Price formation in the Nordic system

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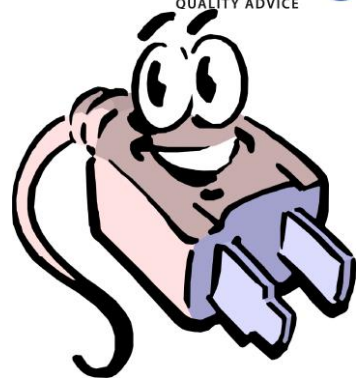
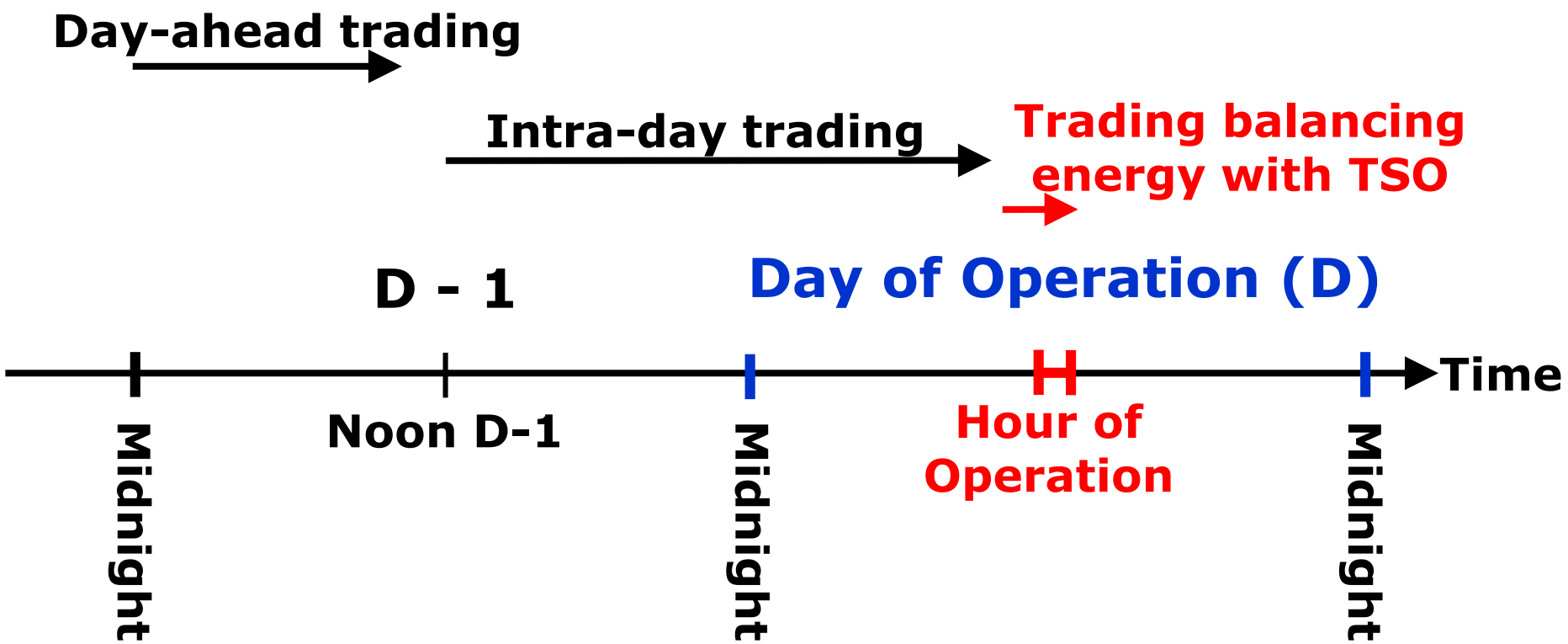


- Trading electrical energy in the European Union.
- Unbundling.
- How to maintain the security of supply by means of the market. Price formation at
  - Markets for balancing energy.
  - Markets for balancing capacity.
- Please also refer to the article *The Liberalized Electricity Market*
  - You'll find the article at the sub-page Facts and findings at www.houmollerconsulting.dk
  - Here, you can also download animated PowerPoint slides with information on EU's markets for electricity and gas
    - ✓For example, you can download the presentation *Capacity markets and The Single European Electricity Market*.

EU: time line for trading electrical energy

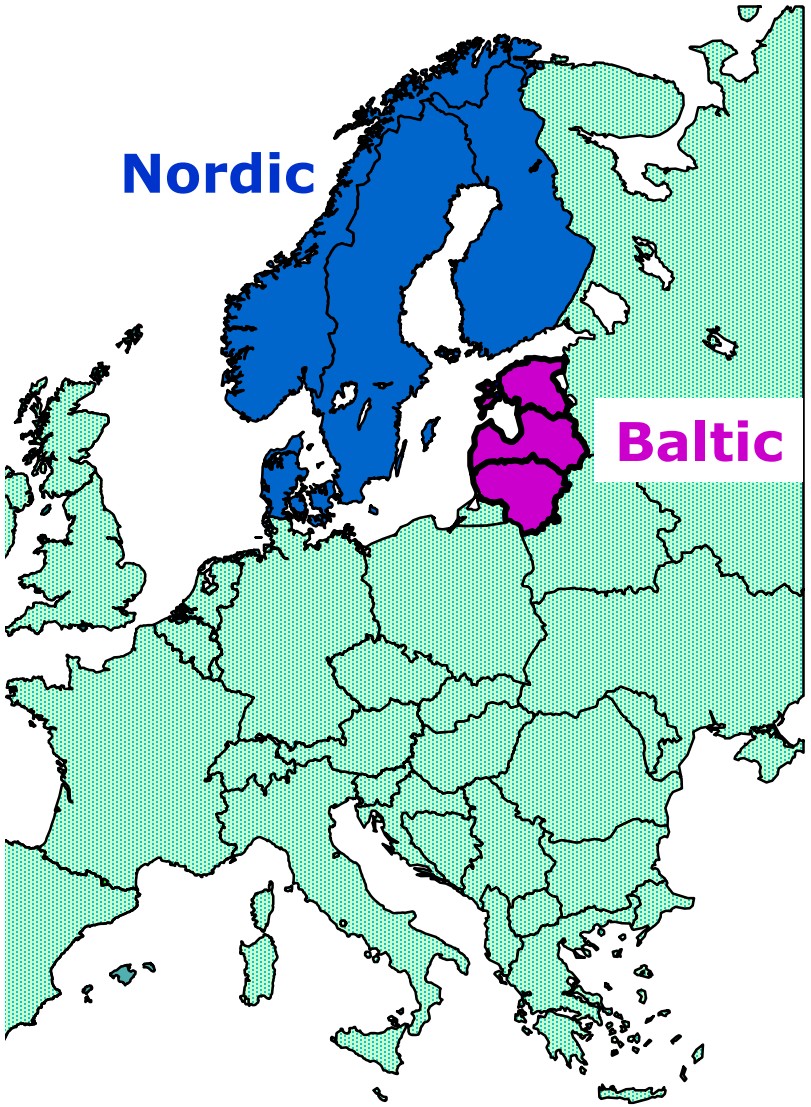
Day of Operation:
The day where the electrical energy is produced and consumed.
Hour of Operation:
The hour where the electrical energy is produced and consumed.

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



The Nordic electricity market – 1

- The four Nordic countries Denmark, Finland, Norway and Sweden.
- The Nordic countries (and the 3 Baltic States) have liberalised their electricity markets and have a common electricity exchange (Nord Pool).
- The Nordic countries: about 27 mill. people.
- Electricity consumption 2018: about 393 TWh
  - Third biggest electricity market in the European Economic Area EEA
    - ✓ EEA = European Union + Norway + Island + Liechtenstein.

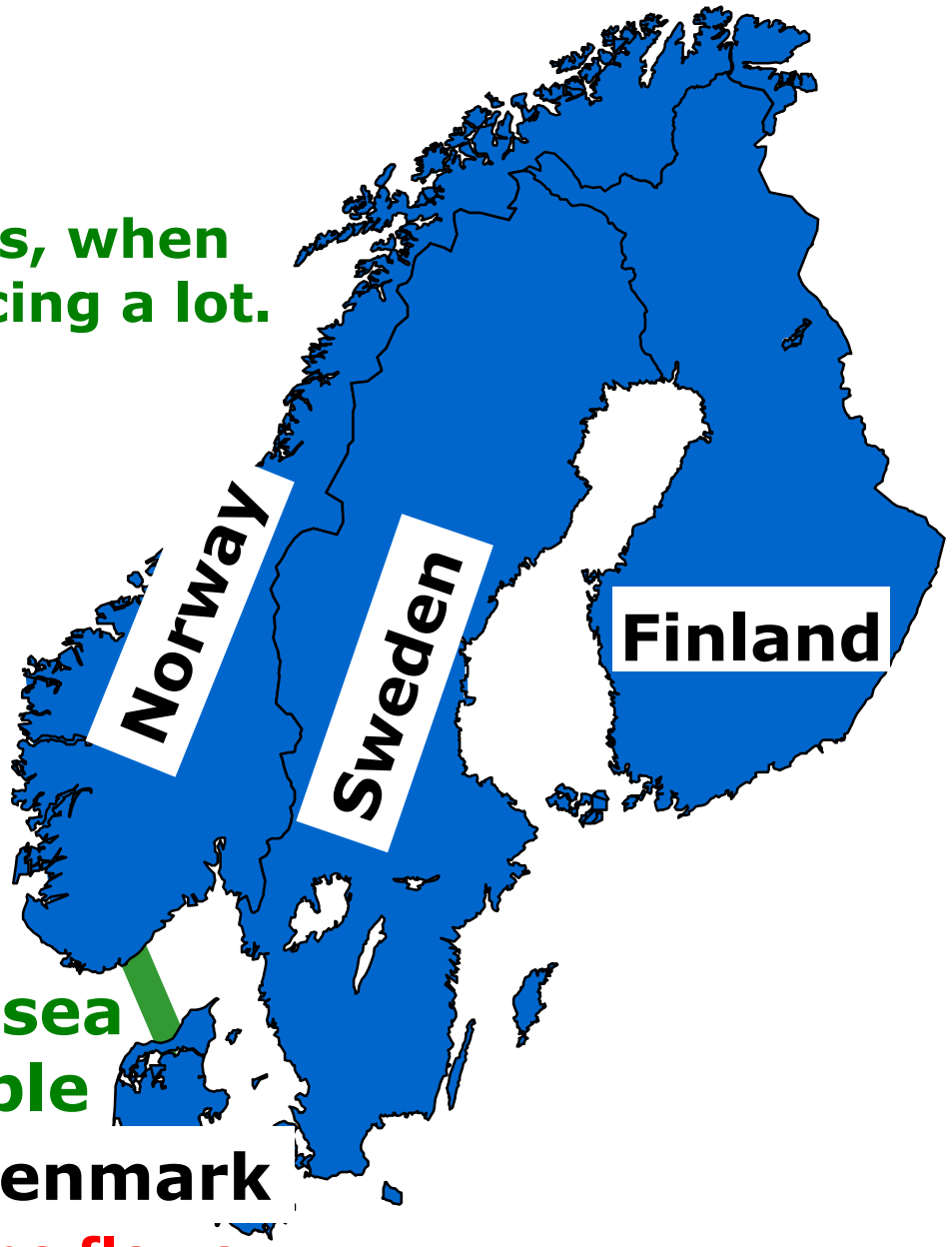


The Nordic electricity market – 2

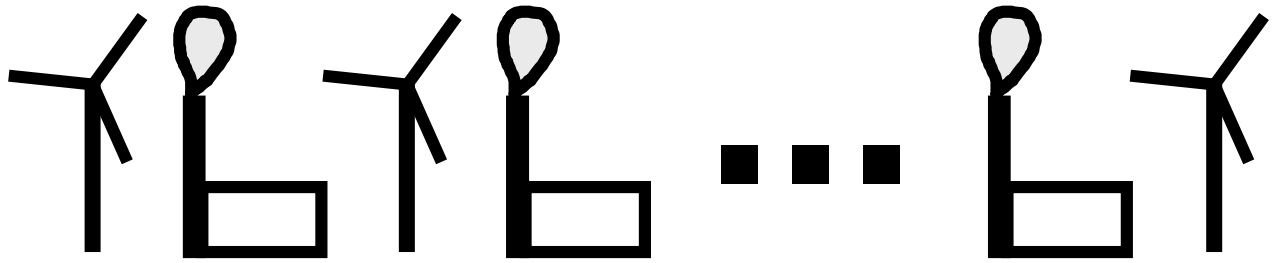
- Norway more than 95% hydro.
- Sweden hydro, nuclear and wind.
- Finland thermal, nuclear and some hydro.
- Denmark wind, thermal and some solar
  - More than 50% of the electricity production in Denmark comes from wind turbines.

The Nordic electricity market – 3

- The Danish-Norwegian combination of renewables and hydro is very fruitful.
- Denmark is exporting during hours, when the Danish renewables are producing a lot.
- Norway exports hydro power, when the production from the Danish renewables is low.
- Great benefit for both countries. Hydro = battery.
- The hourly prices at the day-ahead market are used to make the day-ahead plans for the hourly cross-border flows.
- The prices at the intra-day market is used modify the plans.
- Eventually, the prices at TSOs' market for balancing energy set the flows.



Electricity market: transportation system
European Union



Producers

Transmission System Operator (TSO)

Transmission Grid (DK: above 110 kV)

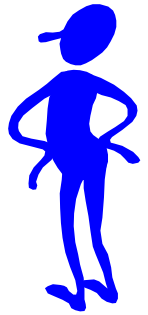
Distribution System Operators (DSOs) (the grid part of the former distribution companies)

Distribution Grid (DK: below 110 kV)

Consumers

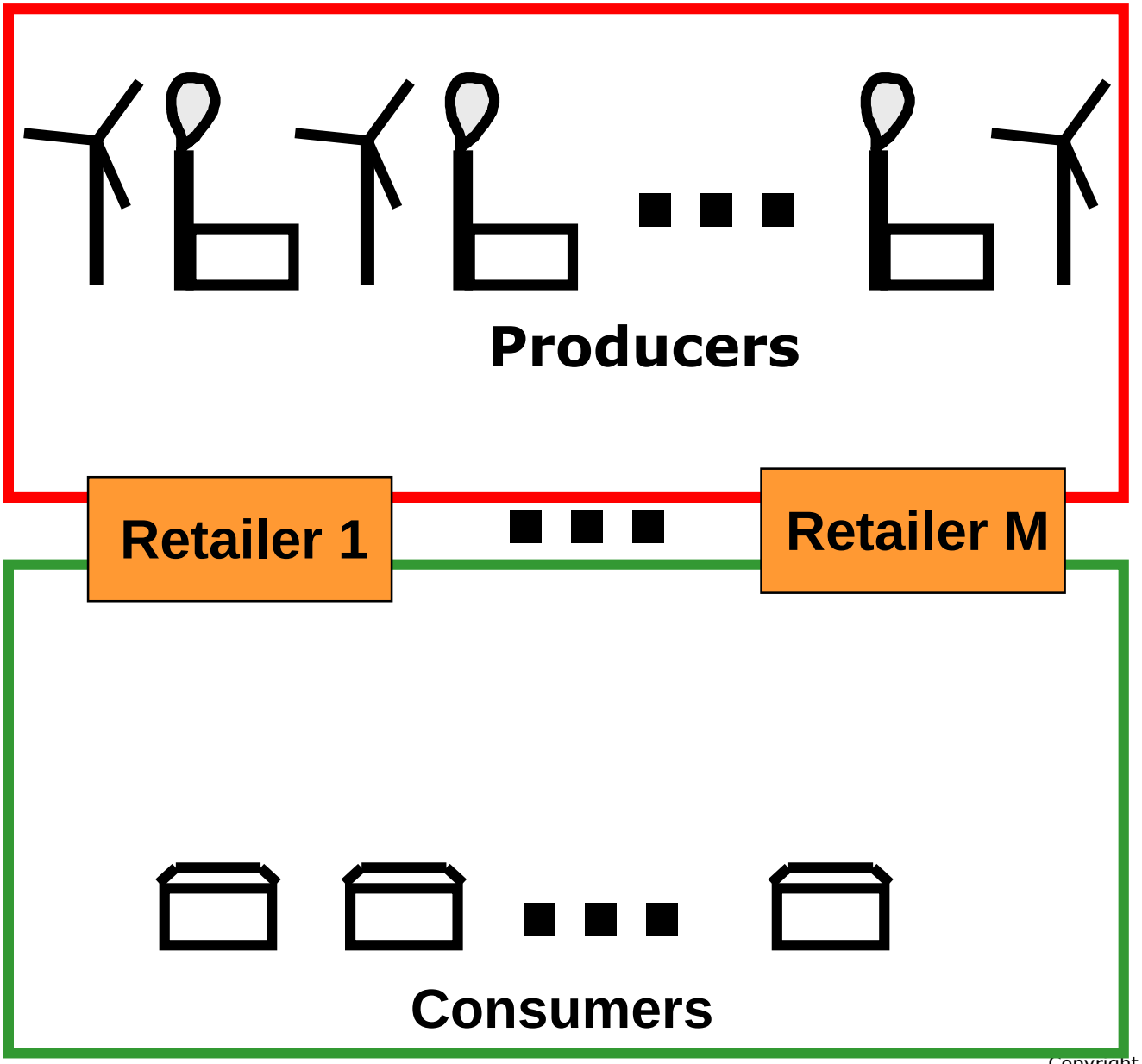
Transmission System Operator (TSO) European Union

- **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).**
  - **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 maintains the security of supply in the TSO's control area.**



TSO

The electricity market: trading system – 1
European Union

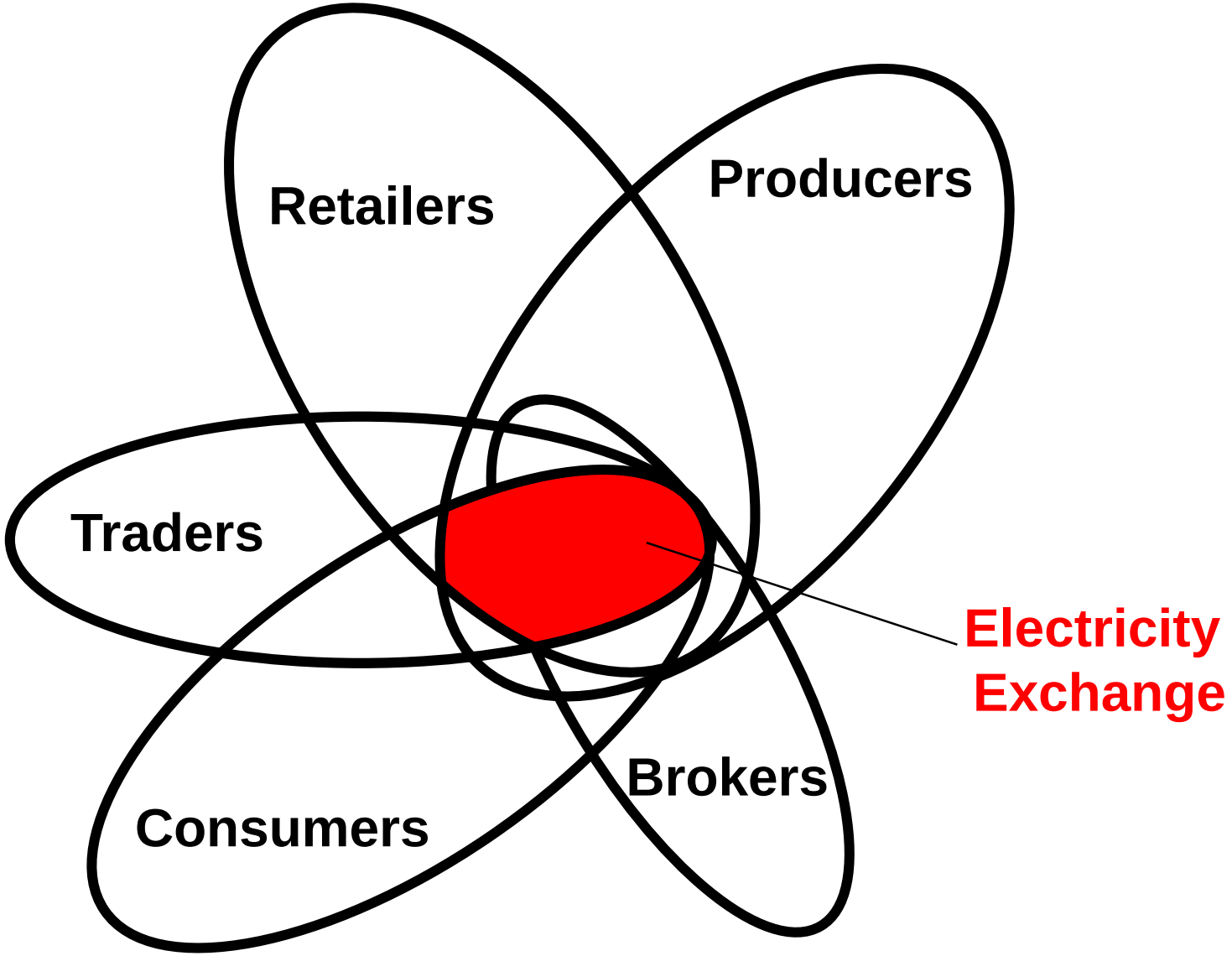


A retailer may be the commercial part of a former distribution company

Wholesale Market

Retail Market

The electricity market: trading system – 2
European Union

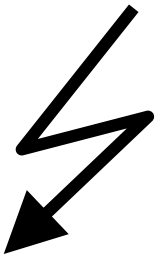


Commercial and non-commercial players

Before liberalisation

Power stations and transmission grid

Distribution companies: local grid and retail



Unbundling

Non-commercial monopolies

Commercial players

After liberalisation

TSO: transmission grid and security of supply

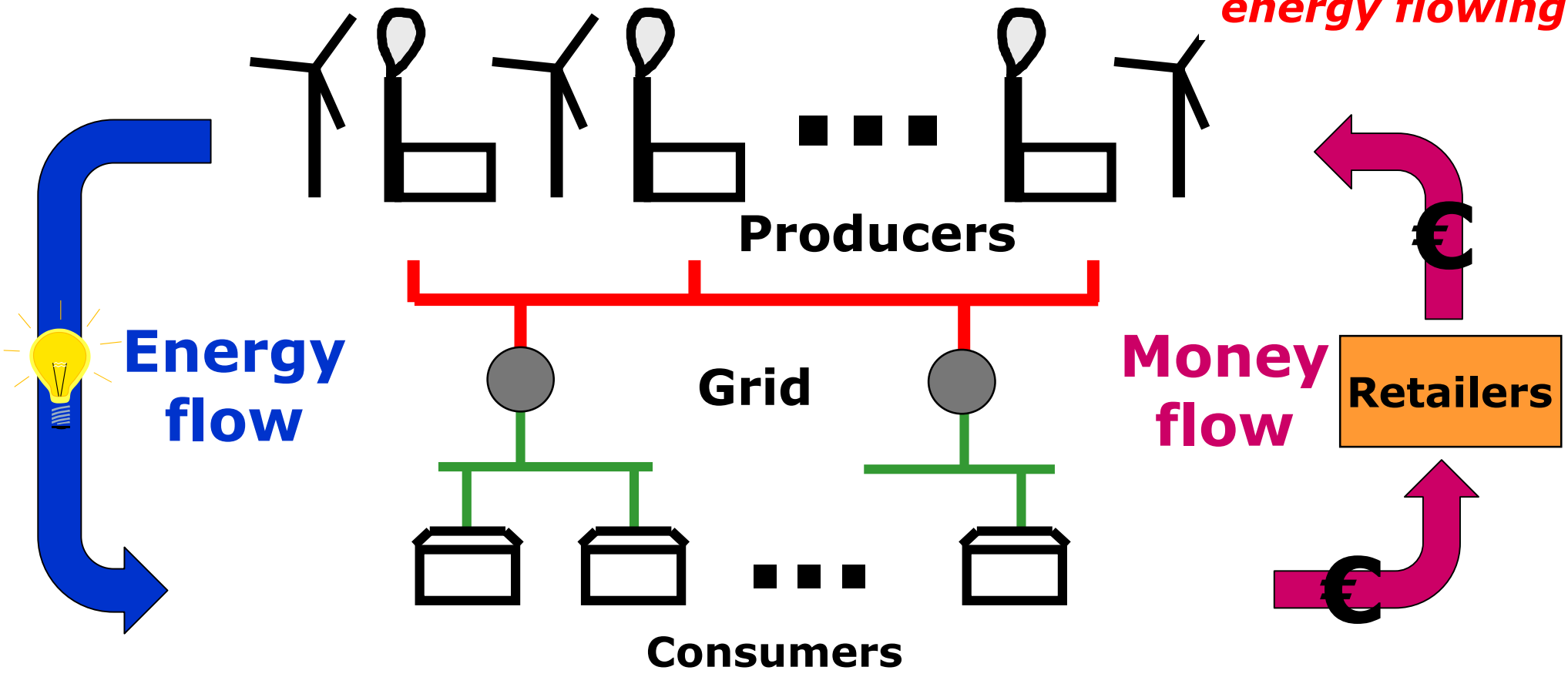
DSO: Distribution System Operators

Producers, retailers, traders, brokers

EU: Two flows

A flow of energy and a flow of money

It's the TSOs' job to keep the energy flowing

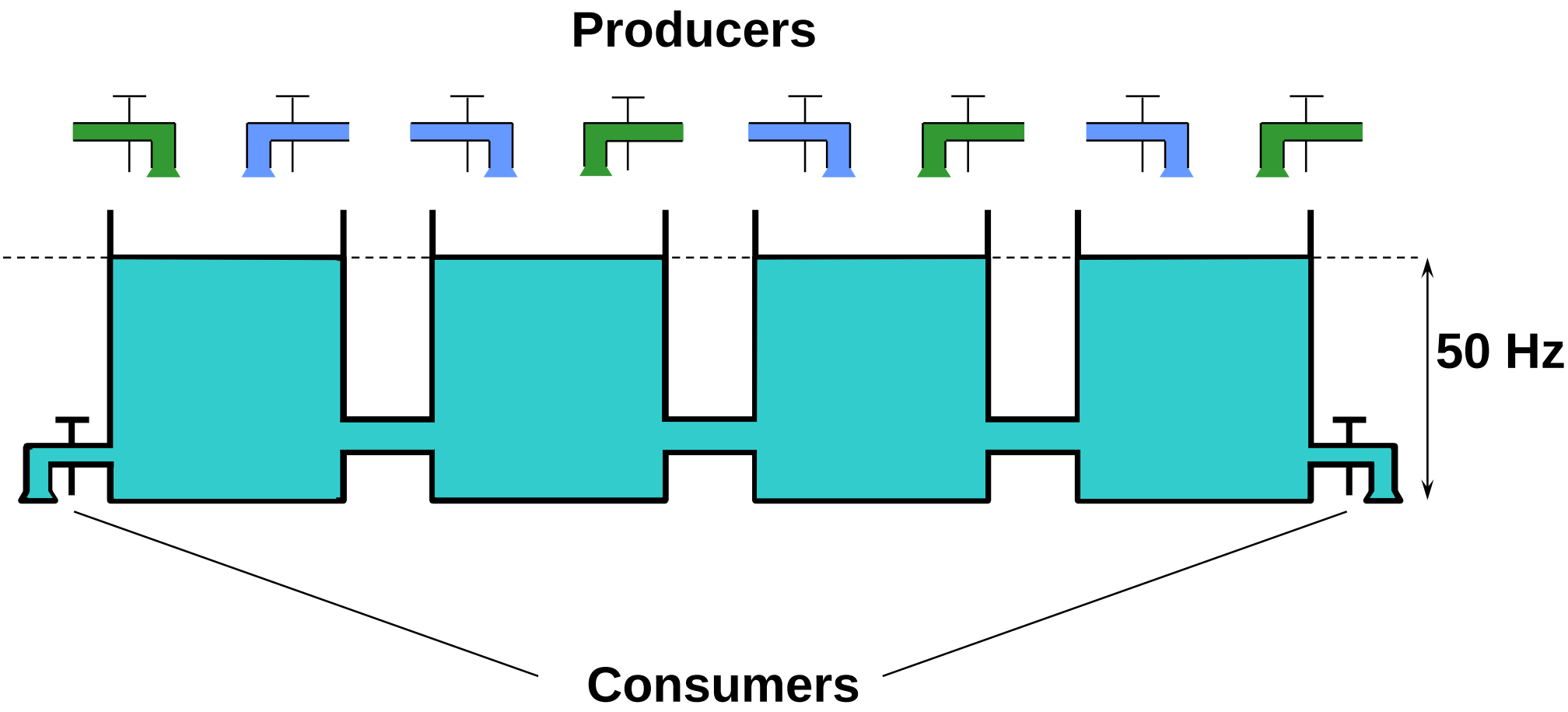


The retailers are not involved in the flow of energy.

But they are heavily involved in the flow of money!

The same for gas.

The Electricity Market



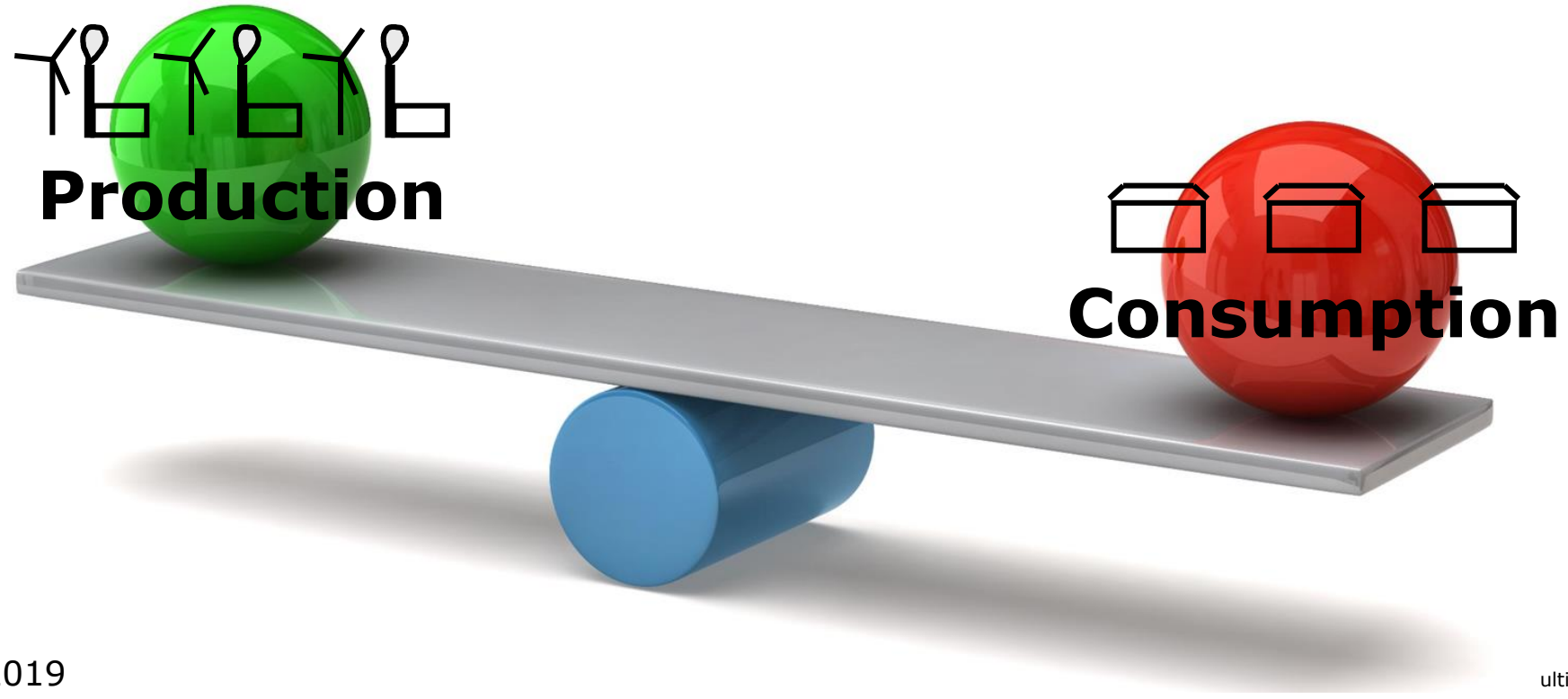
EU: the Transmission System Operator (TSO) operates the high voltage grid and is responsible for the country's security of supply.

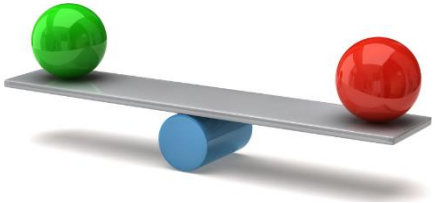
Liberalising the electricity market
Summary

- **The only thing you change when you liberalise the electricity market, is the financial system**
  - **The way the money is flowing, the way the bills are issued, etc.**
- **The physical supervision and maintenance of the electricity system is the same, whether you have market economy or planning economy**
  - **The laws of nature do not change, just because we liberalise the electricity market…**

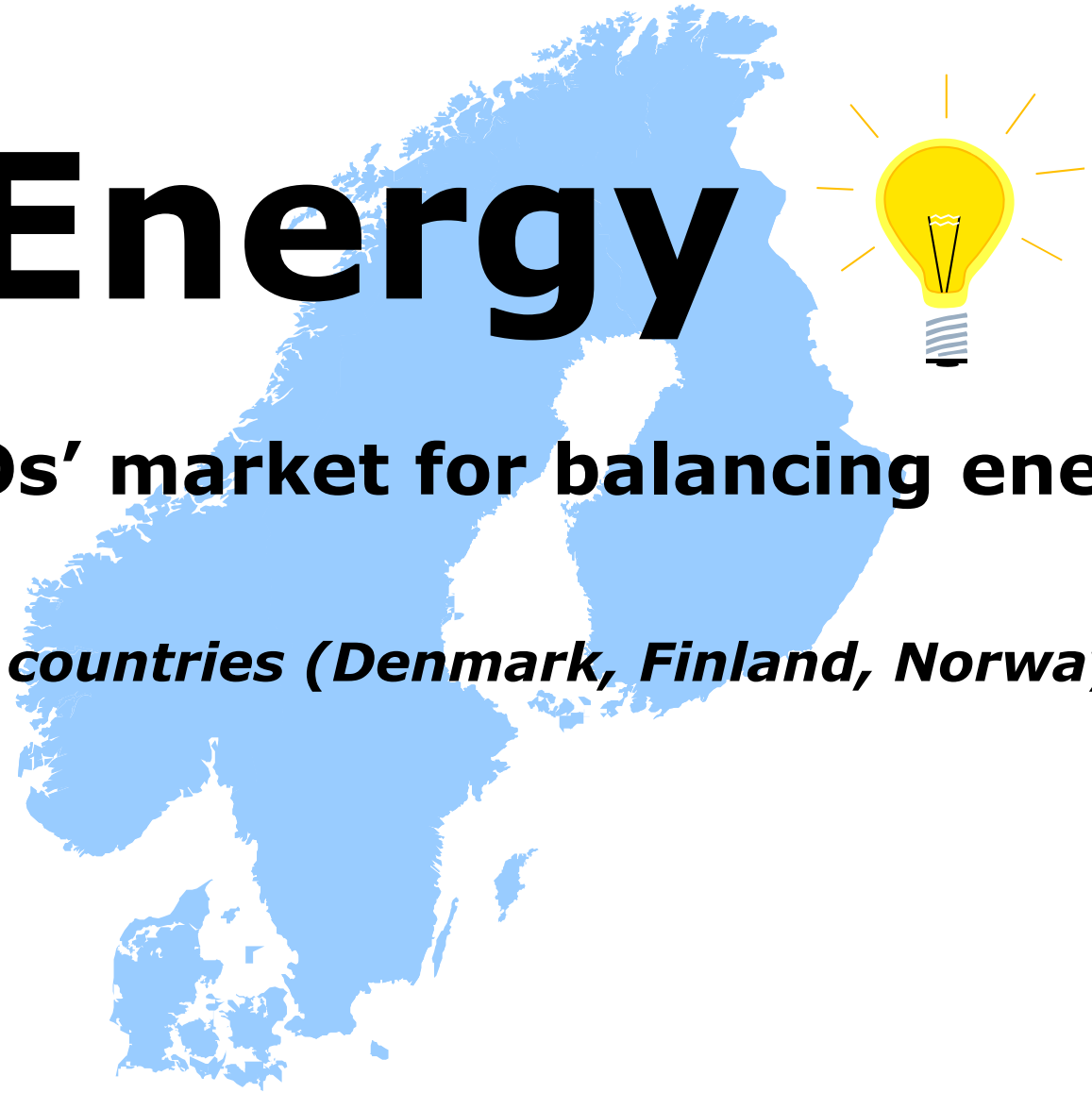
Ancillary services – 1

- 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.





Ancillary services – 2



Energy

The TSOs' market for balancing energy

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

The Nordic TSOs' market for balancing energy

Example for an hour where the production is too <u>big</u>

Result for TSO: a production decrease of 200 MWh

TSO

Sell 200 MWh to producer. Producer's purchase bid price: 30 €/MWh

Producer's initial plan: produce 200 MWh

Producer's marginal costs are 31 €/MWh

Producer : buy at 30 €/MWh and sell at 34 €/MWh

P

The producer has sold 200 MWh to the retailer. Price: 34 €/MWh

Retailer

R

Offers and bids at the Nordic TSOs' market for balancing energy – 1

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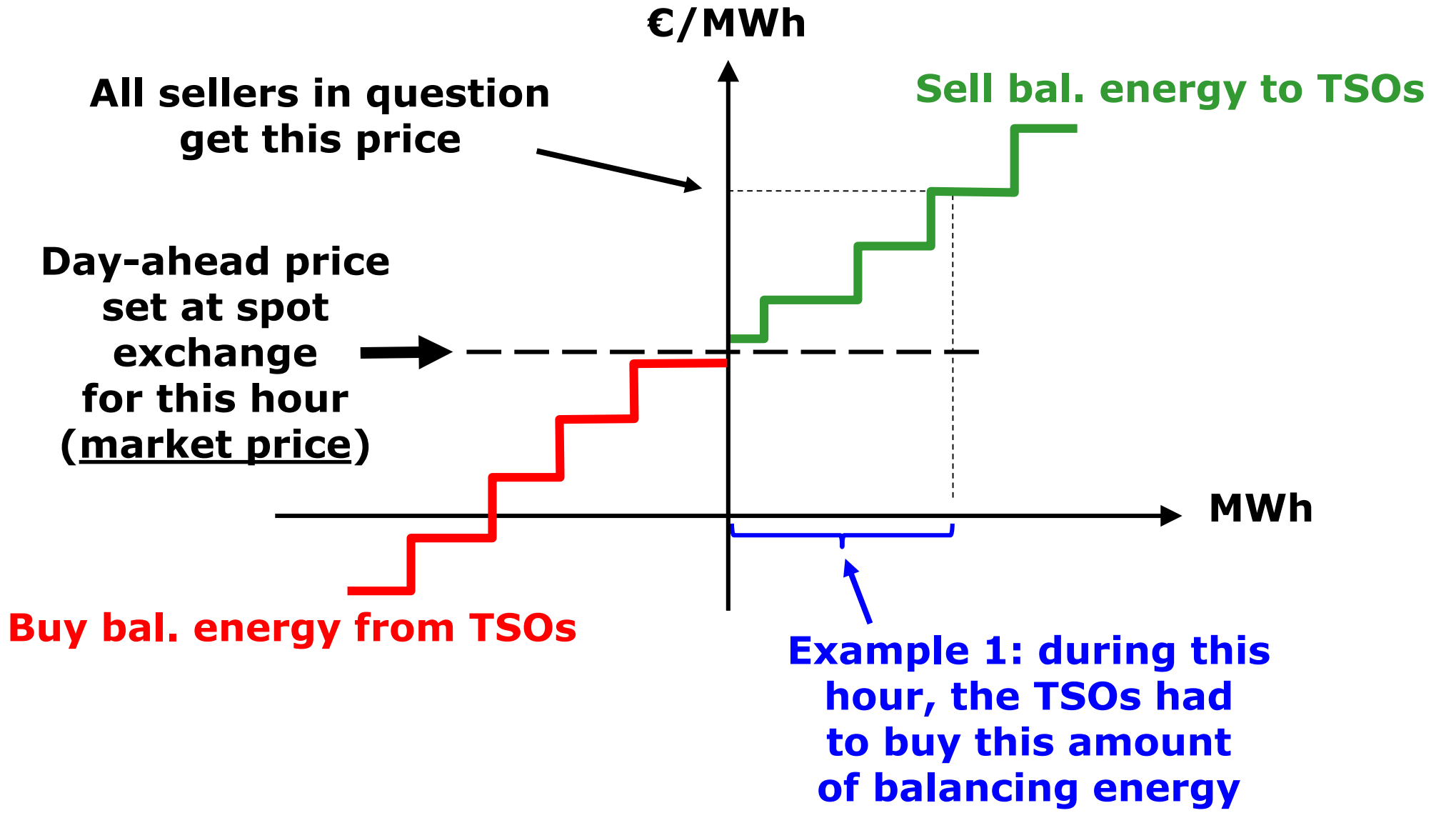
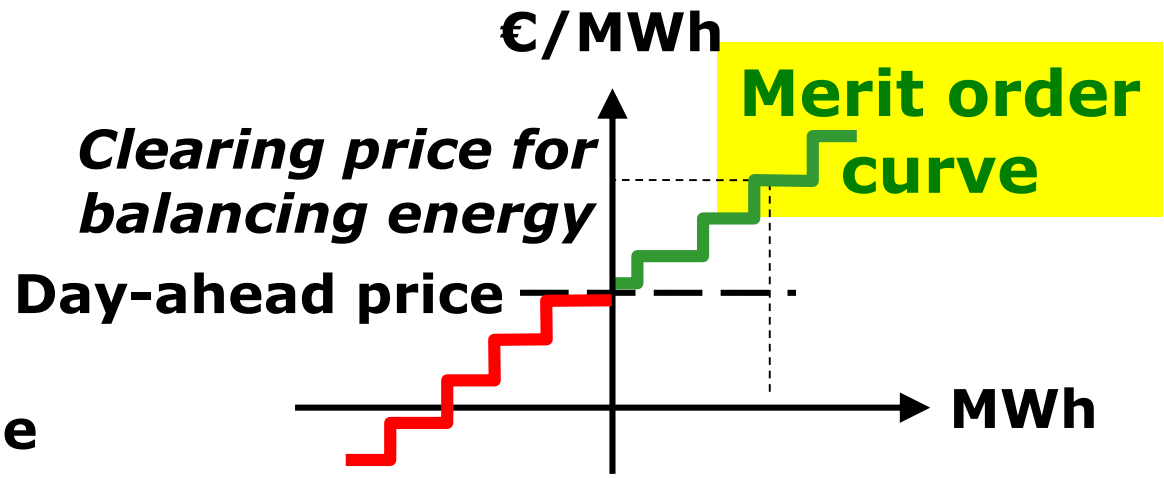
Example for one Hour of Operation



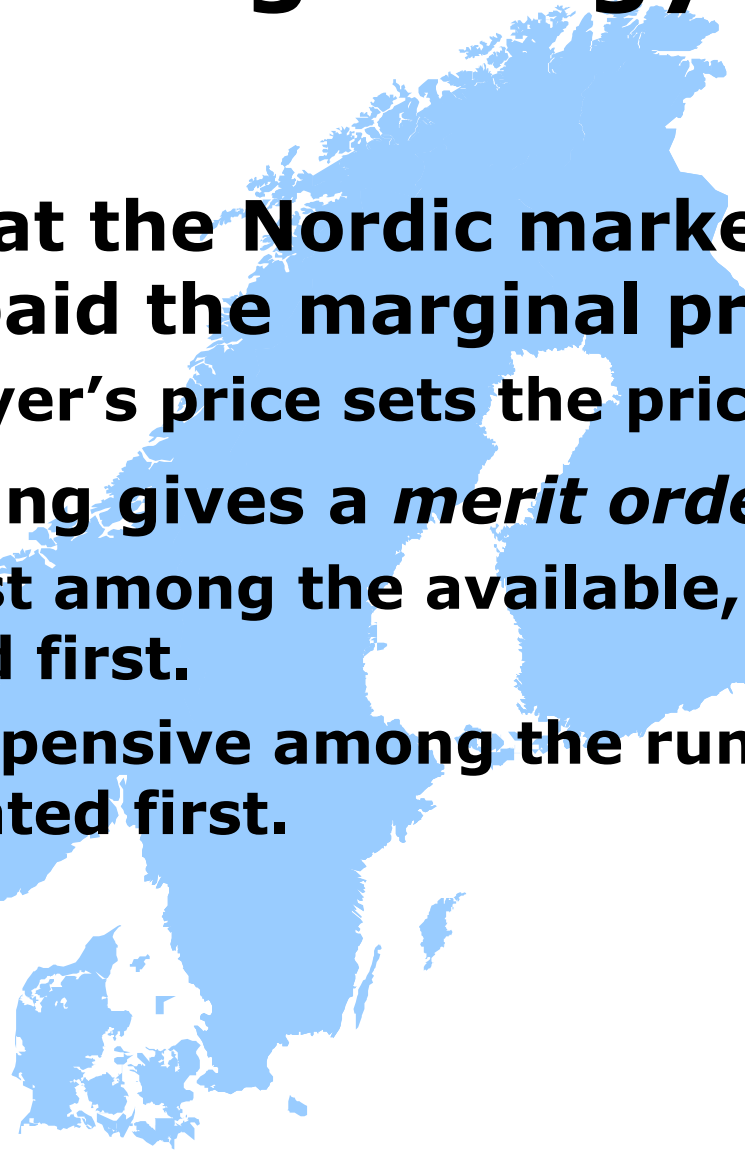
Bidding at the market for balancing energy

- **Assume you have spare capacity, and it's shortly before the start of the Hour of Operation.**
- **So, for the next Hour of Operation, you can offer the TSO balancing energy.**



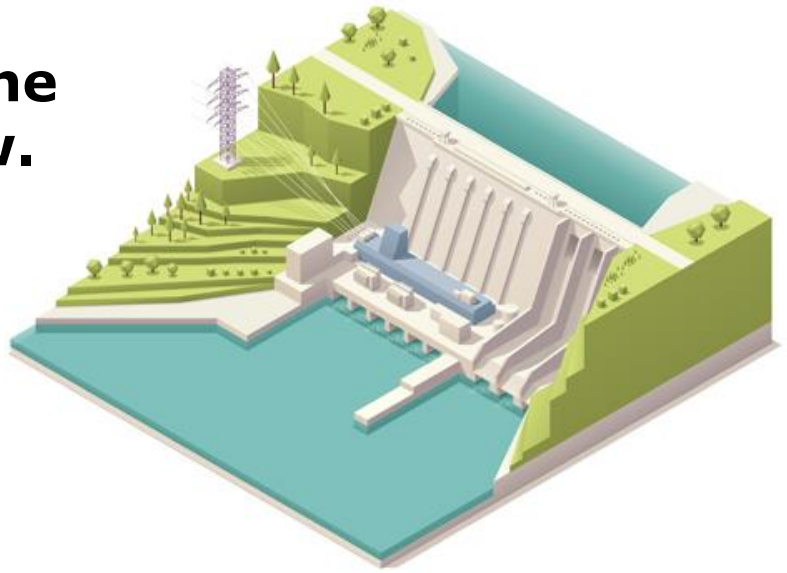
- **Your marginal production costs are 41 €/MWh.**
- **If your offer price is higher than 41 €/MWh, you may price yourself out of the market!**
- **Your offer price is irrelevant, if you manage to sell to the TSO, and you are <u>not</u> the last seller!**
- **The right strategy: use your marginal costs as the offer price.**
- **You'll have a profit, unless you are the last seller.**
- **Even if you are the last seller, you'll not lose money.**

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.**

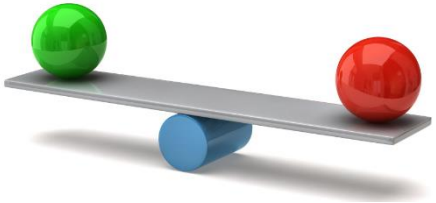
Water value



- Technically, for a hydro power plant, the marginal production costs are very low.
- However, a hydro plant bids according to an estimate of the <u>water value</u>.
- Question: what is the estimated value of the water in the reservoir?
- Answer: this depends on an estimate of the future prices for electricity!
- Morale: do not sell today at a price of 40 €/MWh, if you expect a price of 50 €/MWh next month.
  - You're absolutely willing to sell at 40 €/MWh today, if the expected price next month is 25 €/MWh…

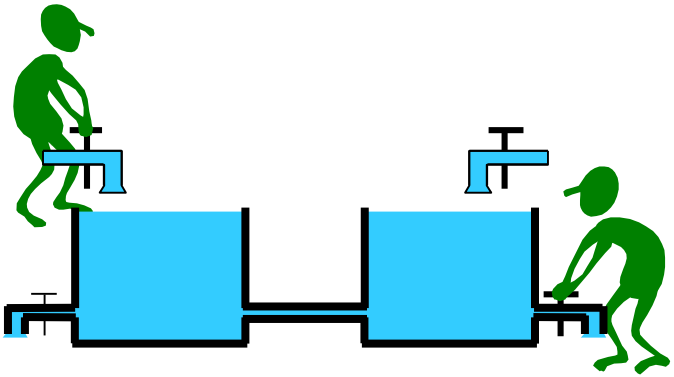
Battery storage

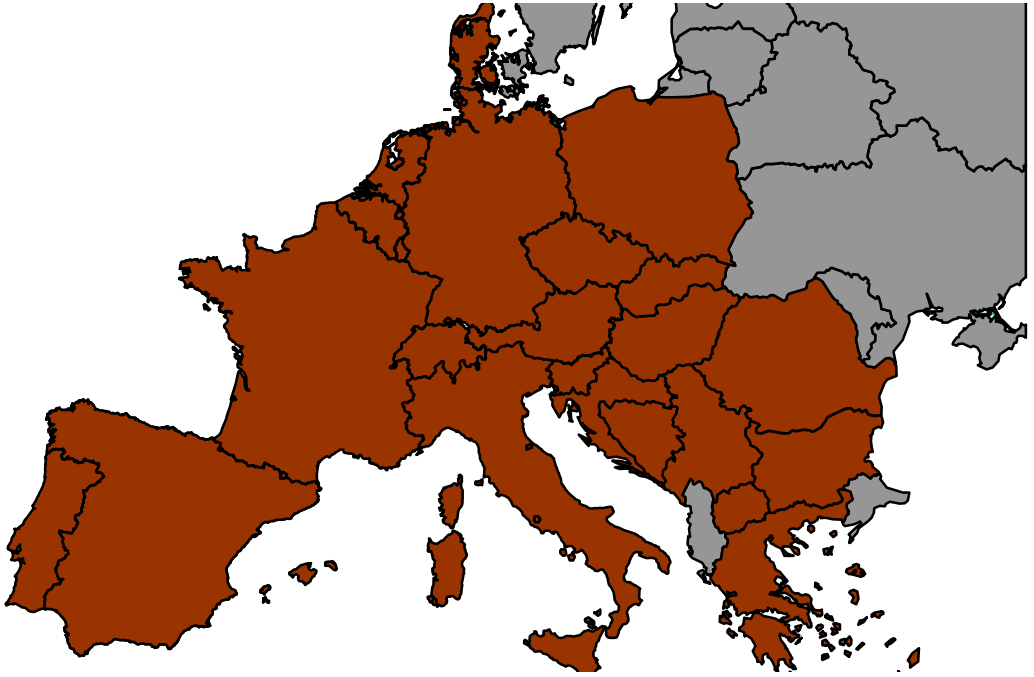
- Same logic for a wind farm with battery storage.
  - The storage time here is typically some hours only.
    - This is fine for smoothing out the wind volatility, though.



Ancillary services – 3

Capacity



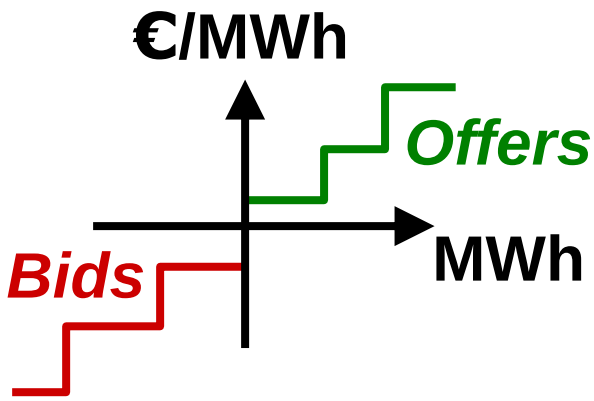


Case: Continental Europe

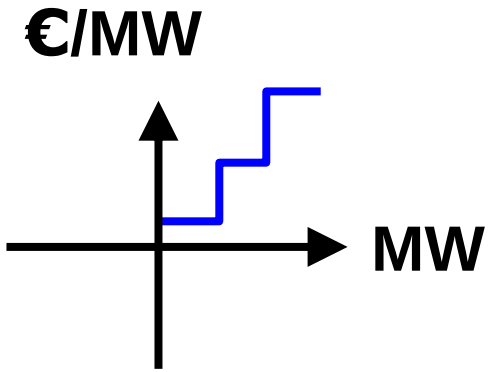
The TSOs' market for balancing <u>capacity</u>

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

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 balance between production and consumption.

Capacity bought by the TSO

Western Denmark as a case

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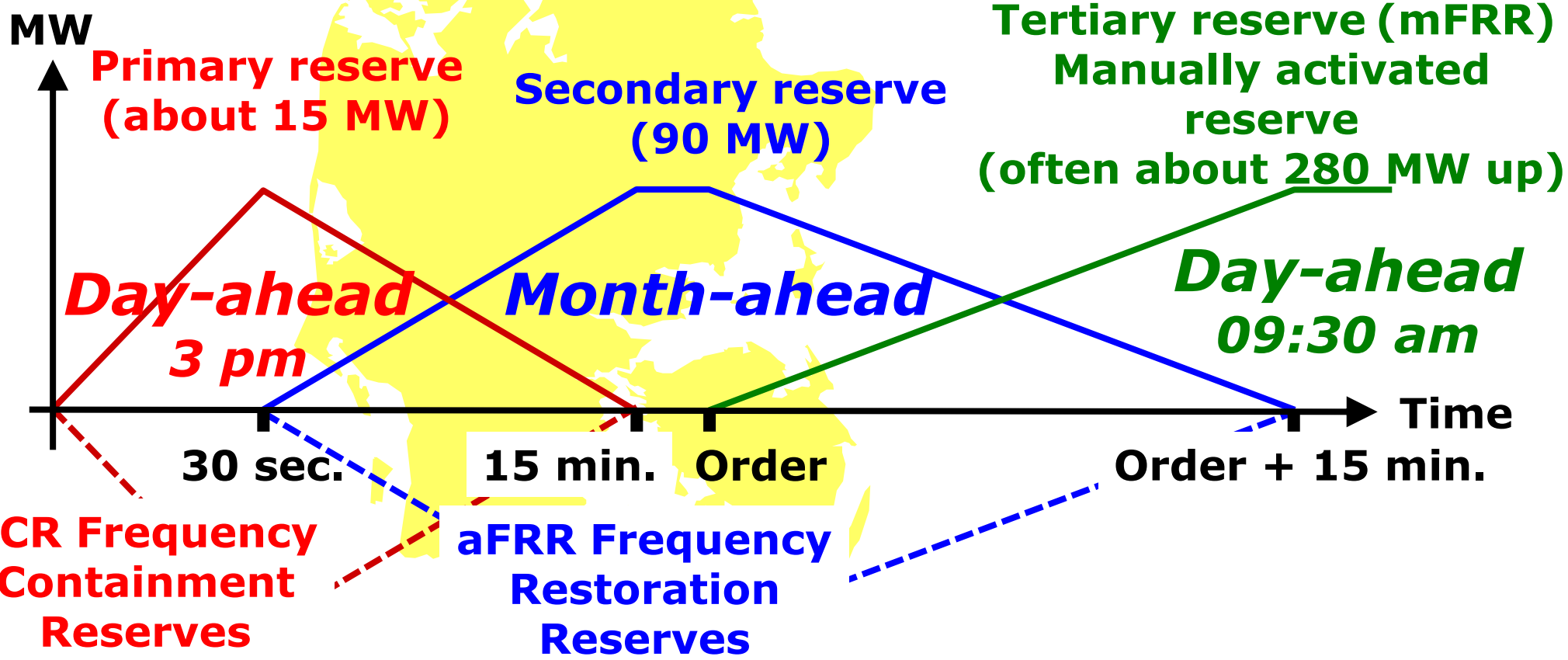
This is the UCTE system

- **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, 2019: wind turbines about 4 900 MW (!).**



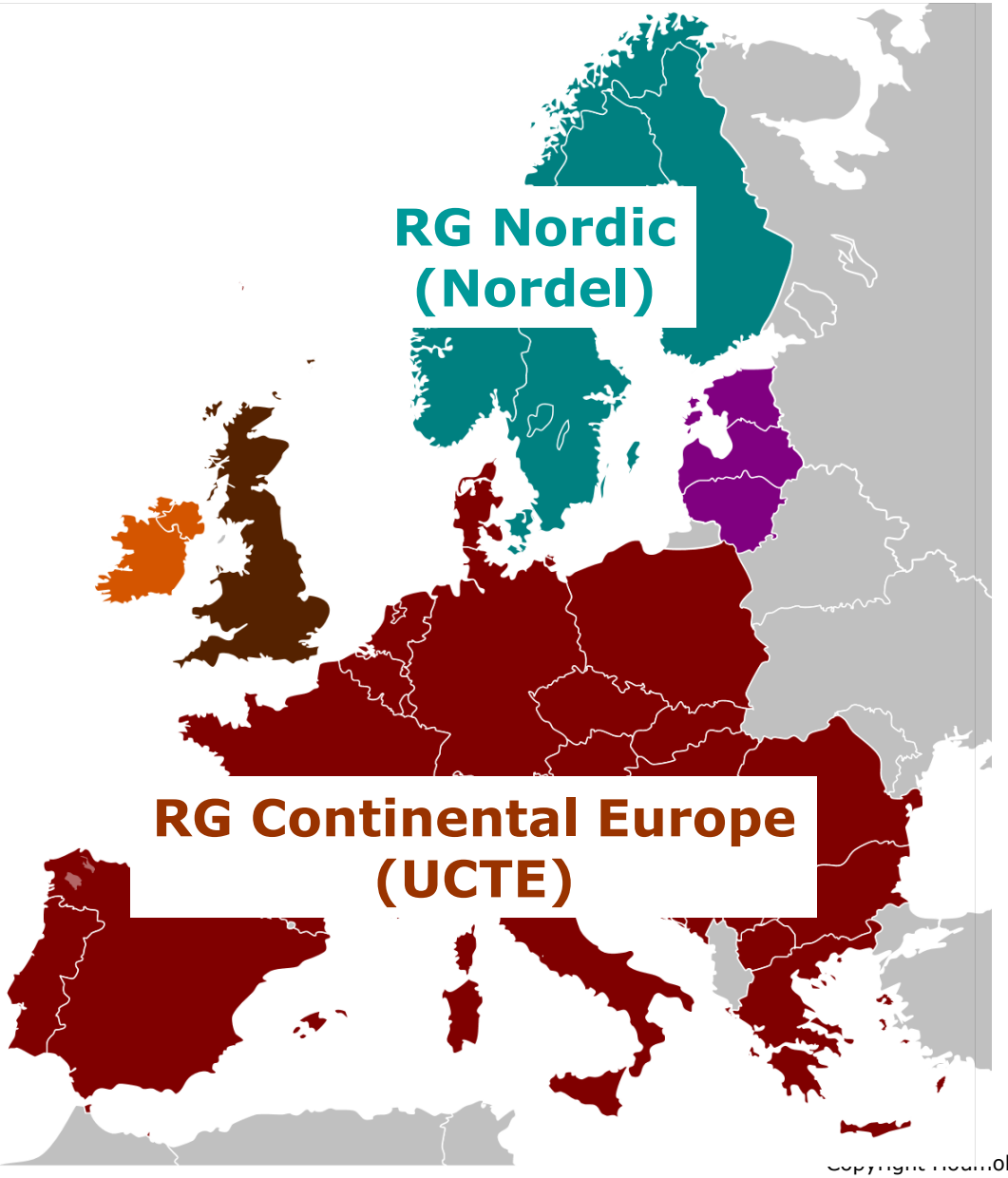
Former name: Union for the Co-ordination of Transmission of Electricity (UCTE). Today RG Continental Europe

Five synchronous grids in EU.

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

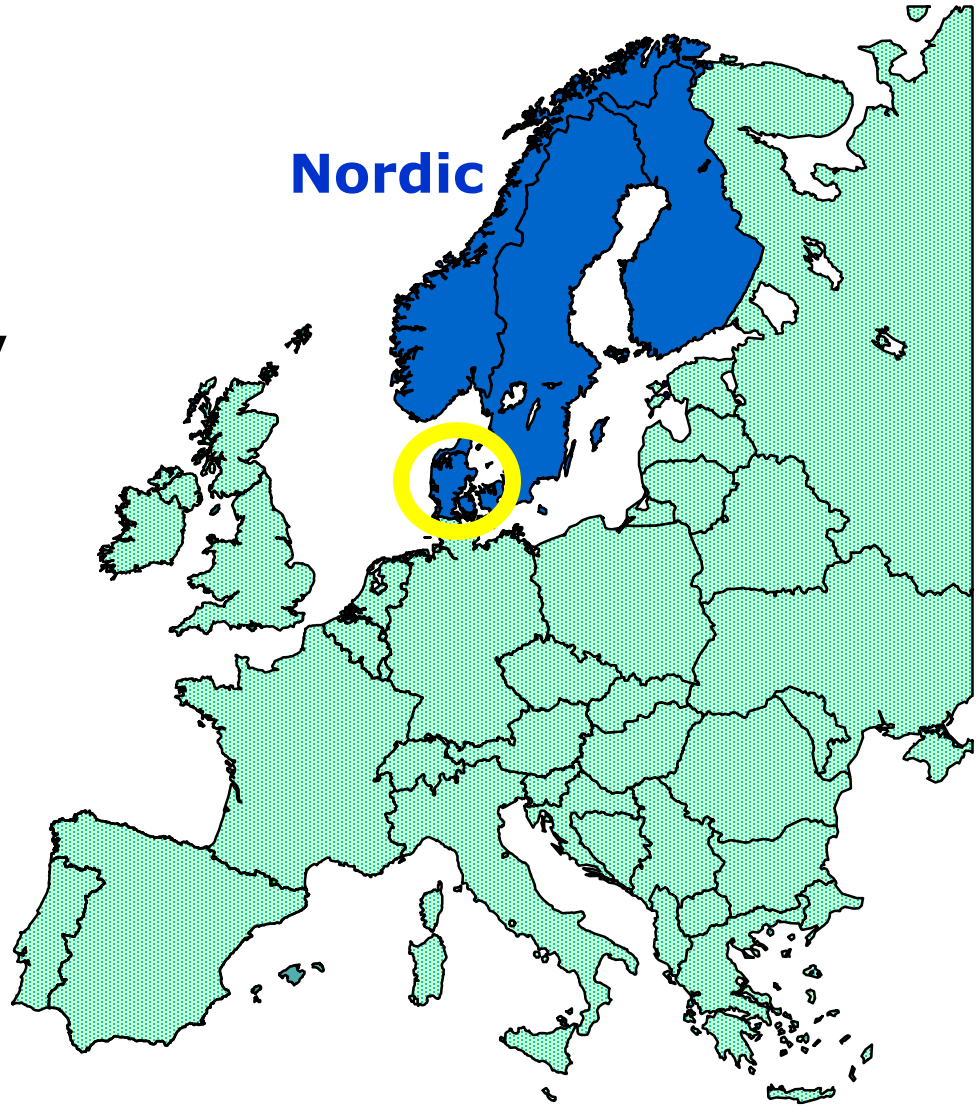
You can trade across DC interconnectors as well as across AC interconnectors

FCR in UCTE: A total of 3000 MW



Denmark as a case

- In Denmark, wind turbines produce more than 50% of the electricity.
- Question: how does the Danish TSO maintain security of supply with so much intermittent energy?
- Answer: by providing <u>price signals</u> for
  - Balancing energy.
  - Balancing capacity.
- To make this work:
  - Low entry barriers to the market.
  - Investors must have **trust**.



Portfolio managers offering ancillary services to the TSO

Smart grid

Commercial agreements

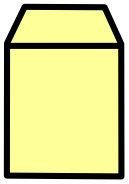
Portfolio manager: retailer or other commercial player. Aggregate small players' service offers

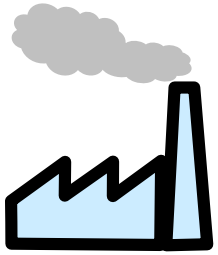
Balancing capacity: offers

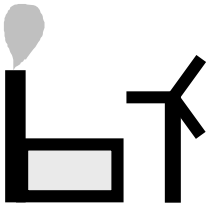
Balancing energy: bids and offers

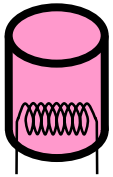
TSO. Buying balancing capacity. Buying and selling balancing energy


House-holds


Offices


Factories


Small power producers


District heating companies

Consumers and producers of electrical energy, who have the ability to change production/ consumption

Thank you for your attention!

And – in your work with the electricity market…

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