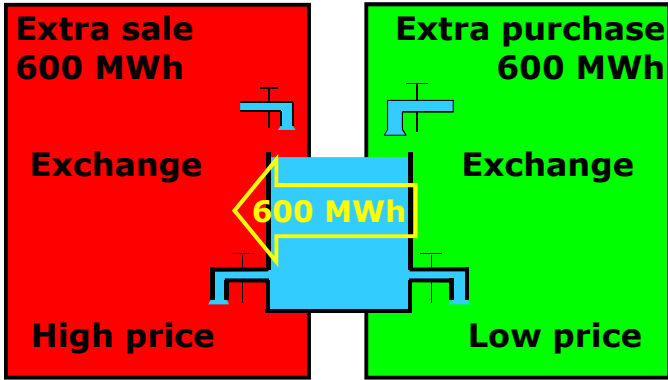
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Market Splitting: the concept

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- The electricity exchange has a **purchase surplus in the low-price zone** and a **sale surplus in the high-price zone**.
- This deliberate imbalance in the exchange's trading ensures an energy flow from the low-price zone to the high-price zone.




The diagram illustrates market splitting between two zones. On the left is a red box representing a 'High price' zone, containing an 'Exchange' with an 'Extra sale' of 600 MWh. On the right is a green box representing a 'Low price' zone, containing an 'Exchange' with an 'Extra purchase' of 600 MWh. A central blue box represents the interconnector, with a yellow arrow indicating a flow of 600 MWh from the low-price zone to the high-price zone.

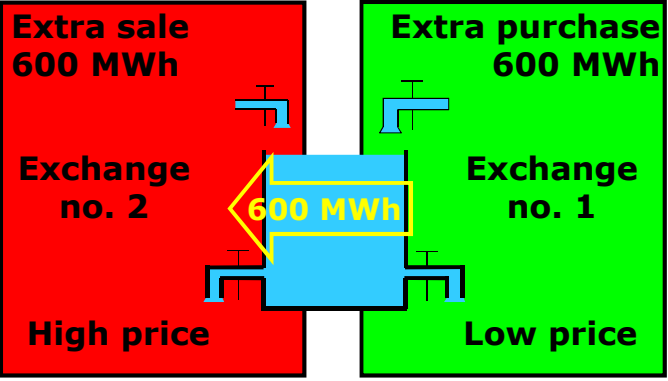
Example for one hour of operation: A capacity of 600 MW betw. two zones with different prices.

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Market Coupling: the concept

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- The market coupler buys in the low-price zone and sells in the high-price zone.
- This cross-border trading done by the market coupler ensures an energy flow from the low-price zone to the high-price zone.

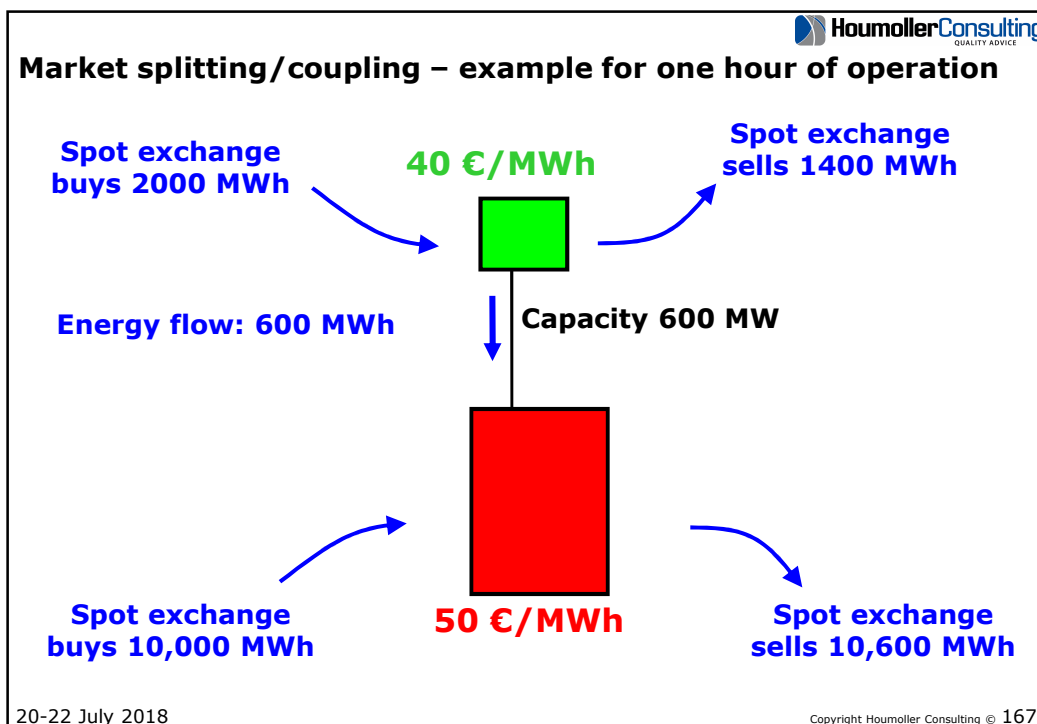


The diagram illustrates market coupling between two zones. On the left is a red box representing a 'High price' zone, containing 'Exchange no. 2' with an 'Extra sale' of 600 MWh. On the right is a green box representing a 'Low price' zone, containing 'Exchange no. 1' with an 'Extra purchase' of 600 MWh. A central blue box represents the market coupler, with a yellow arrow indicating a flow of 600 MWh from the low-price zone to the high-price zone.

Example for one hour of operation: A capacity of 600 MW betw. two zones with different prices.

Implicit auction

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Simplified terminology

- Originally, in the Nordic area, we used the term *market splitting*
 - ❑ In spite of a common spot exchange, we had to *split* the market into price zones, which normally have different spot prices.
- When we started promoting this system to the rest of Europe, we invented the term *market coupling*
 - ❑ Because *market splitting* sounds negative
- The introduction of the term *market coupling* was pure spin.
- However, now *market coupling* seems to be the only term used.
- Hence, in the following, I'll only use the term *market coupling*.

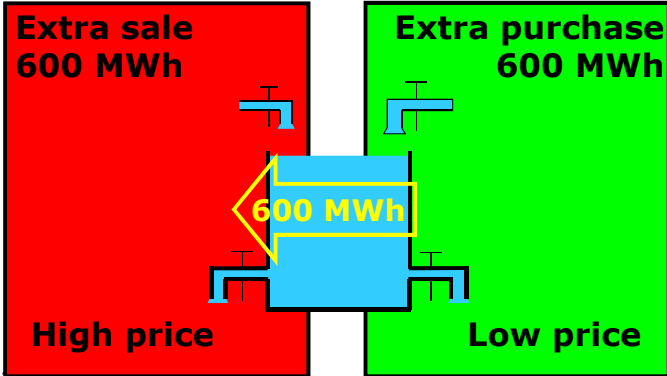
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Where can you use market coupling?


As day-ahead congestion management system

- **Necessary condition: on both sides of the border, the electricity exchange(s) must have good liquidity.**
- **Without good liquidity, the prices at the exchange(s) may not truly reflect the value of the commodity electrical energy.**



Example for one hour of operation: A capacity of 600 MW betw. two zones with different prices.

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What are the advantages?

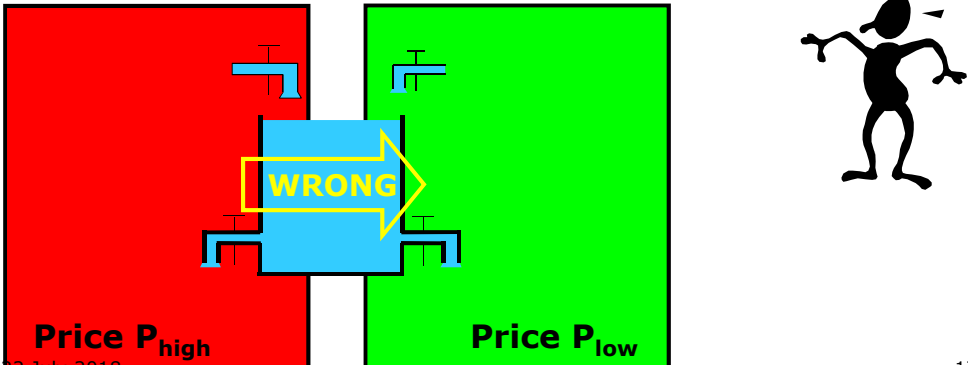
When you use implicit auctions

- **This system is neutral and fair for all players in the market.**
- **When the implicit auction system is operated the right way:**
 - ❑ **All trading capacity on every bottleneck will be utilised during every hour of operation with economic optimal energy flows.**
 - ❑ **The grid is a resource for society. If the grid is underutilised, society will have a loss.**
- **A disadvantage: when you introduce implicit auctions, the spot exchanges become monopolies**
 - ❑ **For each price zone, you can only have one spot exchange**
 - ✓ **Because: for each price zone there must be one, unique price per hour.**

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When the energy is flowing in the wrong direction

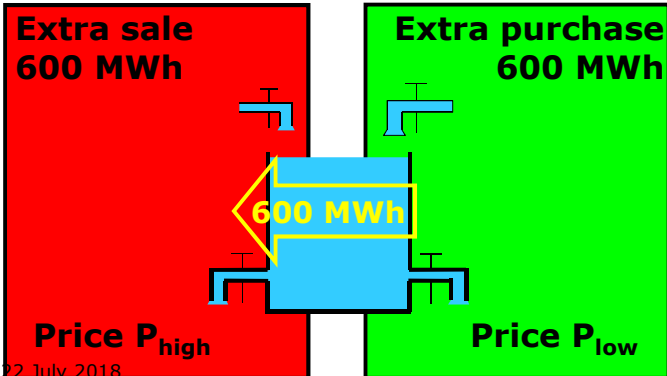
- With wrong flow: inefficient, expensive producers in the high-price zone are up and running
 - ❑ Supplying to both their own country and the neighbouring country.
- At the same time, efficient producers in the low-price country are not producing (standing idle)
 - ❑ This is bad for both countries.



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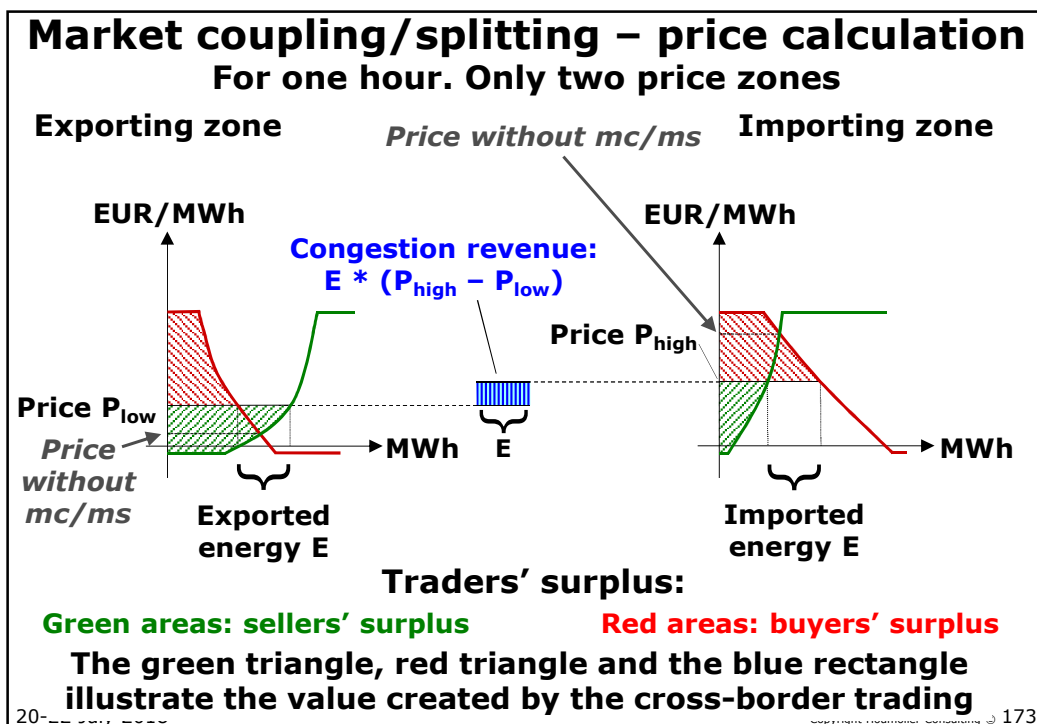
Congestion revenue/rent

- The 600 MWh is bought at price P_{low} and sold at price P_{high} .
- The arbitrage revenue (the so-called congestion revenue) is $(P_{high} - P_{low}) * 600 \text{ MWh}$.
- The arbitrage revenue is given to the capacity owners (most often TSOs).



Example for one hour of operation: A capacity of 600 MW betw. two zones with different prices.

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Value created by the spot trading

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- For one hour of the next day: consider two neighbouring price zones with different prices P_{low} and P_{high} .
- If the market coupling system sends the energy E from the low-price zone to the high-price zone, the so-called congestion rent (or congestion revenue) is
 - $E * (P_{high} - P_{low})$.
- Normally, the congestion rent is given to the capacity owners.
- Actually, the total value created by the spot trading is the sum of the following two components:
 - The sum of all the red/green areas (the traders' surplus).
 - The congestion rent (the capacity owners' gain).

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The welfare criterion HoumollerConsulting QUALITY ADVICE

- **When selecting the preferred solution, the price calculation software aims at maximising the value created by the spot trading.**
- **With reference to the previous slides: the software aims at maximising the sum of**
 - ❑ The traders' surplus (all the red/green areas).
 - ❑ The congestion rent.
- **The maximization runs over all links, all price zones and all 24 hours of the next day.**
- **Hence, the software aims at maximising the following sum:**

$$\sum_{24 \text{ hours}} \left[\sum_{\text{All links between price zones}} (\text{congestion rent}) + \sum_{\text{All price zones}} (\text{traders' surplus}) \right]$$

This is the so-called "welfare criterion".

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Spot calculation HoumollerConsulting QUALITY ADVICE

Every day, shortly after noon, the spot software calculates the spot prices and the market coupling flows for the market coupling area.

All price zones and all interconnectors in the coupled region are included in the calculation.

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Spot trading and market coupling – 1

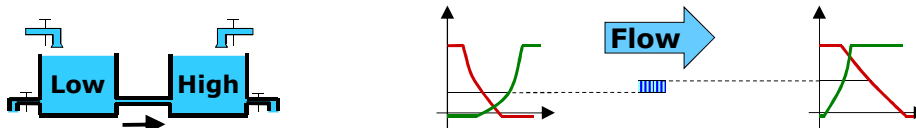


Summary

Market coupling and spot prices:

Use the bids submitted by the market players to the spot exchanges.

Use the bids to calculate the spot prices and the day-ahead plans for the energy flows across the grid bottlenecks.



Market coupling and spot price calculation are two sides of the same coin:

The spot prices determine the direction of the market coupling flows.

The market coupling flows have a huge influence on the spot prices.

The spot calculation calculates the prices and the market coupling flows in one operation! Using the market players' bids.

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Integration of electricity markets



First step: in each of the two countries/regions, There is an incumbent. The two incumbents trade with each other (bilateral, cross-border trade).

Country 1
TSO₁

Second step – more competition in both countries/regions: more market players in both.

Country 2
TSO₂


Now there are many market players, who want cross-border capacity. How to grant the capacity?

The two TSOs run an explicit auction system, where the market players can buy cross-border grid capacity. After having bought cross-border capacity, the market players can trade across the border.

Third step: a spot exchange in both countries. You establish market coupling or market splitting.

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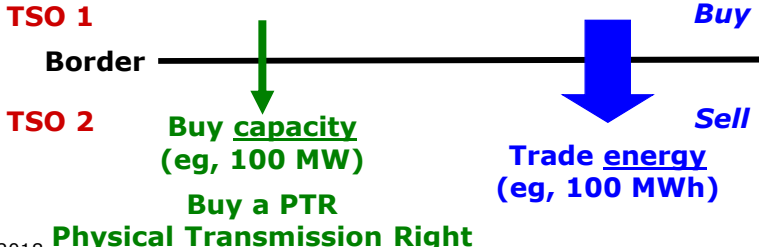


Explicit auction


The two TSOs at each side of the border can run a co-ordinated explicit auction system

- **First:** At the explicit auction, the market players buy capacity in the direction, which he believes is the right direction.
- **Second:** After having bought capacity in a given direction at the border, a market player can trade energy in this direction.

Case for one hour of operation
Market player: "I believe direction south is the right one"



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Why implicit auctions?

- The border Germany-Western Denmark as an example:
 - ❑ Previously, all the capacity was sold at annual, monthly and daily explicit auctions by the Danish TSO and the German TSO.
 - ❑ *During about 25% of the hours the energy flowed in the wrong direction (towards the low price zone) !*
- For this border, the Danish TSO Energinet.dk made an estimate of Germany's and Denmark's socio-economic loss, when the trading capacity was not used as it should
 - ❑ ie, either the energy flowed in the right direction, but there was unused capacity; or the energy flowed in the wrong direction.
- Here you have the numbers. Please note – this is for one link only:
 - ❑ 2004 EUR 16.6 mill.
 - ❑ 2005 EUR 30.3 mill.
 - ❑ Five first months of 2006: EUR 10.1 mill.
- ❑ **For comparison: in 2006, Nord Pool's operating costs were EUR 7.5 mill.**

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Market coupling combined with explicit auctions – 1




- **Example:** How to combine market coupling with a system, where the market players can buy cross-border capacity at annual and monthly explicit auctions.
- **Assume the *use-it-or-sell-it* principle applies to capacity bought at the annual and the monthly explicit auctions**
 - ❑ The players who have bought capacity at the annual or the monthly explicit auctions must early in the morning report if they want to use the capacity the following day.
 - ❑ Unused capacity is given to the market coupling
 - ✓ In return, the players get the capacity's congestion rent (if any).

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Market coupling combined with explicit auctions – 2

Example: A north-south border.
We consider one, given hour of the next day.



- **Assume players with capacity from the annual and the monthly explicit auctions in total ship 400 MWh in direction north.**
 - ❑ ie, they create a flow of 400 MW in direction north.
- **Net principle:** In this case the following capacity is given to the market coupling:
 - ❑ Direction **north**:
✓ (Total trading capacity) - 400 MW
 - ❑ Direction **south**:
✓ (Total trading capacity) + 400 MW.
- **Market coupling will ensure all this capacity is used with energy flowing in the right direction!**
 - ❑ Precisely that is the advantage of the market coupling.

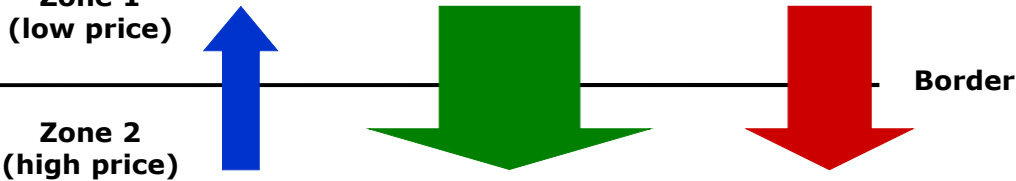
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Market coupling combined with explicit auctions – 3

Example: In total, the players with capacity from the annual and the monthly explicit auctions create a flow of 400 MW in the wrong direction

Zone 1 (low price) **Auction** + **Market coupling** = **Net flow**




Zone 2 (high price) **400 MW** + **400 MW + Trading capacity** = **Trading capacity**

Border

Result: All trading capacity is used with electricity flowing in the right direction!


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What was the message?

- **Answer: You do not need to eliminate the explicit auctions altogether in order to ensure well functioning cross-border trading regimes**
 - Replacing the daily auctions with market coupling will do.
 - ie, you only have to change the day-ahead congestion management system.
- **The system on the previous slides gives the market a simple, *easy-to-understand* system**
 - Plus a well functioning cross-border trading system
 - ✓ Where all capacity on every bottleneck will be utilised during every hour of operation with electricity flowing in the right direction.

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Subsidy systems for renewables



In this presentation, renewables are facilities producing electricity using renewable energy as input

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Feed-in tariffs in Europe

- **During a certain time period, the owner of the renewable gets a fixed price per kWh.**
- **Previously, this was the dominant system in Europe**
 - ❑ **The TSO had to buy the electricity at the fixed price.**
 - ❑ **Hence, this electricity was not sold at the market.**
- **Now, even for those European renewables, who have a fixed feed-in tariff, the electricity is normally sold to the market**
 - ❑ **To the local spot exchange.**
- **If the price at the spot exchange is lower than the guaranteed feed-in tariff, the state or the TSO compensates the owner of the renewable**
 - ❑ **The price transparency provided by the spot exchange is used.**
- **Hence, at the outset, electricity from renewables is sold at the market.**

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European auction systems

- **To establish a new wind farm, new solar cell farm, etc.**
 - ❑ **The state can operate an auction system.**
- **The winner of the auction is the company, which is willing to accept the lowest feed-in tariff**
 - ❑ **Hence, the winner is the seller with the lowest price.**
 - ❑ **This is sometimes called a reverse auction.**
- **Often, the fixed feed-in tariff will be granted for the first XX TWh produced by the renewable.**
- **Normally, the price at the local spot exchange is used as the reference**
 - ❑ **When the spot price is lower than the guaranteed feed-in tariff, the owner of the renewable is compensated.**

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Auction systems – recent cases Germany and India

- **Case Germany: the German government plans to have 2 auctions per year**
 - ❑ **At the auction April 2018, no wind projects were winners.**
 - ❑ **32 solar cell projects were winners. The total capacity of all the projects was 200 MW.**
 - ❑ **The average price was 0.0467 €/kWh ≈ 6.66 PKR/kWh.**
- **Case India: auction at the start of April 2018 for 2 GW wind capacity**
 - ❑ **Most of the capacity was sold at a price of 2.51 INR/kWh ≈ 4.45 PKR/kWh.**

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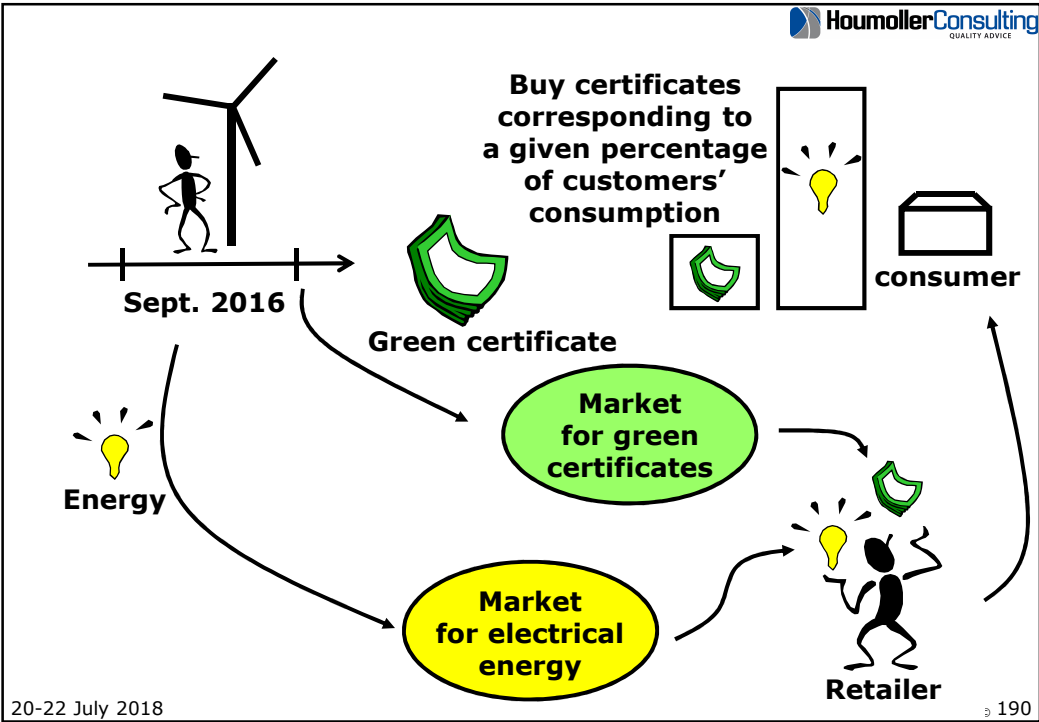
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Green certificates

The basics

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The basics of green certificates

Summary


- **The target is set politically.**
- **How the target is met is decided by the market.**
Competition decides:
 - The size of the subsidy.**
 - The types of renewable technologies employed to meet the target.**
- **This is a tool well suited to an well organized ends-and-means process**
 - Where a target is first set.**
 - And the road to the target is then decided**
 - ✓ **In this case: decided by the market.**

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Team exercise

- **CTBCM Road Map and Implementation Plan and best international practices**
 - Please compare the two and discuss the way forward for Pakistan.**
- **Please prepare to present your conclusions.**



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Thank you for your attention!

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