Energy Markets Operation

Dr. Athanasios Dagoumas
Ass. Professor in Energy and Resource Economics,
University of Piraeus

Definitions

Definitions

Spot price is the current market price at which an asset is bought or sold for immediate payment and delivery. i.e. day-ahead market for power market.

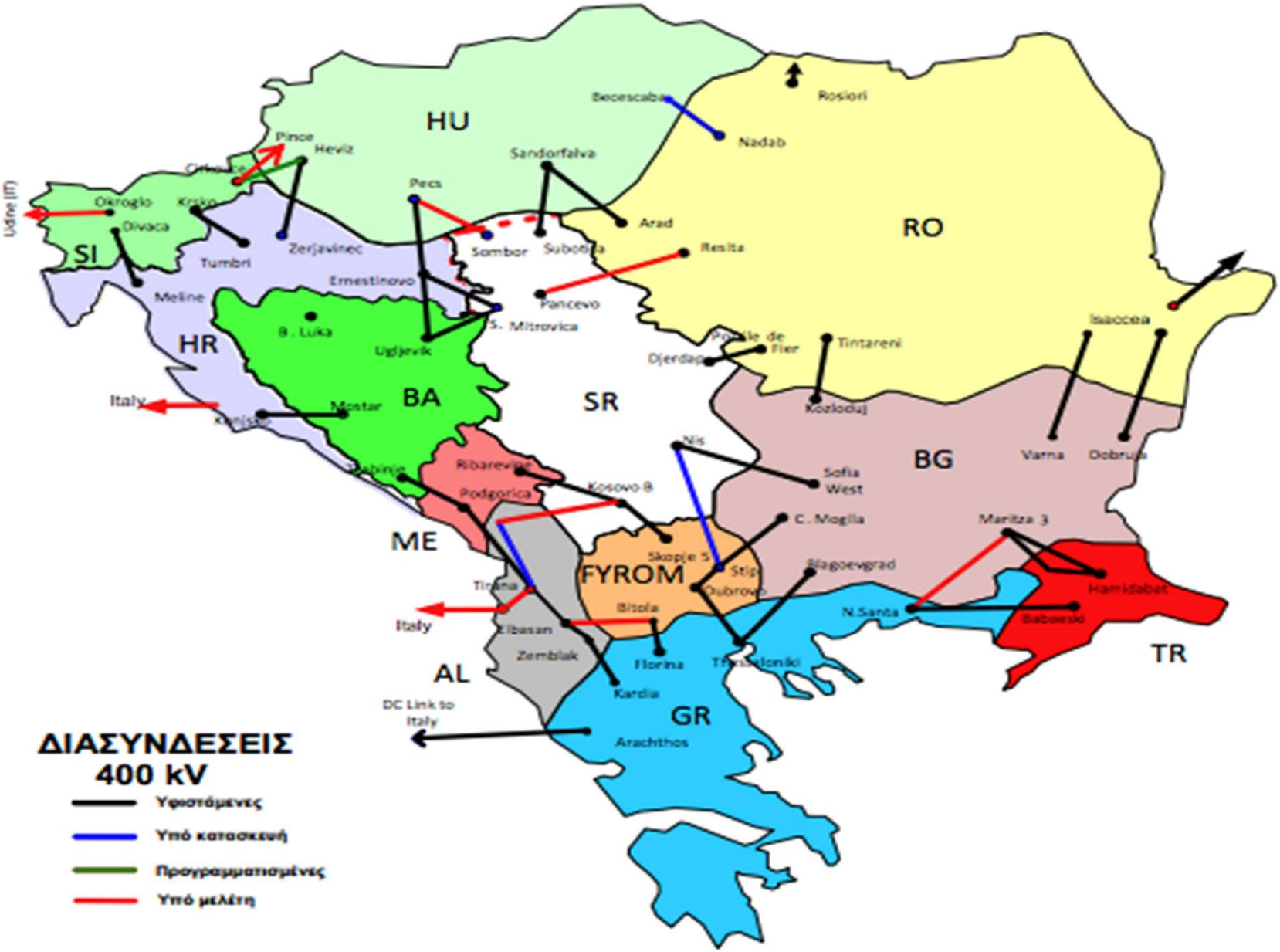
Bottleneck is a congestion point in an energy system that occurs when the capacity of this point is used at its fully capacity. This leads to different prices on the edges of the point. i.e. interconnection between Italy and Greece is used at maximum capacity, leads to different prices in the two systems.

Zone is a geographical area i.e. North Italy

Node is a point in an energy system, i.e. High Voltage Substation (to medium voltage) in Belgrade.

There is a capability for **nodal pricing** instead of **zonal pricing**, namely the existence of different spot prices in nodal level instead of zonal level. The bottleneck is the node or zone respectively.

Electricity interconnections in Balkans



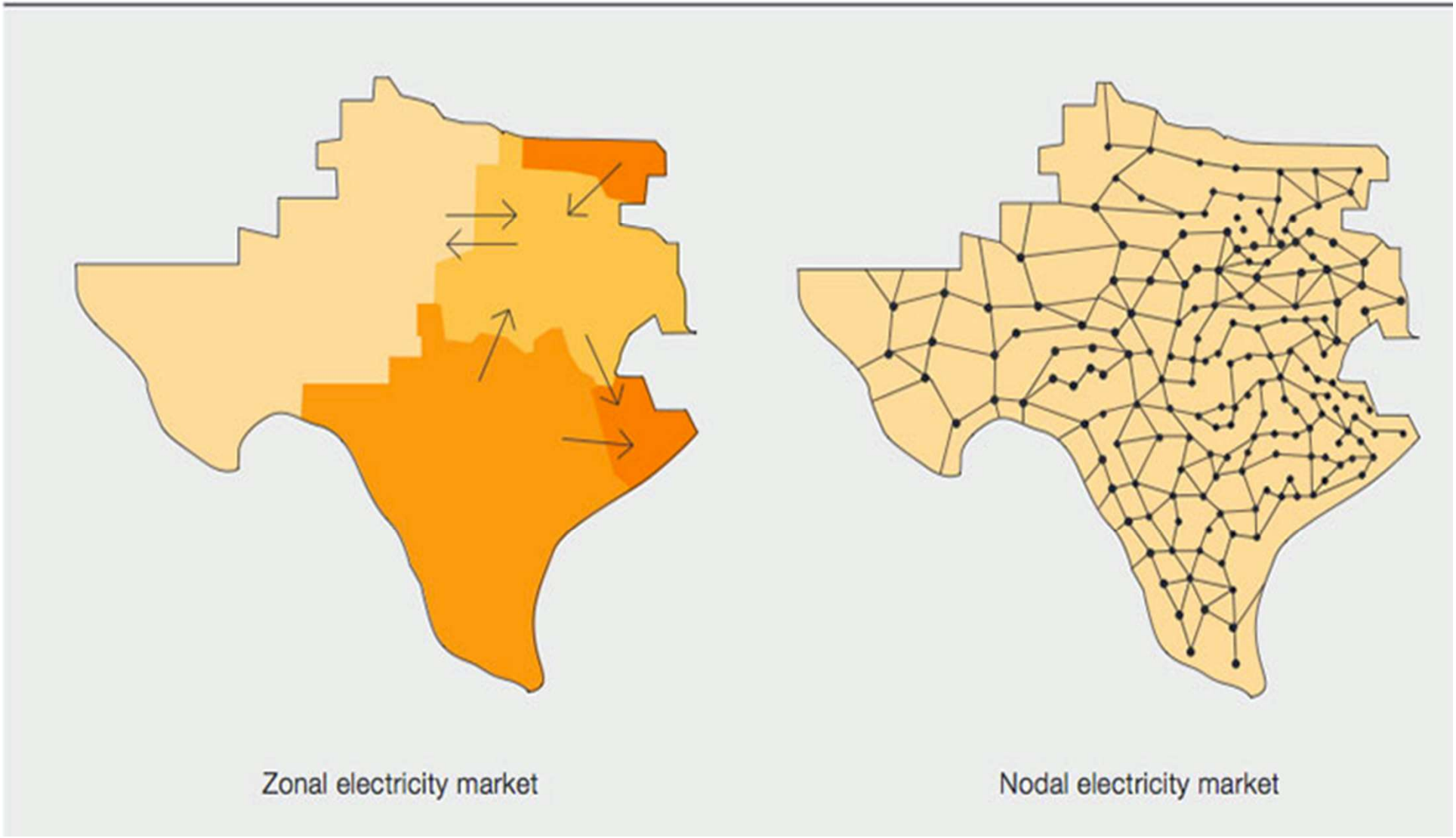
Price zones

Case: the Baltic-Nordic area

- 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.

Texas electricity market transformation

1 Zonal and nodal electricity markets



Definitions

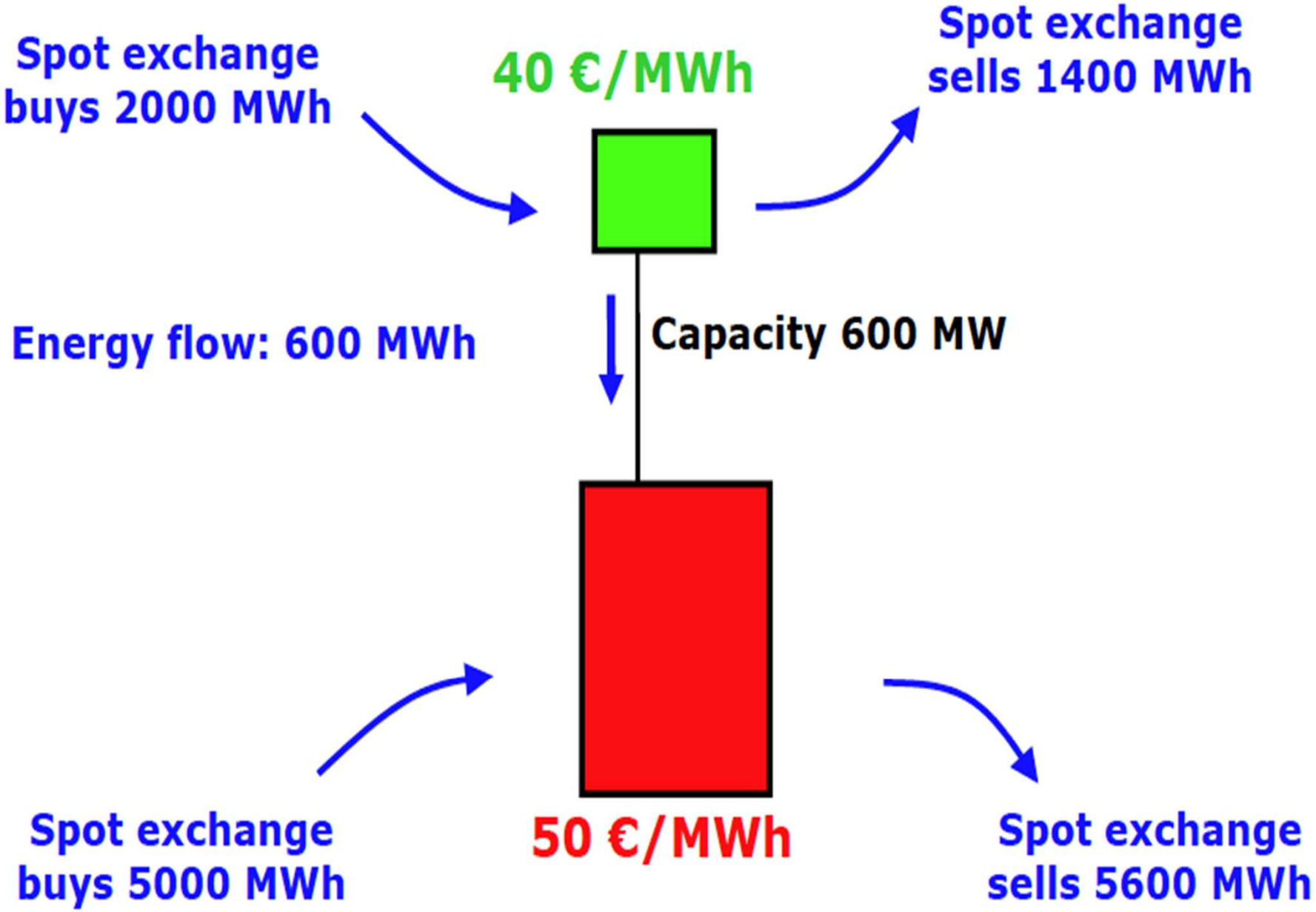
Market coupling is the price convergence among different markets, practically the distribution of energy flows between markets in order to converge their spot prices.

A similar definition is that of **market splitting**, where the difference lies on the fact that in such case the market is operated by a single energy exchange (rather than several exchanges that use the same market algorithms)

Market splitting was used in Nordpool, for the integrated operation of Scandinavian power market.

Market coupling is procedure adopted in Europe for creating an internal energy market in electricity and gas.

Market splitting/coupling – example for one hour of operation



Definitions

In **market splitting** we have **one** market operator (\or energy exchange) which determine the energy flows and energy transactions among different zones

- LAGIE for North and South system in Greece,
- Nordpool for Baltic – Nordic area.

In **market coupling** we have **two** operators (or energy exchanges) that determine the energy flows and energy transactions among different zones

- market coupling among Central Western Europe (CWE) and Baltic – Nordic area.
- market coupling among Greece Italy and Greece Bulgaria in the future

Implicit auction of the allocated transmission capacity is the way for the implementation of market coupling or market splitting.

Definitions

Implicit and/or explicit auctions are used for the grid congestion management system

Explicit auction is an auction of transmission rights at annual, monthly, daily basis, before the day-ahead market

Implicit auction is the capacity allocation in every interconnection simultaneously with the day-ahead market

Implicit auctions are preferable, as **energy flows always** from the cheaper to the more expensive market

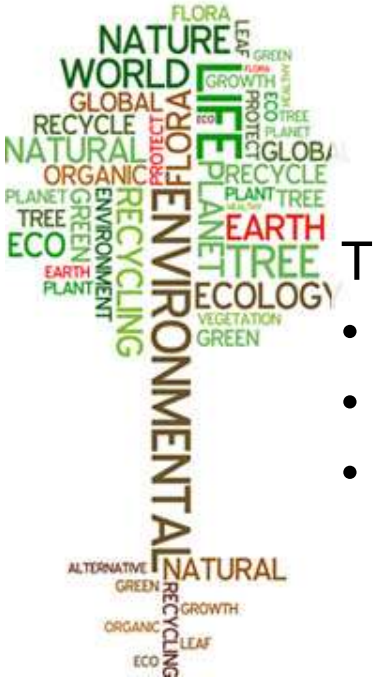
In explicit auctions it is noticed that for about 20% of the power flows in European markets takes place in not «rational» direction, namely from the expensive to the cheap market.

Definitions

Market Operator - MO, operates the energy market (i.e. power), and has extended responsibilities to supplementary tasks i.e. LAGIE in Greece is responsible for the RES compensation and Guarantees of Origin

Energy or Power eXchange - EX or PX, solves the market and estimates the energy transactions i.e. European Energy eXchange – EEX, IBEX in Bulgaria, SEEPEX in Serbia

They are companies, that can be state owned or not



The markets they operate are:

- Day-ahead market
- Intra-day market)
- Forward markets and derivatives

Ορισμοί

Clearing is the clearing of the market, in practice it is the determination of the quantities and amounts purchased or sold by each Market Participant

Settlement is the market settlement, in practice it is the delivery and payment of the relevant obligations

- Physical settlement = product delivery
- Financial settlement

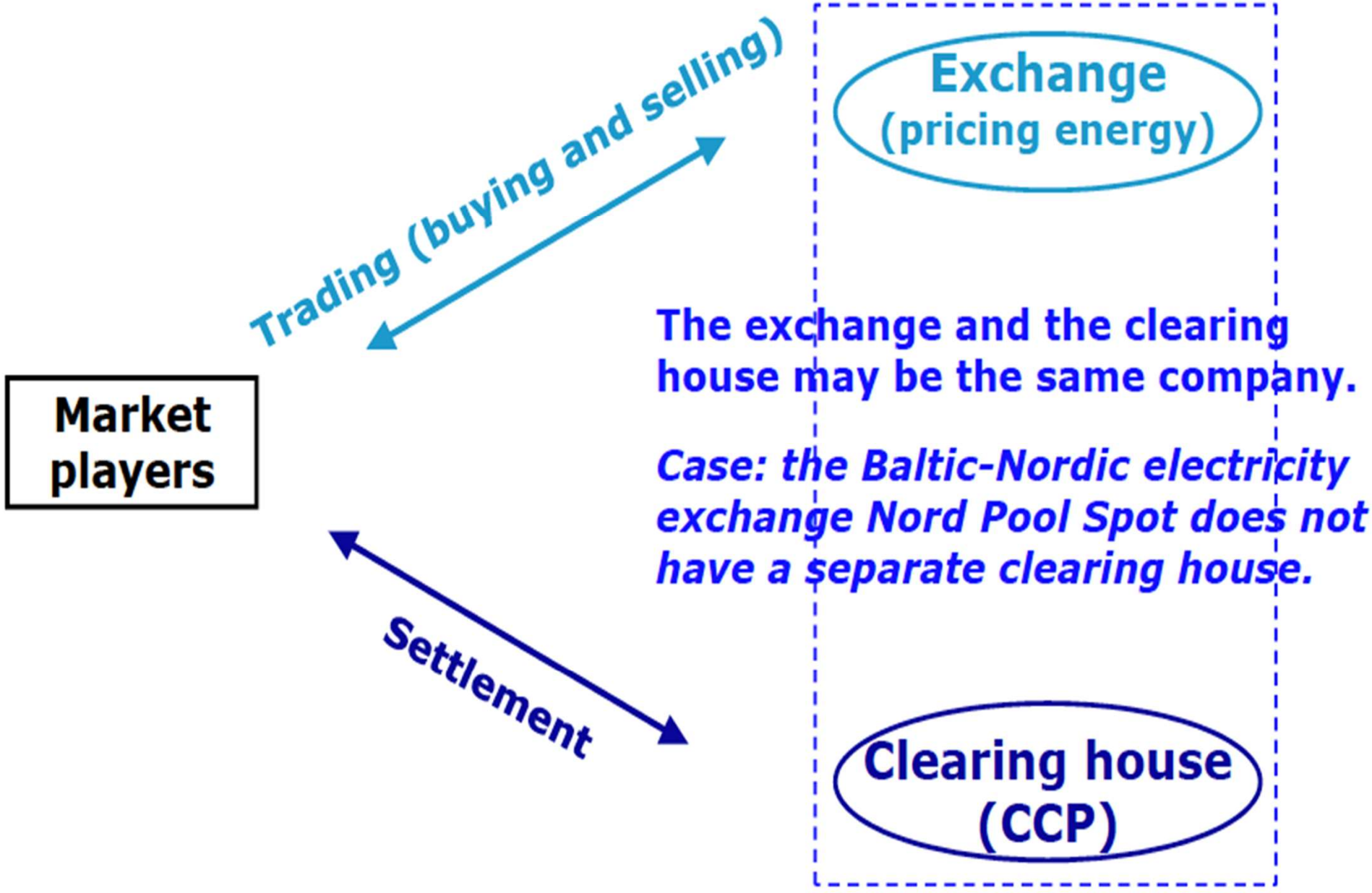
Clearing House, i.e. European Clearing House – ECC

has the responsibilities of both clearing and settlement, issues the relevant invoices and additionally offers margining and financial risk coverage for market participants (guarantees for participation).

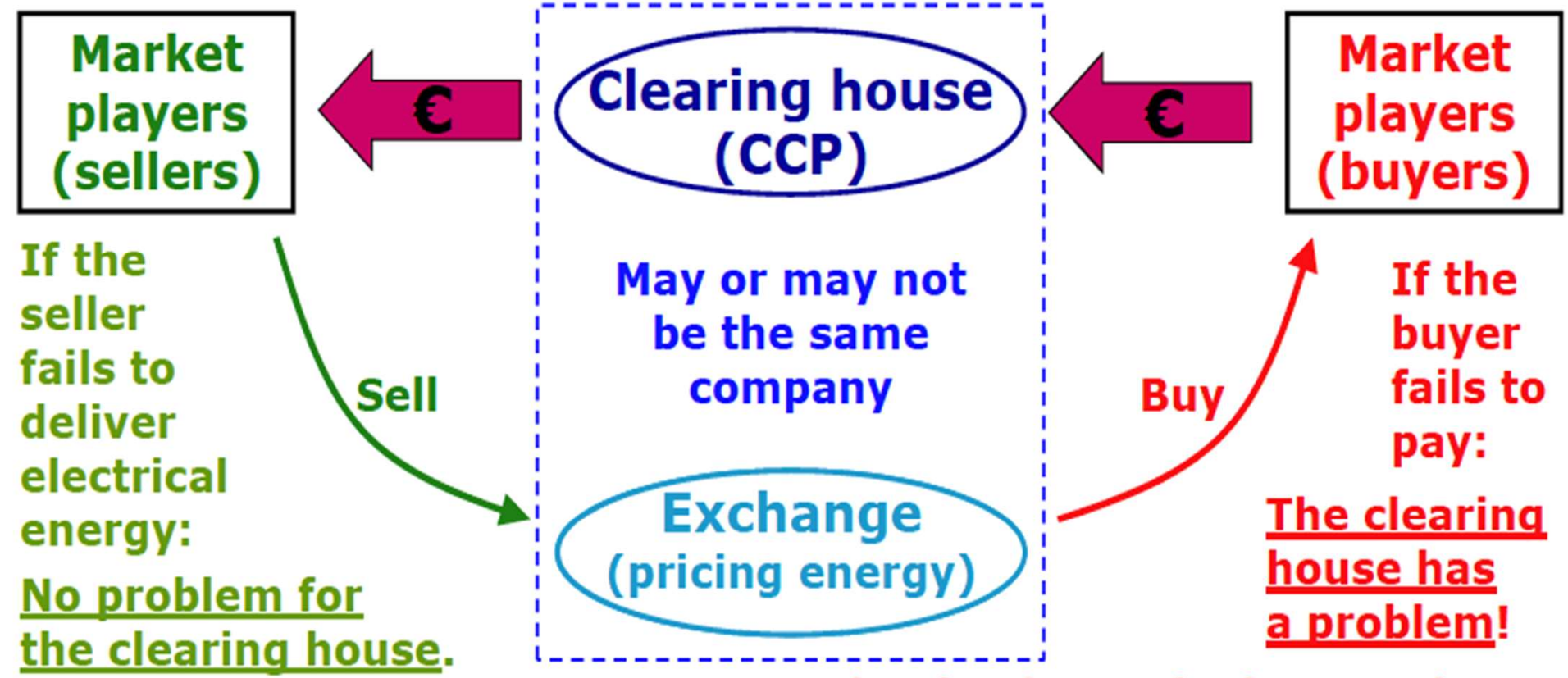
Payments are made at specific times, e.g. 20:00 CET for business days (TARGET2)

The ECC offers margin to the Market Participants in their transactions

Clearing House



Clearing House



Clearing House

The settlement

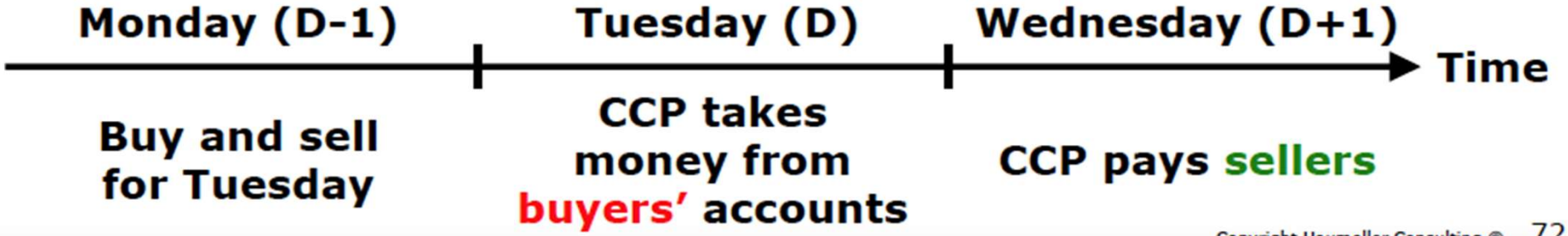
Case: Nord Pool Spot's settlement of spot trading

The Day of Operation (D) is the day, where the energy is produced and consumed.

Assume D is Tuesday.

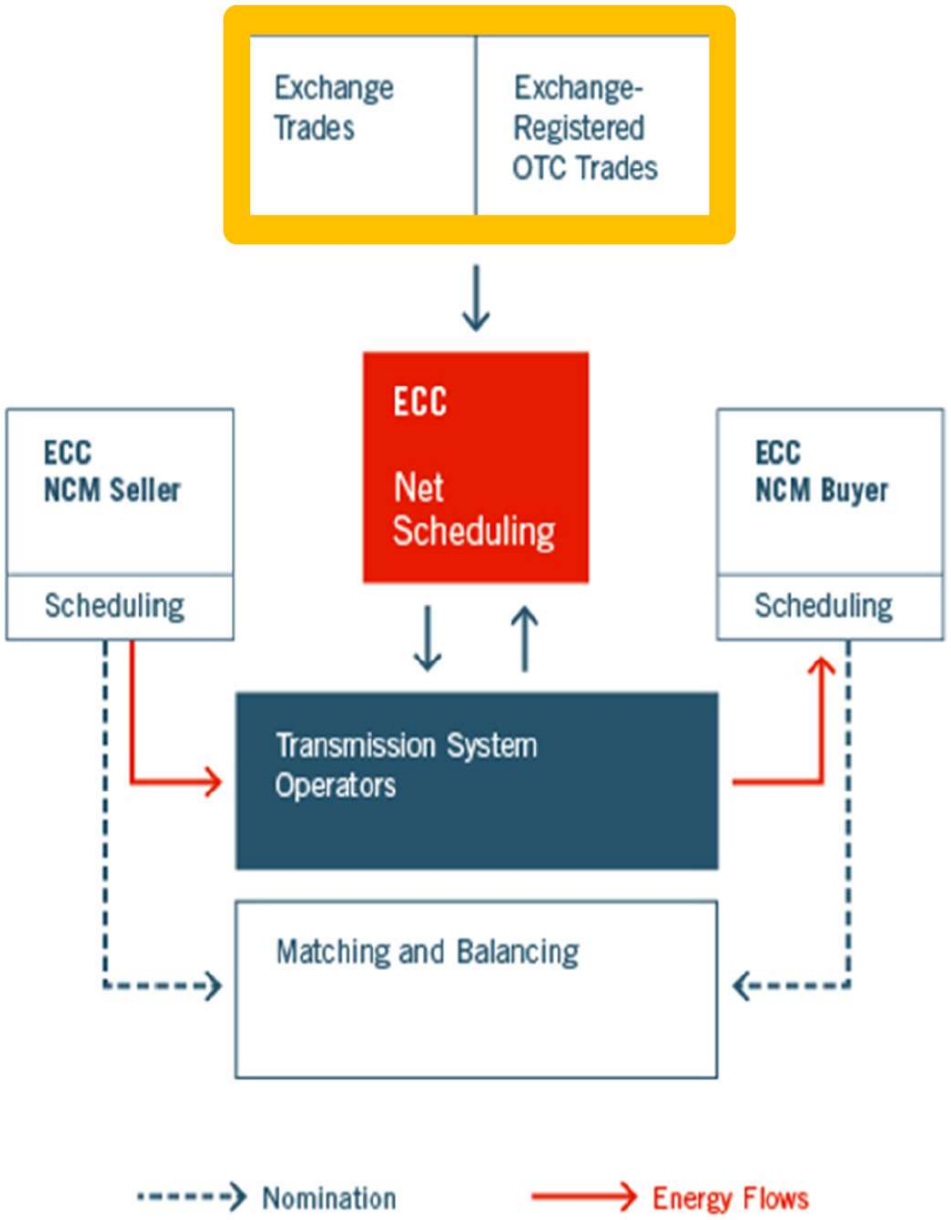
In this case, the energy was traded at the exchange Monday.

CCP has authority to take money from the players' accounts



Clearing House

Physical Settlement
www.ecc.de



Market types

Power markets are differentiated:

A. If the **dispatch of power plants** is done centrally or by each participant (eg ADMIE or PPC itself determines which PPC units will work)

B. To the extent of **bilateral contracts**

Central dispatch

Energy Exchanges: Nordpool, Australia, California (old design), Spain, Poland, Ontario

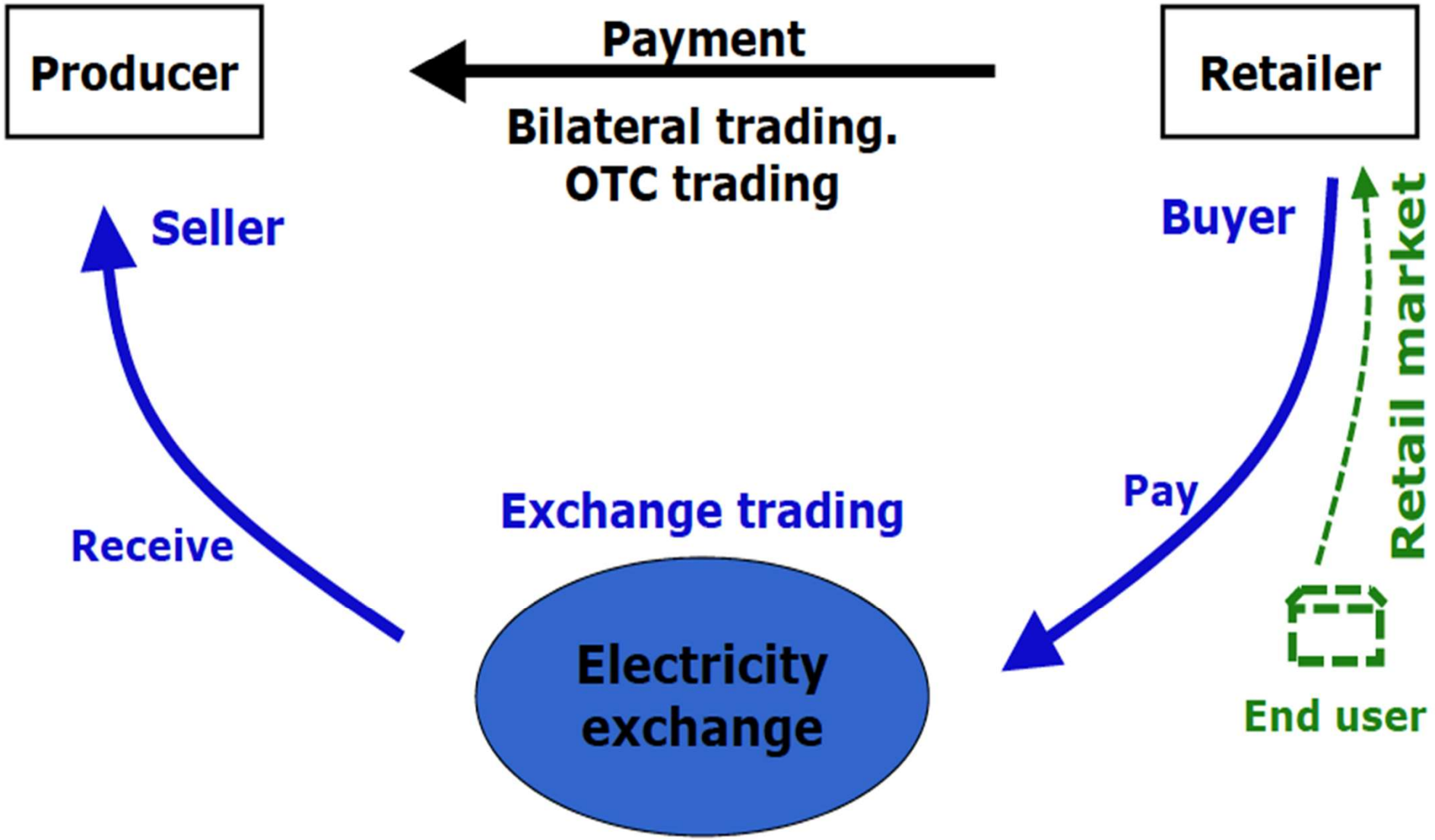
Mandatory Pools: Britain (until 2001), various markets in the USA, Greece, Chile, Alberta, Argentina, Columbia, Singapore

Self-dispatch

Bilateral contracts 100%: Britain (since 2001)

Bifurcated markets: NY, PJM 60% Self-scheduled – 40% Dispatched voluntarily

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



Basic Differences

Energy exchanges:

- Simple hourly orders (offers and declarations) of price and quantity
- Simple, common rules
- Voluntary basis

Mandatory Pool:

- Complex offers (tecno-economic data)
- Complicated algorithm flor the unit commitment
- It can be combined with co-optimization of power and ancillary services
- Mandatory participation

Risk management in energy markets

Financial products

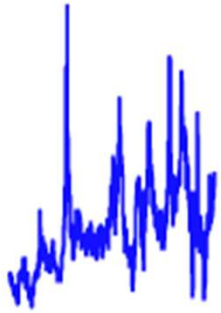
What is the reason of existence of financial products and derivatives?

To hedge against changes in the spot market of the energy product and to risk management

Retailer's need for hedging

Originates from end users requesting fixed prices

Whole-sale market



Retailer needs hedging

R

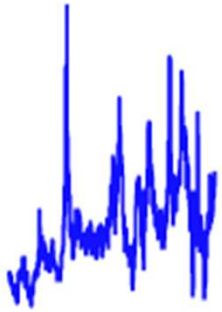
Retailer must provide fixed price

End user requesting fixed price
(eg, fixed price for the next calendar year)

Producer's need for hedging

Originates from the risk of low prices

Whole-sale market



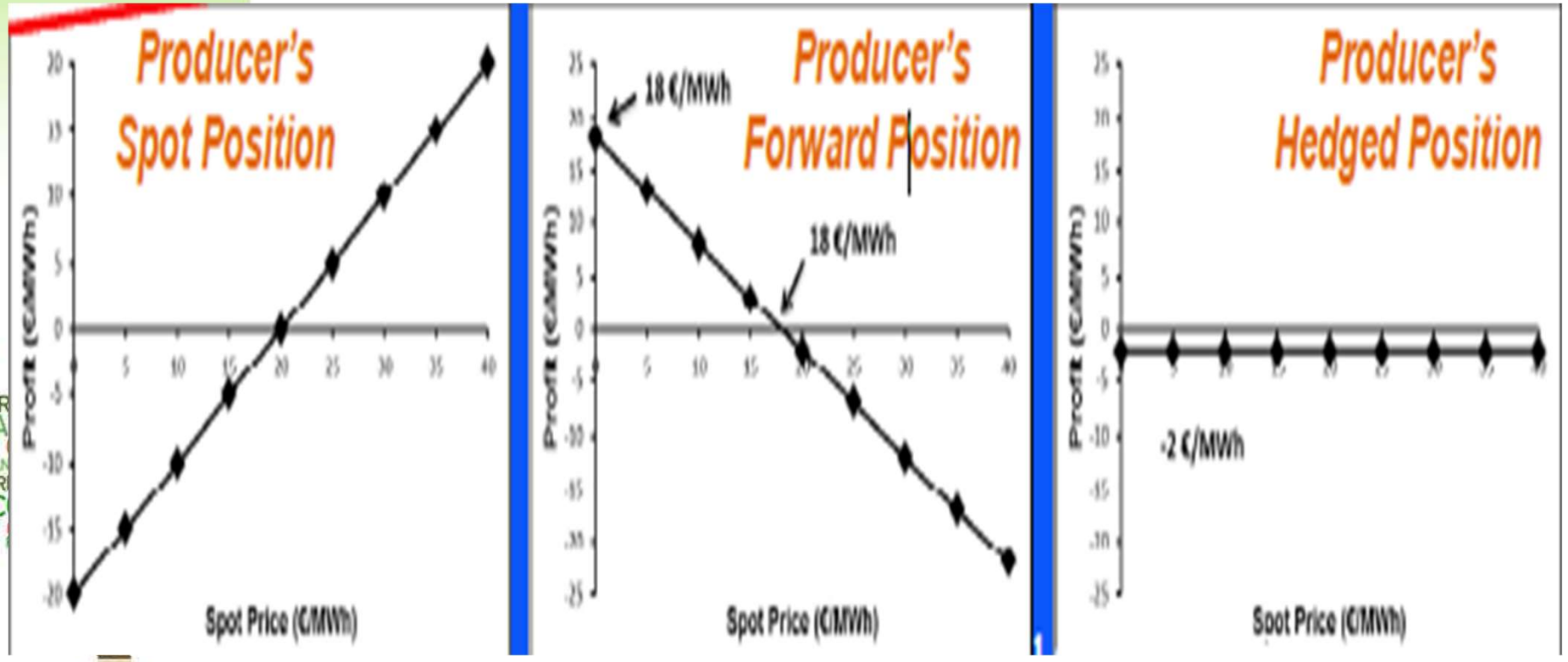
Producer needs hedging

P

Producer has many fixed costs

Pay for the investment in power plants
and pay for other fixed costs

Risk management for a producer



Financial products

How a financial contract operates?

A **producer and retailer** sign a financial contract for 1000 MWh for January in price of **50 €/MWh**.

Scanrios:

- If the spot price is **52 €/MWh**, then the **producer pays the retailer 2 €/MWh**
- If the spot price is **48 €/MWh**, then the **retailer pays the producer 2 €/MWh**
- If the spot price is 50 €/MWh, then there is no extra transaction.

In fact **a risk management of the spot market** evolution has taken place, as its result **does not affect their total transactions**. Both the producer and retailer will sell/buy energy at the price of **50 €/MWh**

Financial products

In fact, a retailer when approached by a consumer suggests a sale price e.g. 52 € / MWh

Therefore, if the retailer is satisfied with a profit of 2 € / MWh, then if a financial contract with a producer is closed at 50 € / MWh he has zero risk from the spot market.

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

<u>The retailer will first look to close a financial contract with a producer!</u>

Because of the financial contract the retailer can buy in the spot market without risk, otherwise <u>the participation of the retailers in the spot market would be more limited</u>.

Financial products

For a retailer, risk management is needed for several cases:

1. A **retailer without production plants** wants a financial contract to operate without risk.

2. **Vertically integrated company with its own production**. The goal here is have similar production and consumption volumes, so as to by-pass the spot market.

3. Retailer that hedges risk through **energy trading in interconnections**.

Typically, retailers are a combination of the above.

Financial products

A further option for the retailers is the **transfer the risk to the final consumers**.

- With **clauses that are activated under certain market circumstances**
  - i.e. if spot market is above 50 €/MWh, the consumer pays the difference.
  - i.e. if the cost from the wholesale market supplementary mechanisms (Capacity markets…) are above 10 €/MWh, ο καταναλωτής πληρώνει τη διαφορά.

This is not preferable, as the special clauses are not popular for the final consumers.

QUERY: do we need all these?

YES, because **without competition among retailers** in liberallized markets, the prices for the final consumers will not be decreased.

Financial products

Similarly, **producers need their own financial contracts** to protect themselves from **low spot market prices** (which is very common now because of the penetration of reneables)

QUERY: And the spot market then what does it need?

It is necessary because it gives a **price signal** of the market on which the financial contracts are based!

And ultimately, affect the formation of the retailers' contracts to final consumers.

The spot and the financial market are interdependent and interdependent!

Financial products

What are the financial products that are offered?

The simple is to make a **bilateral contract between producer and supplier** (**<u>Over The Counter - OTC</u>**).

However, for the sake of transparency and better pricing,

Financial products are auctioned on energy exchanges (futures, forwards).

Products are **<u>structured on the basis of risk-hedging needs</u>**.

But they can not satisfy all the needs, for example if the retailer finds a customer with a specific consumption profile, it is extremely difficult to precisely provide the same financial derivative.

Financial products

Also, the products must have **liquidity**, so practically few products are built.

They are usually distinguished based on the **hours related** to:

- **Base-load products (eg 24 hours a day)**
- **Peak-load products (eg at times 19-21)**

Their **duration** from the time of their auction:

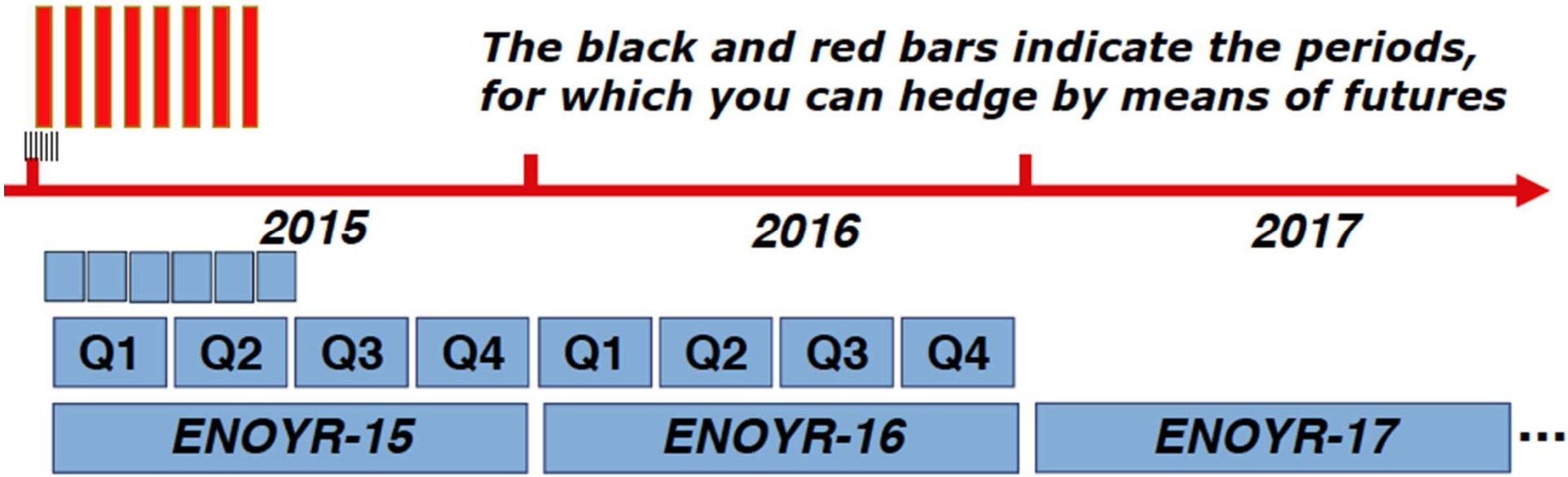
- Days or weeks
- Quarterly, semester or yearly

Financial products

8 nearest weeks

Futures: Days and weeks

The black and red bars indicate the periods, for which you can hedge by means of futures



Forwards: Months, quarters and years

6 nearest months

The quarters in the nearest two years

10 nearest calendar years

The blue rectangles indicate the periods, for which you can hedge by means of forwards

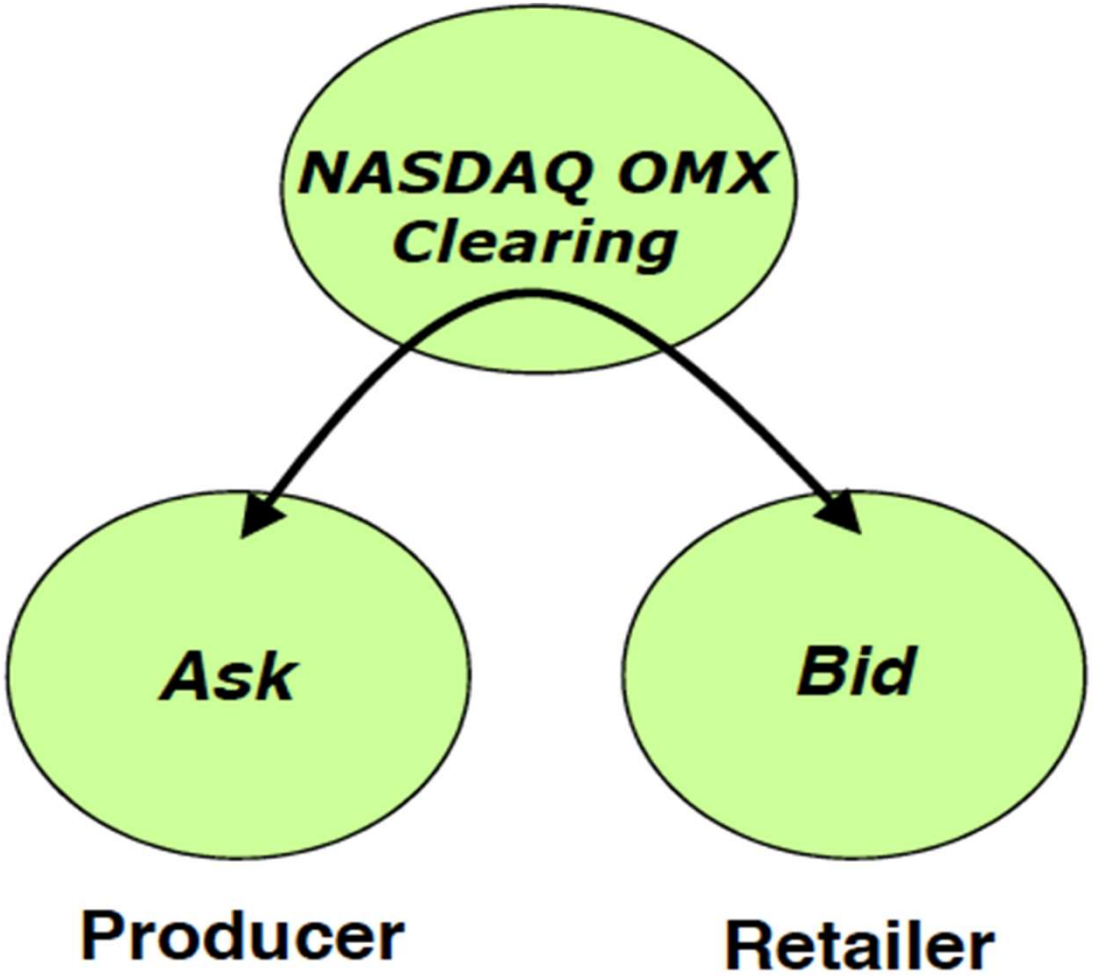
Financial products

In contradiction with the spot market, the auctioning of financial products is **continuous trading**, that is all the working hours of an energy exchange.

How does it work?

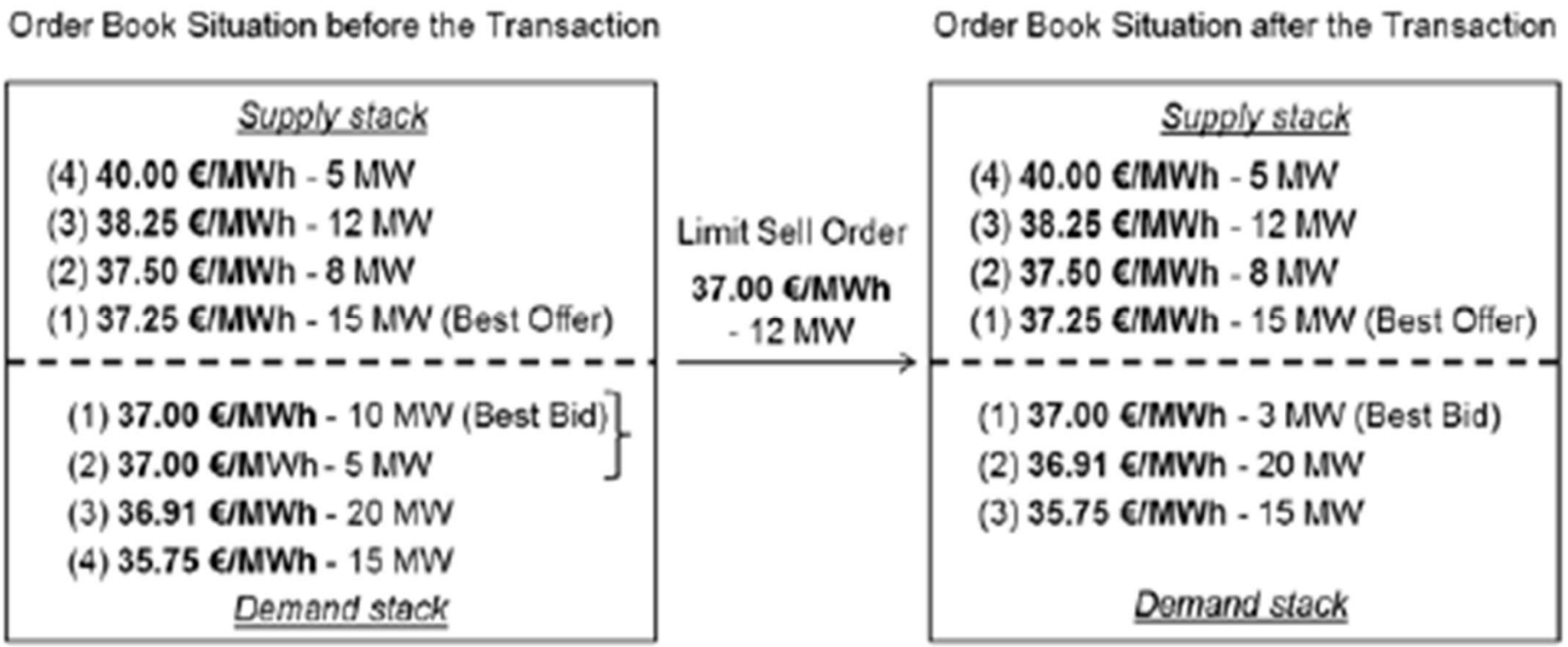
- A **producer offers quantity and price for a product on the energy exchange**, e.g. Nasdaq OMX (the Nordic financial exchange) at a price
- The **retailer submits an offer** (quantity and price) for this product and if it meets the price of the producer buying it.
- If the original offers of the producers and suppliers do not find an agreement, **they adjust their bids until a match is reached**

Financial product



The producer has Ask position & the retailer Bid position

Financial products



Tenders are distributed (**descending for producers, ascending for retailers**) and there is agreement for 12 MW at price of 37€ MWh.

In the right box, the remaining bids are **shuffled after this transaction**. Should a participant adjust its offer to make an agreement.

Financial products

A very important prerequisite for the orderly functioning of the financial product market is the existence of a **reliable spot price**.

The combination of a "reliable" spot market and a financial contract replaces a bilateral long-term contract.

Risk management is evident in any case

Case: a retailer has sold electricity to a customer for 2014 at a fixed price of 42 EUR/MWh.
The customer's expected consumption is 100 MWh

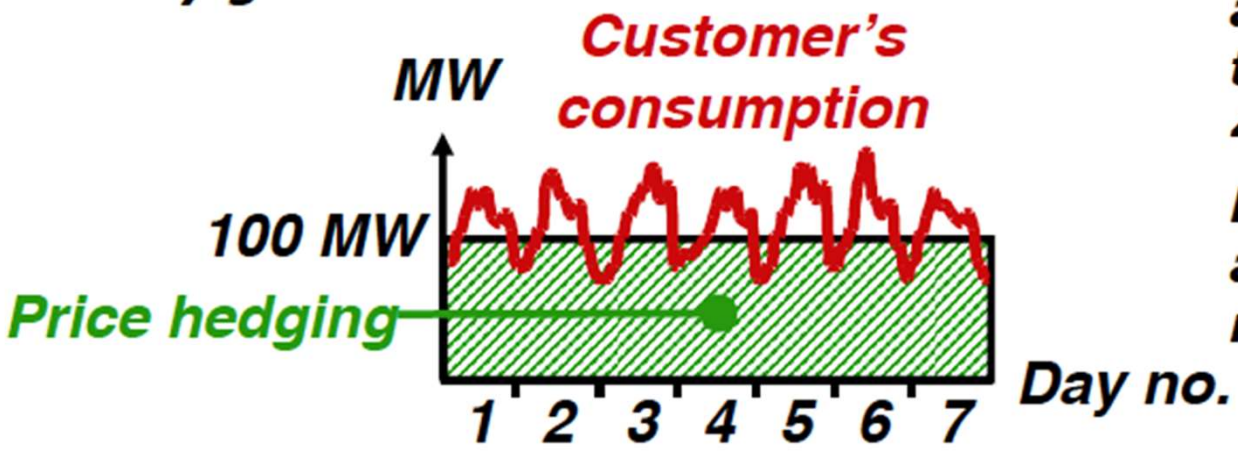
The customer's consumption profile is <u>not</u> flat!

The customers' consumption is high when the spot price is high.

The hedging is done according to a flat profile, however

When the financial contracts are settled, it's done according to the simple average of the spot price.

For any given week:



Example: the simple average may be equal to the hedging price of 40 EUR/MWh.

However, the retailer's average purchase price may be 44 EUR/MWh!

Case: Transformation of the Greek wholesale power market

Greek wholesale power market

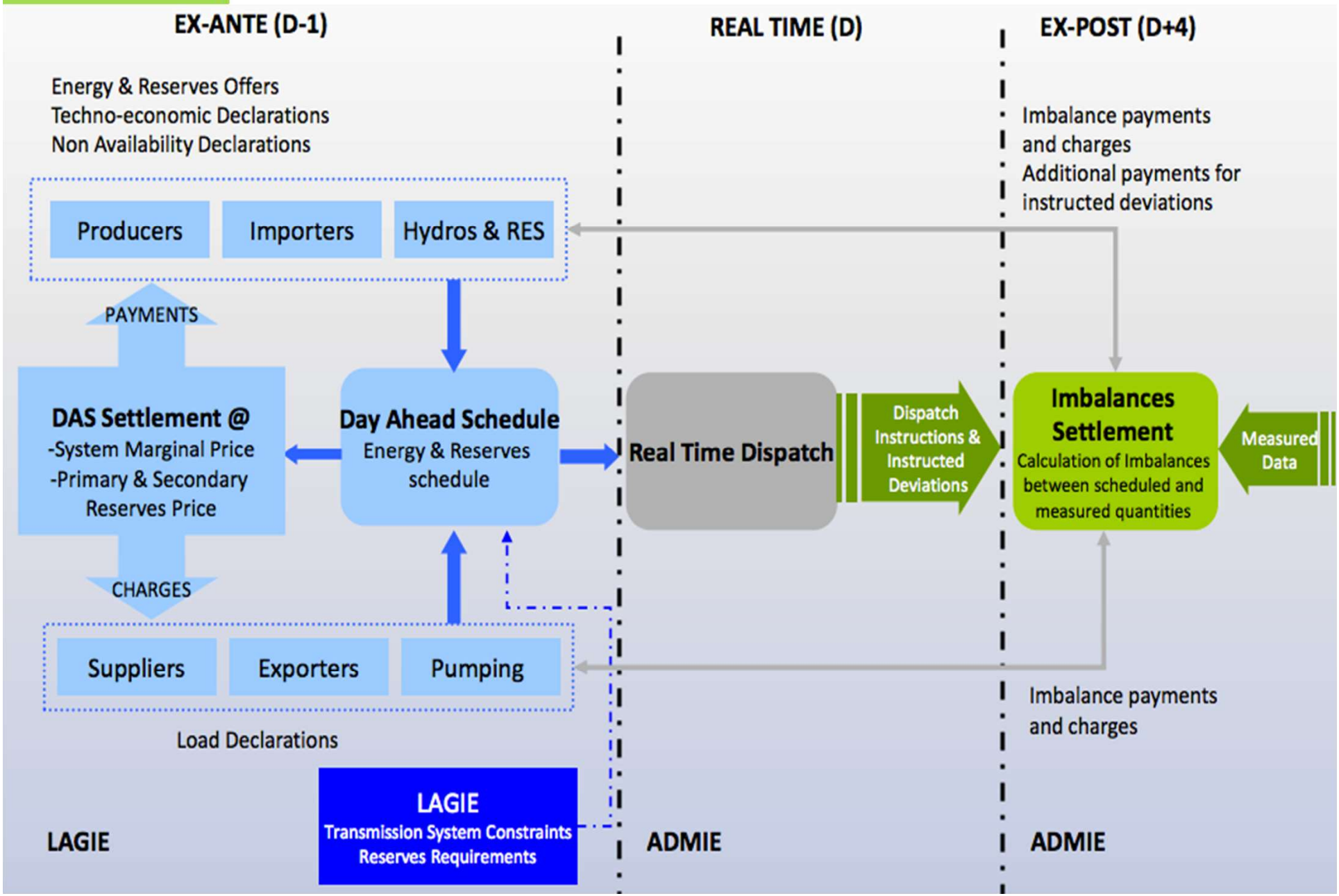
consists of two distinct markets:

- **Long-term Capacity Market**
- **Short-term Wholesale Market for Energy and Ancillary Services,**

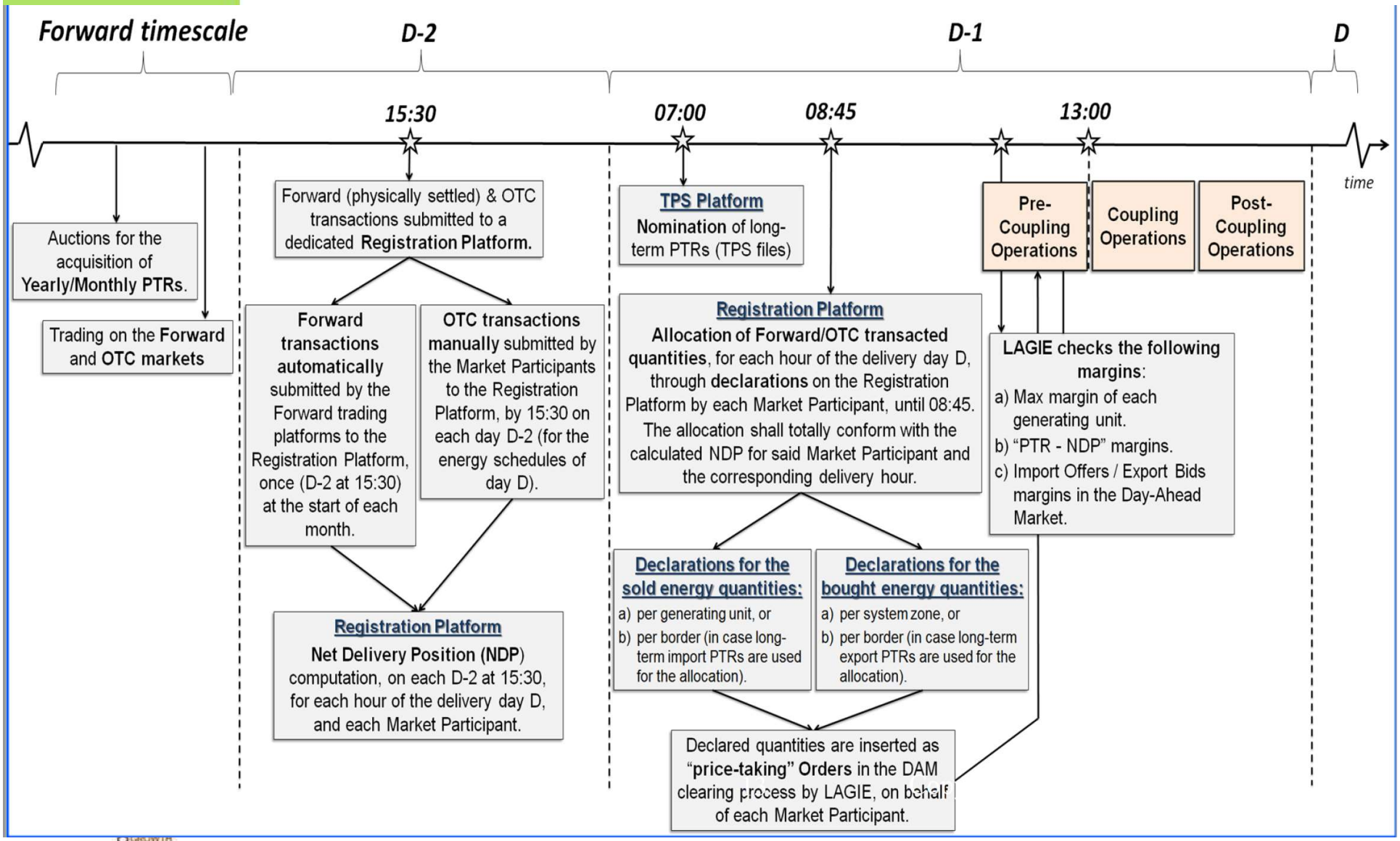
It also includes the **acquisition of Physical Transmission Rights (PTR) - explicit auctions**

to serve cross-border exchanges with all the interconnected countries: Italy, Albania, FYROM, Bulgaria and Turkey

Greek wholesale power market

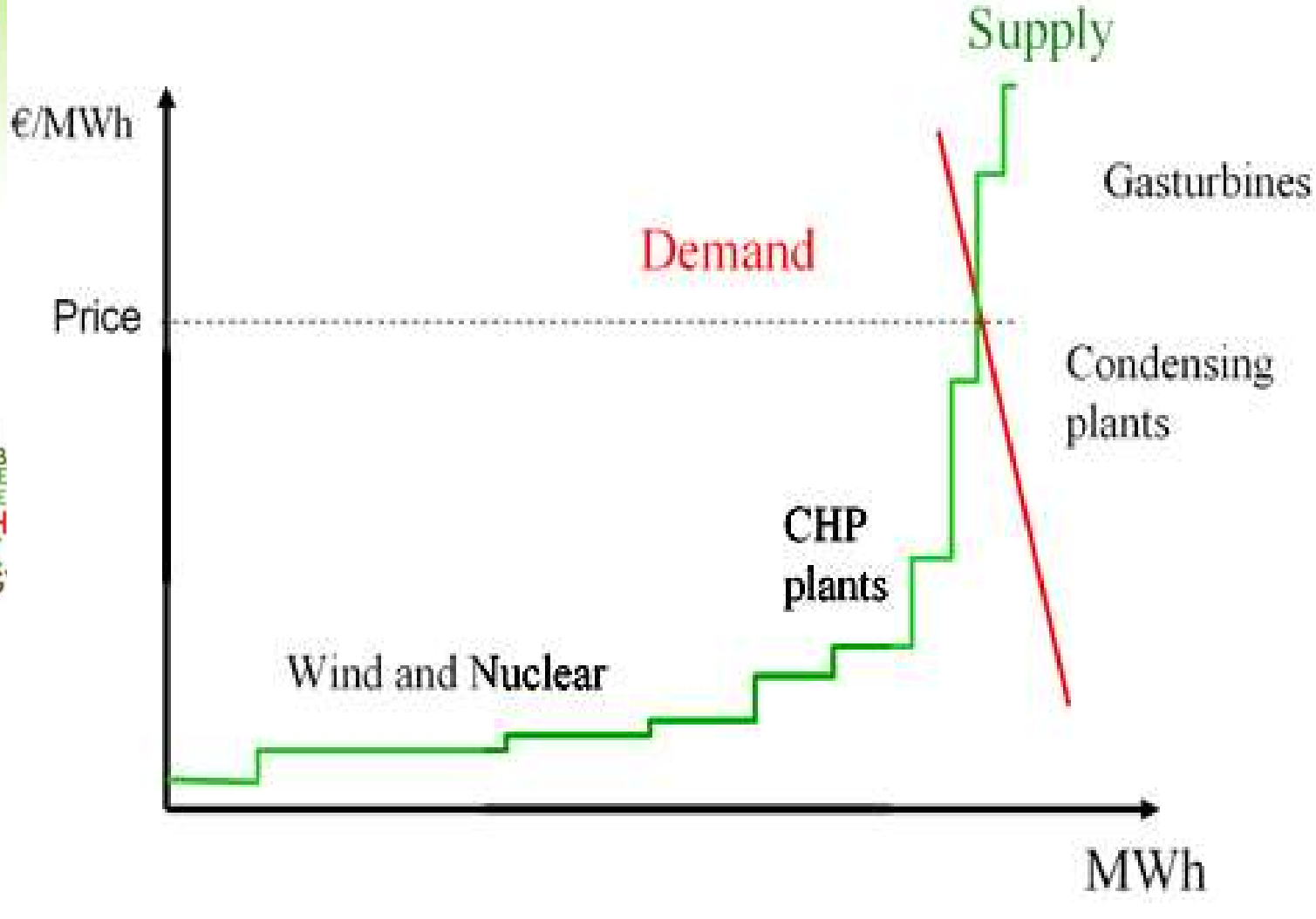


Daily Energy Scheduling



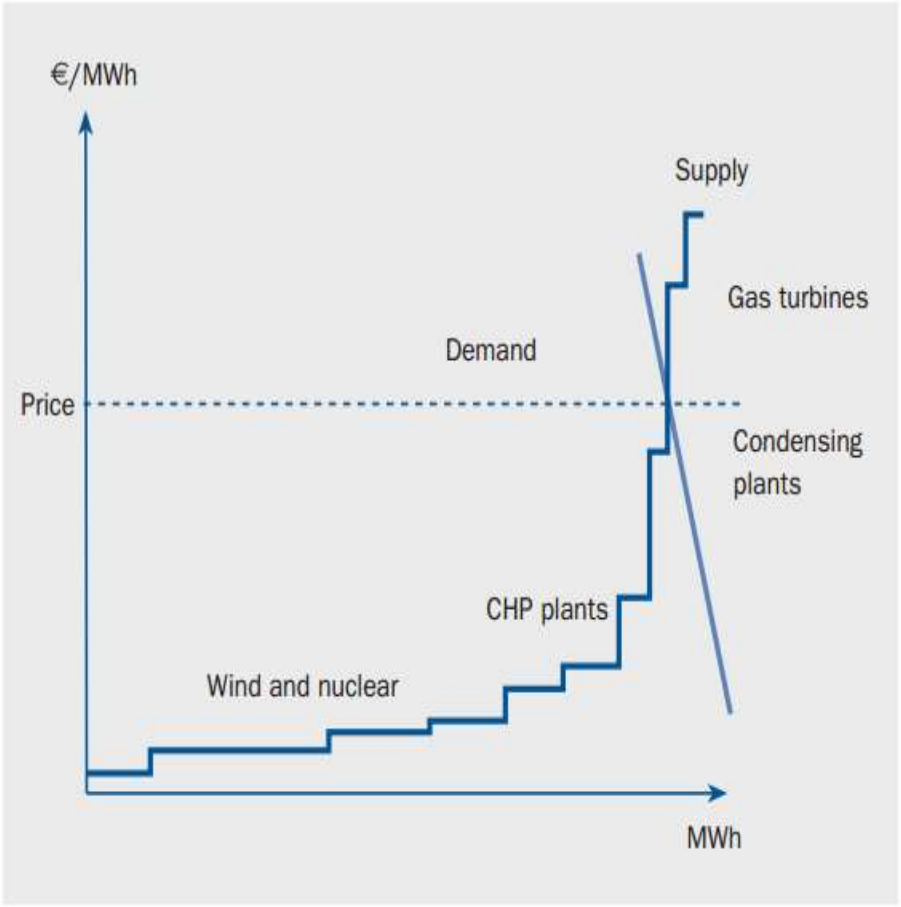
Source: ECCO, 2017

Supply and demand curve



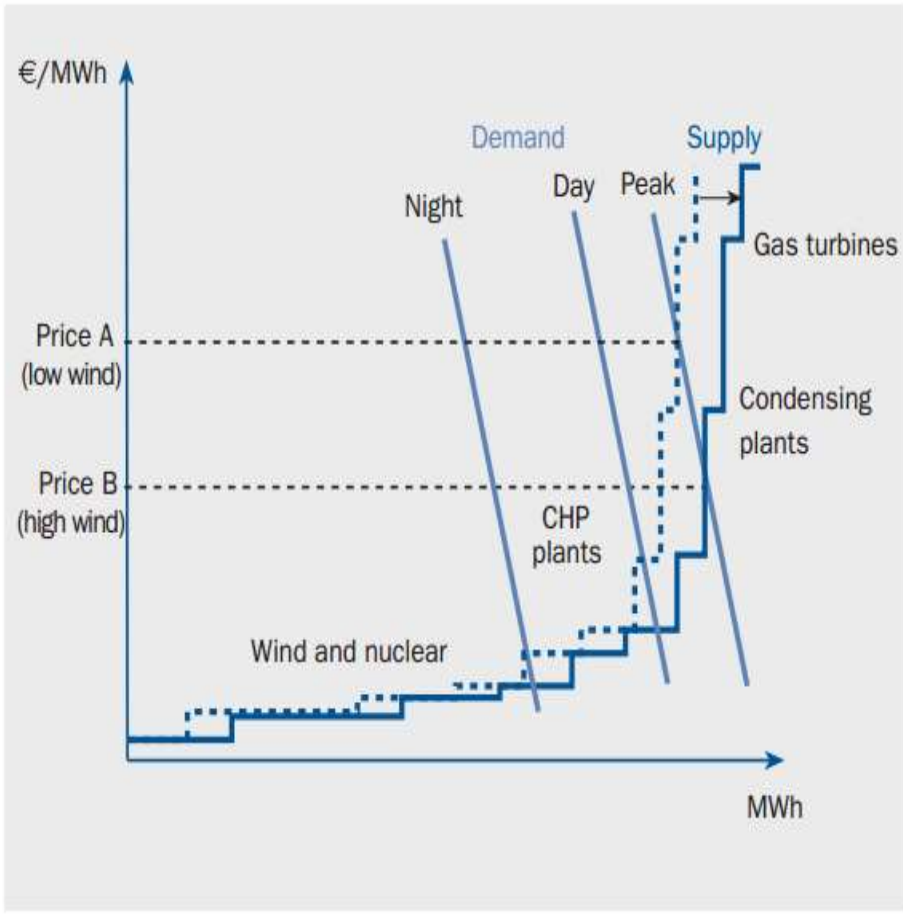
Supply and demand curve

FIGURE 0.10: **Supply and Demand Curve for the NordPool Power Exchange**



Source: Risø DTU

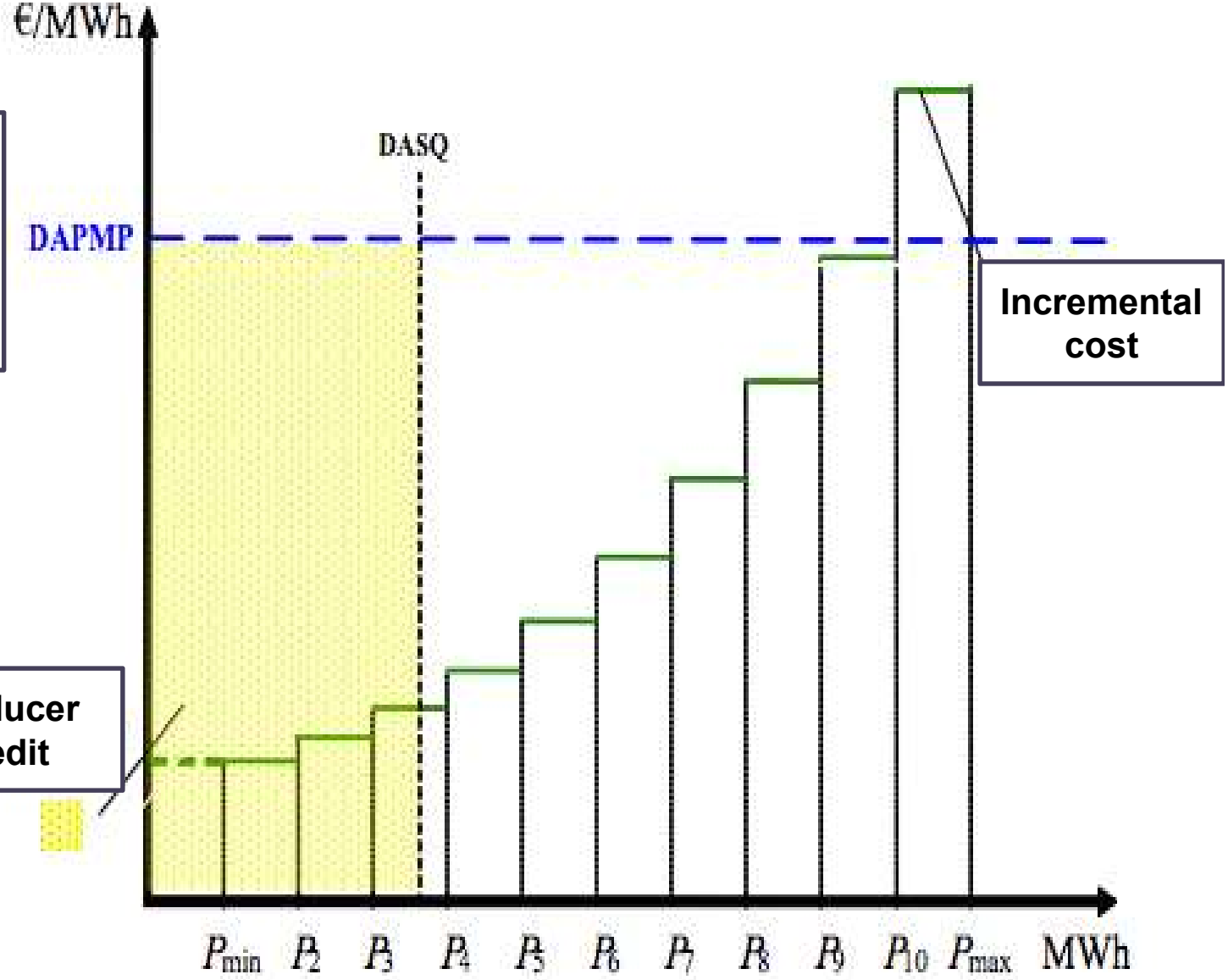
FIGURE 0.11: **How wind power influences the power spot price at different times of day**



Source: Risø DTU

Producer settlement in day-ahead market

DASQ = quantity in day-ahead market
DAPMP= price in the day-ahead market
Pmin, P1-P10 = power (volume) steps of the power plants



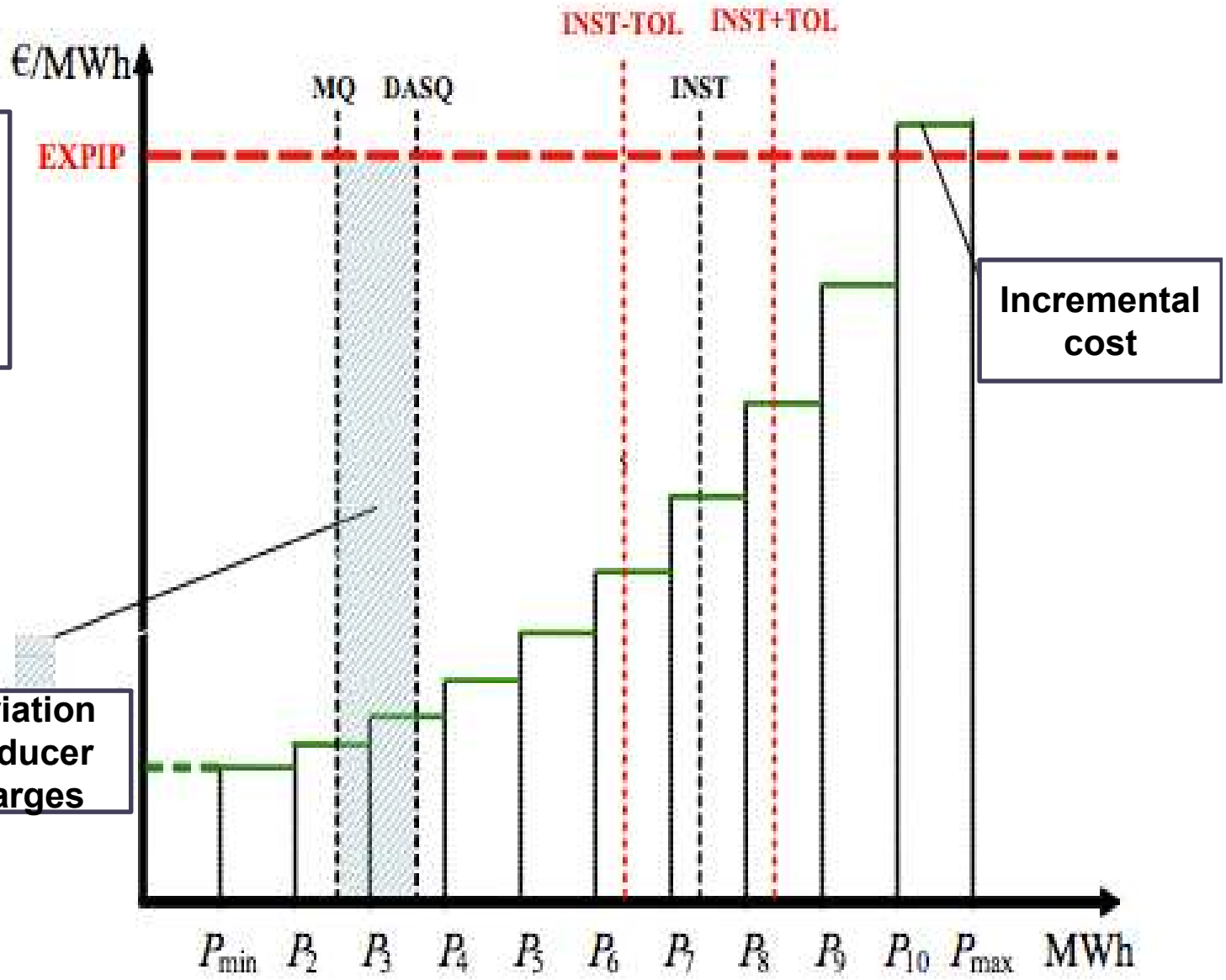
Deviations

The energy that a producer has been asked to produce in the Day Ahead Schedule (DAS) of Day Ahead Market (DAM) may deviate from the actually measured for a number of reasons:

- Technical impossibility of a producer
- Producer gaming strategy
- To get an order to increase or decrease production from the TSO.
  - Where the producers can comply
  - or fail to comply (non-compliance charges)

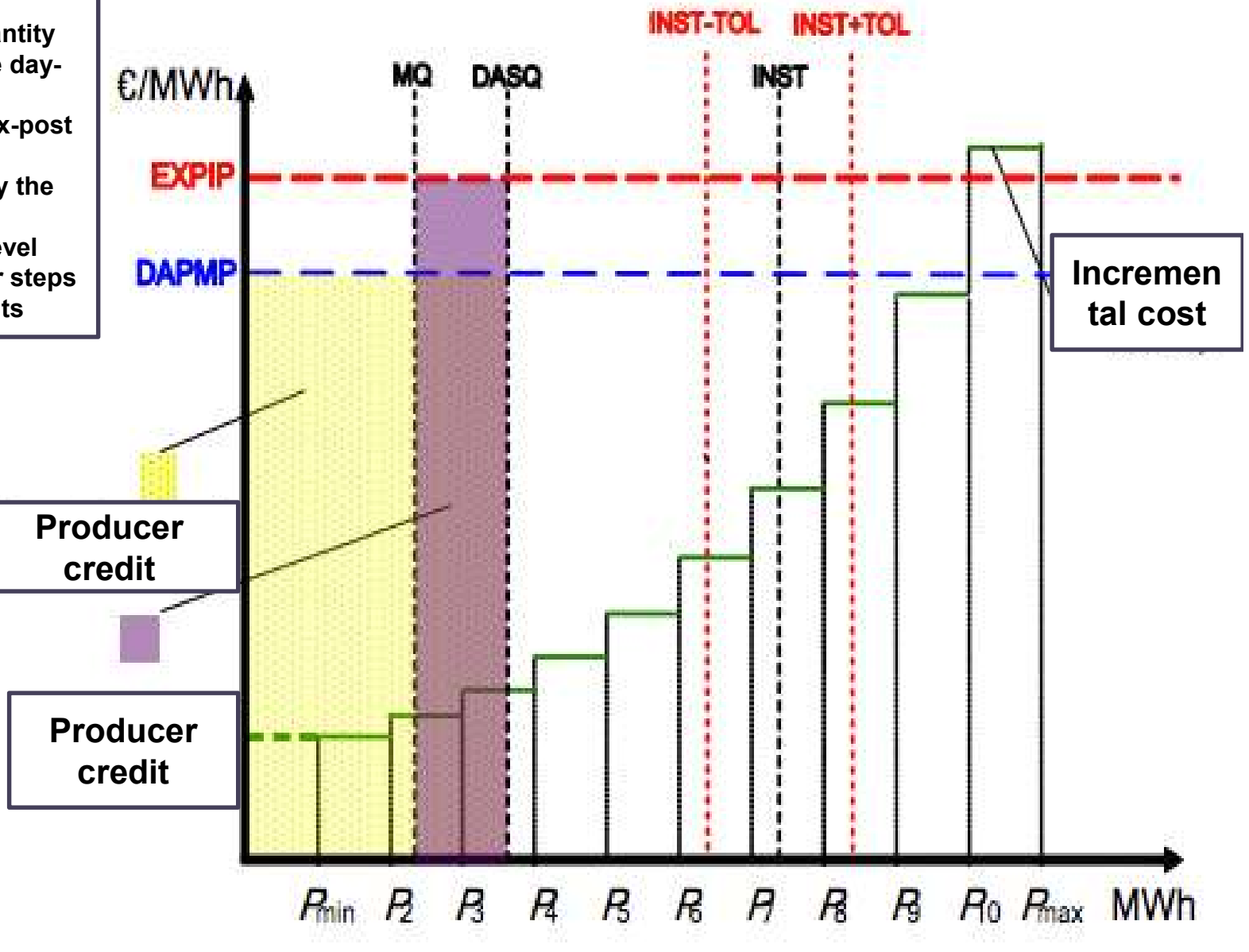
Deviations settlement

DASQ = quantity in day-ahead market
MQ = measured quantity
INST= Instruction by the TSO
TOL = Tolerance level
Pmin, P1-P10 = power steps of the power plants



Total debit/charge of a producer

DASQ = quantity in day-ahead market
MQ = measured quantity
DAPMP= price in the day-ahead market
EXPIP= price in the ex-post market
INST= Instruction by the TSO
TOL = Tolerance level
Pmin, P1-P10 = power steps of the power plants



Integration of European electricity market – «target» model

The Greek electricity market, according to a RAE report in 2012, required changes, divided into three categories:

Design elements of the existing market **that need to be restructured**:

- Modifying Market Solution **Algorithm** / Offer Format
- **Separation** of Energy Market and Ancillary Services market
- Conversion of Short Term Interconnection Auctions to **Implicit**
- Create an **Intraday Market**
- Replacement or Removal of the Variable Cost Coverage Facility
- Adapt schedule to **European Price Coupling** (EPC)
- Assignment of **Clearing House**
- Modification of a Manually Set Maximum / Minimum Offer Price

Integration of European electricity market – «target» model

Elements of the existing market structure that **should be reconsidered**:

- Market Participation / Physical Delivery **Bilateral Contracts**
- **Balancing Market clearing**
- Capacity market

Integration of European electricity market – «target» model

Structural changes in the market through regulatory measures aimed at **improving the competitive conditions** and ensuring the system's adequacy and reliability:

- **Third party access to energy resources**, currently managed exclusively by PPC
- **Withdrawal of old** PPC units
- Conclusion of Capacity Availability Contracts (PPCs) between PPC and other participants, or the establishment of mechanisms for the exchange or auction of **energy futures** products
- **Examination of the way RES** is participating in the electricity market

Integration of European energy markets

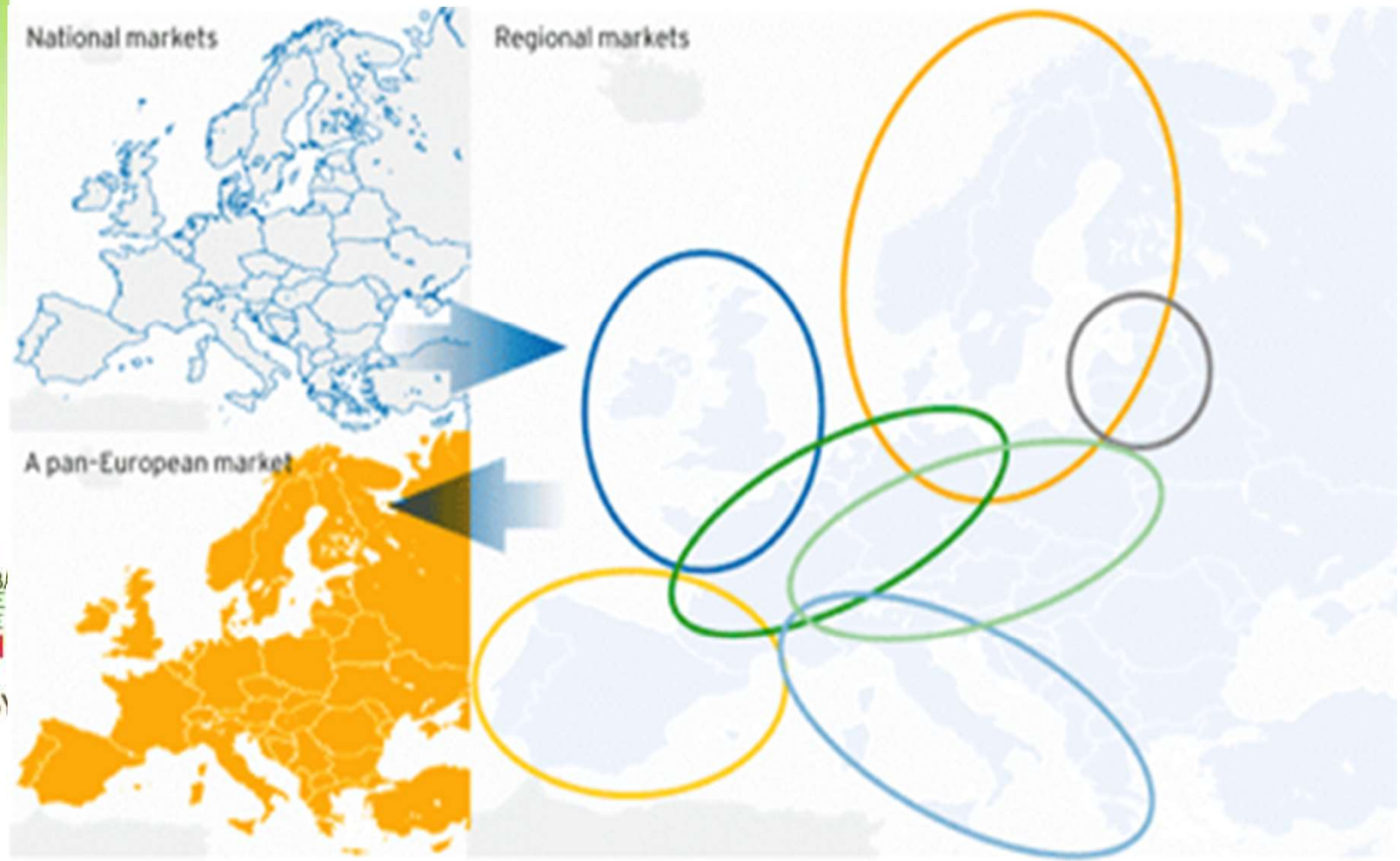
Why does Europe want the integration of its energy markets?

The European Economic Area was created on 1/1/1994 and is based on free movement:

- **Persons,**
- **Commodity/Goods,**
- **Services**
- **Capital**

The European Union has a common market for all commodities, but not for electricity and gas.

A pan-European energy market



An intermediate step in moving from today's national energy markets towards a pan-European market is the creation of regional markets in order to first integrate neighbouring markets. In February 2006, the European regulators launched an initiative to create seven regional markets, defined as: Central-West, Northern, UK and Ireland, Central-South, South-West, Central-East and Baltic.

Integration of European energy markets

How will integration into the electricity market?

- **Common rules and timing** for the solution of day-ahead and intraday markets (ACER, EUROPEX)
- **Integration of Network Codes** into national legislation (ACER, ENTSOE) on common rules for the management of energy systems and the functioning of balancing markets and allocation of interconnection capacity.

Practically the Target Model is one **EU wide congestion management system**

Integration of European energy markets

Connection Related Codes

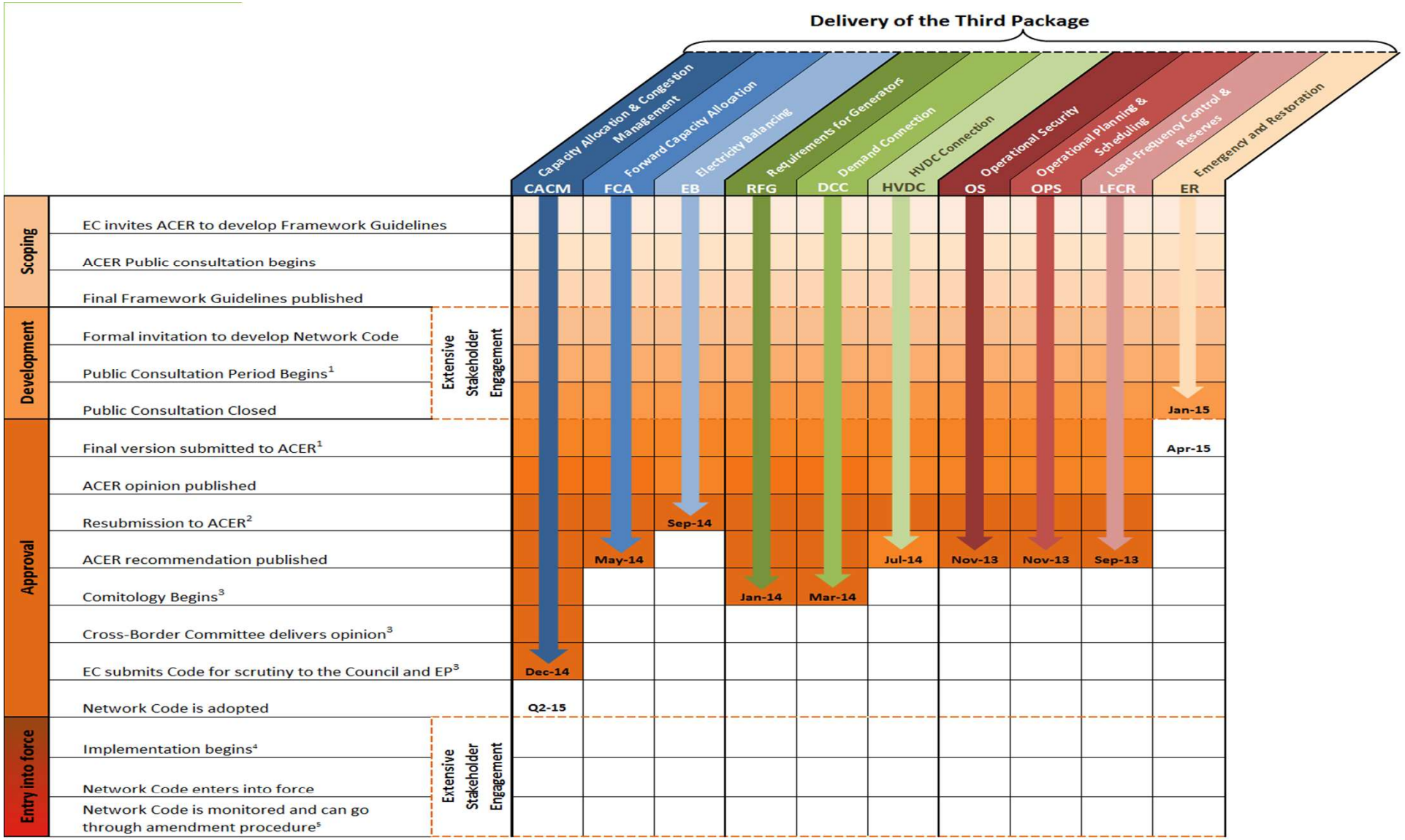
- Requirements for Generators (RfG)
- Demand Connection Code (DCC)
- HVDC Connection Code (HVDC)
- Connection Procedures (CP)

System Operation Related Codes

- Operational Security Network (OS)
- Operational Planning & Scheduling (OPS)
- Load Frequency Control & Reserves (LFCR)
- Operational Procedures in an Emergency (EP)
- Staff Training (ST)

Market Related Codes

- Capacity Allocation & Congestion Management (CACM)
- Forward Capacity Allocation (FCA)
- Balancing Network Code (BAL)



Disclaimer: The purpose of this chart is to provide overall transparency of ENTSO-E's network code development. All forward-looking dates are provisional until confirmed. Stakeholders will be informed and invited to all confirmed events by means of official communication

1: In accordance with ENTSO-E's Network Code Development Process, an internal re/drafting and approval is done before public consultation and submission of the code to ACER.
2: In case ACER does not attach a recommendation to its opinion, ENTSO-E has the opportunity to resubmit the code
3: Changes in process may occur if the Regulatory Procedure with Scrutiny is replaced by the Delegated Acts Procedure for Network Codes validation
4: Some provisions are going through early implemenentation before this stage. Estimated implementation period vary from 18 months for NC OPS to 39 months for NC FCA. For NC EB, a 6 years phased introduction period is planned.
5: The amendment procedure is yet to be determined

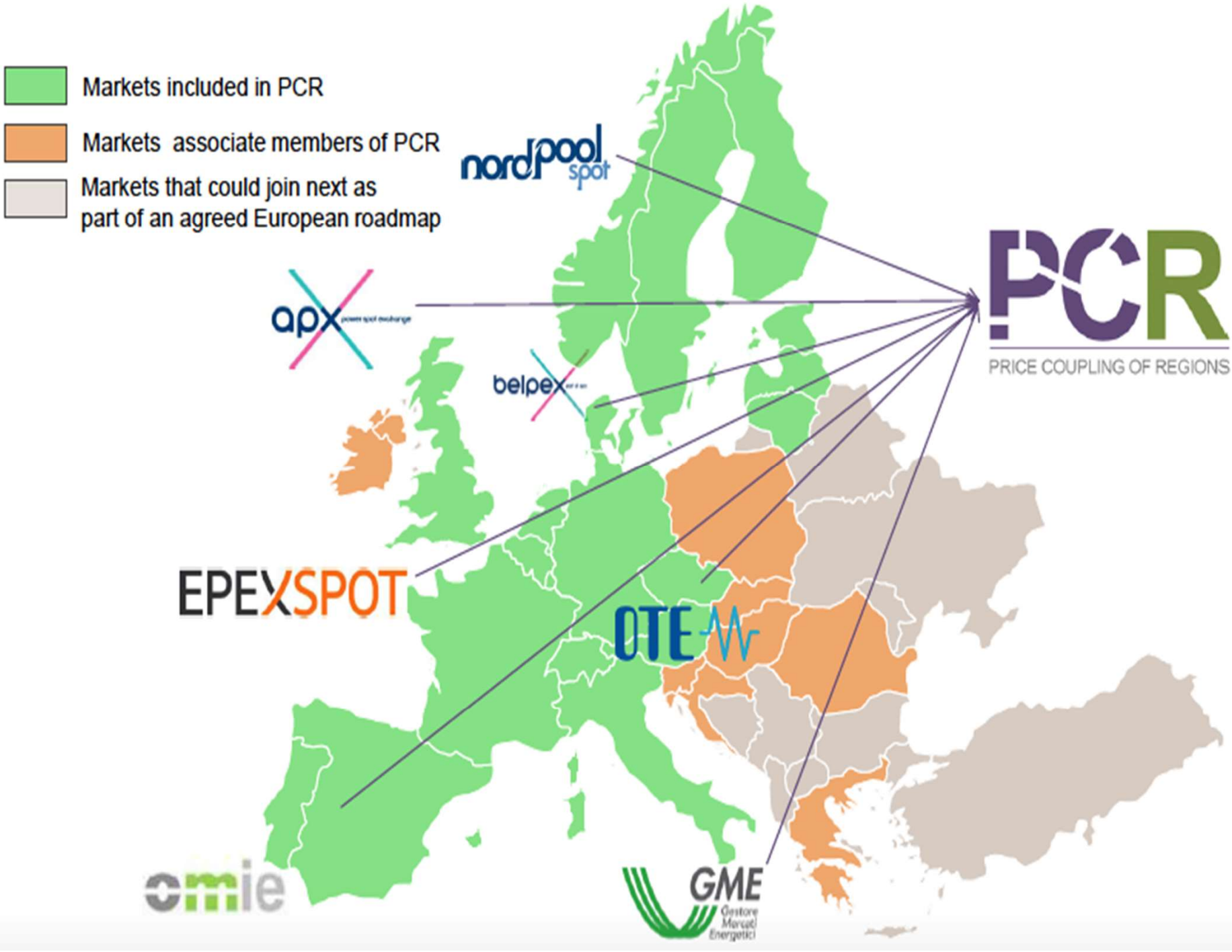
Integration of European energy markets

The **Project Price Coupling of Regions (PCR),** supported by EUROPEX, aims to develop a common solution to the interconnection of energy markets with the following **3 principles:**

- **An algorithm**
- **Decentralized governance**
- **Decentralized operation**

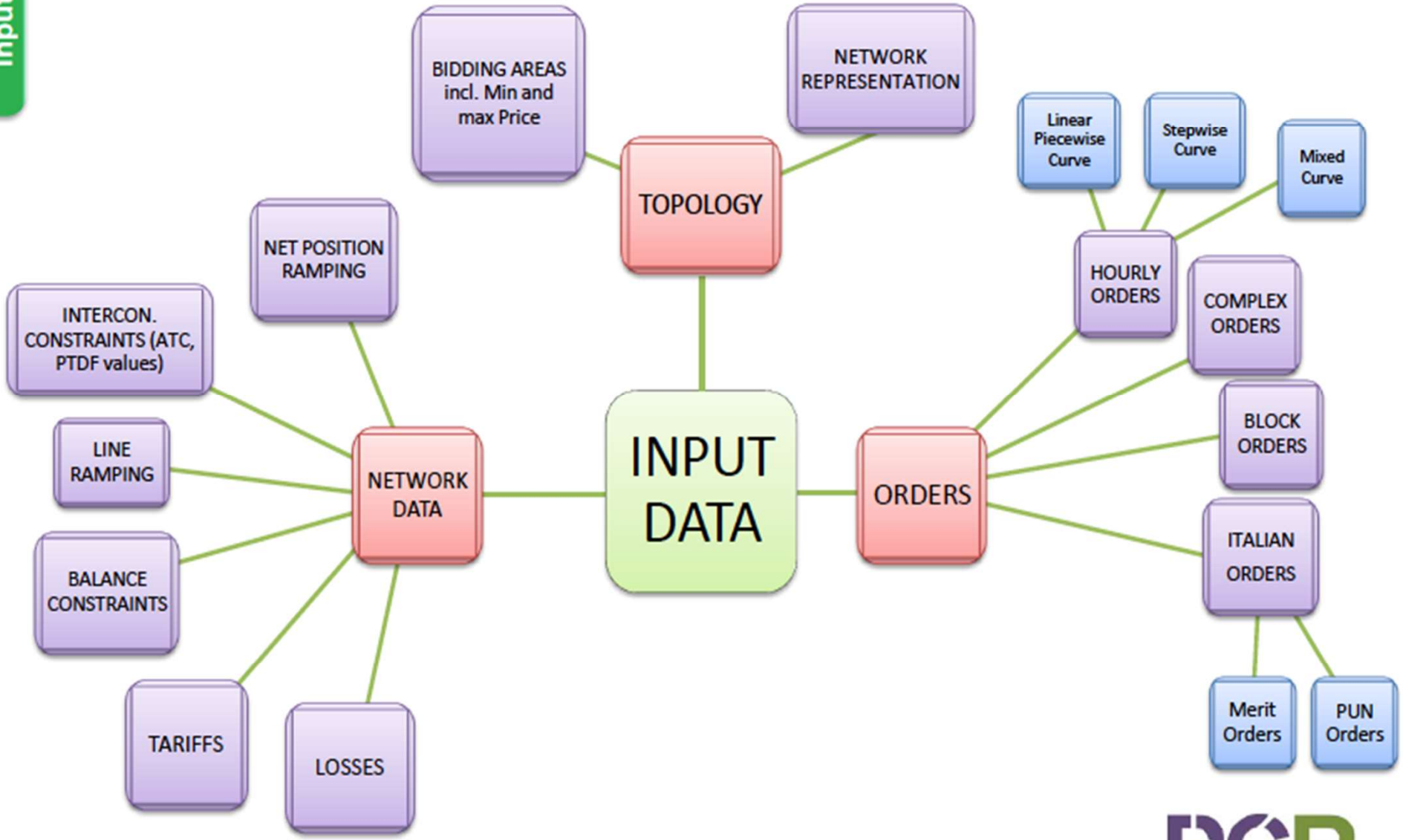
EUPHEMIA: EU + Pan-European Hybrid Electricity Market Integration Algorithm

<u>is the algorithm that implements market coupling</u>


Markets included in PCR
Markets associate members of PCR
Markets that could join next as part of an agreed European roadmap
nordpool spot
apx
belpex
EPEXSPOT
OTE
omie
GME
Gestore Mercati Energetici
PCR
PRICE COUPLING OF REGIONS

Input data

INPUT DATA

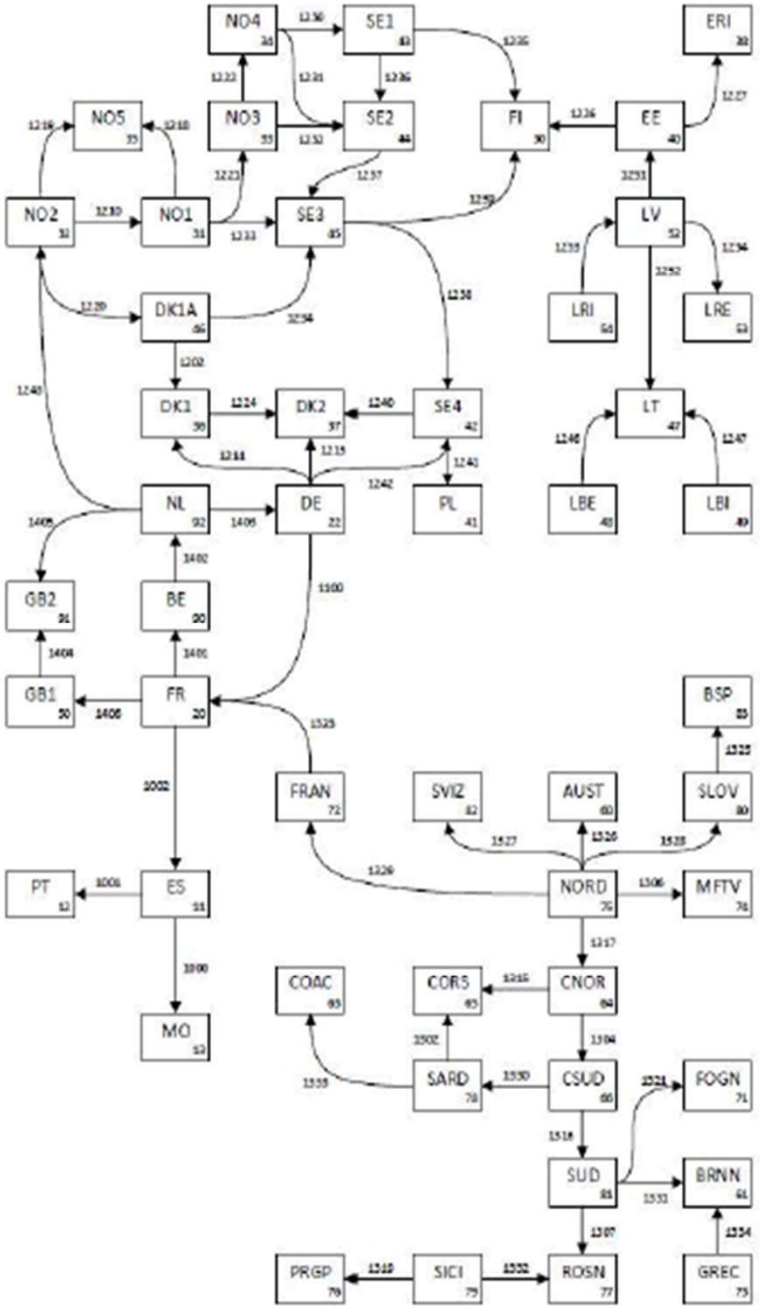


PCR
PRICE COUPLING OF REGIONS

Input data

MARKET DATA

- Each PX (Market) operates several bidding areas
- All bidding areas are matched at the same time
- A different price can be obtained for each bidding area
- The price for the bidding area must respect maximum and minimum price market boundaries



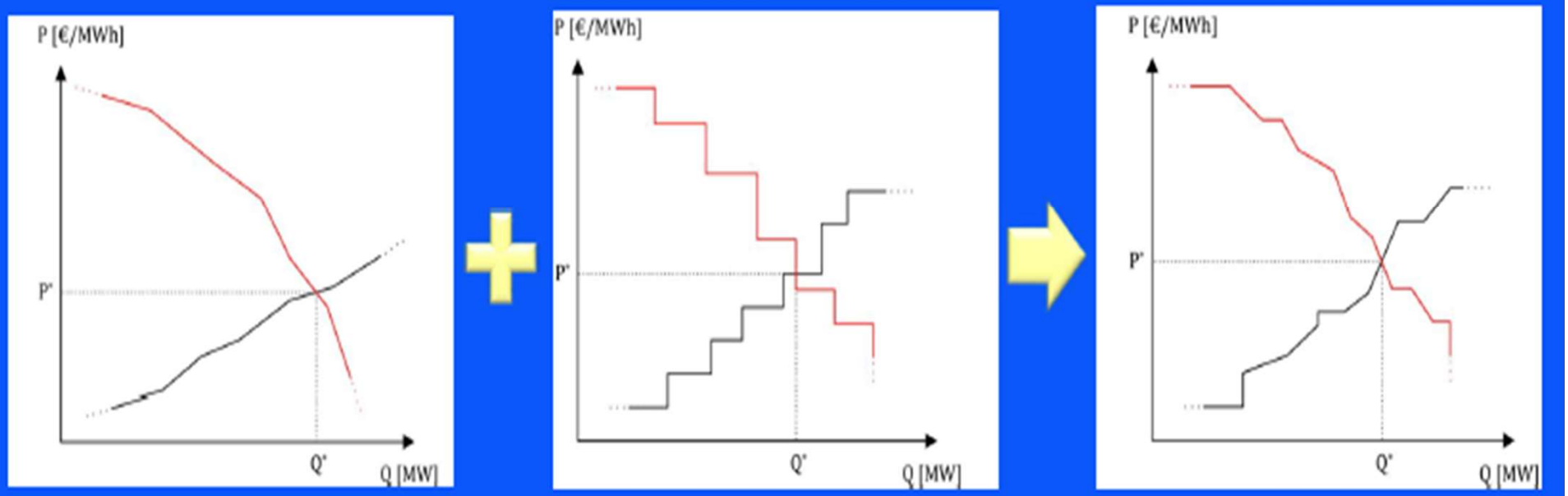
Simple Hourly Orders

✓ EUPHEMIA supports a variety of orders currently submitted in CWE, Nordpool, MIBEL and GME

Piecewise Linear

Stepwise

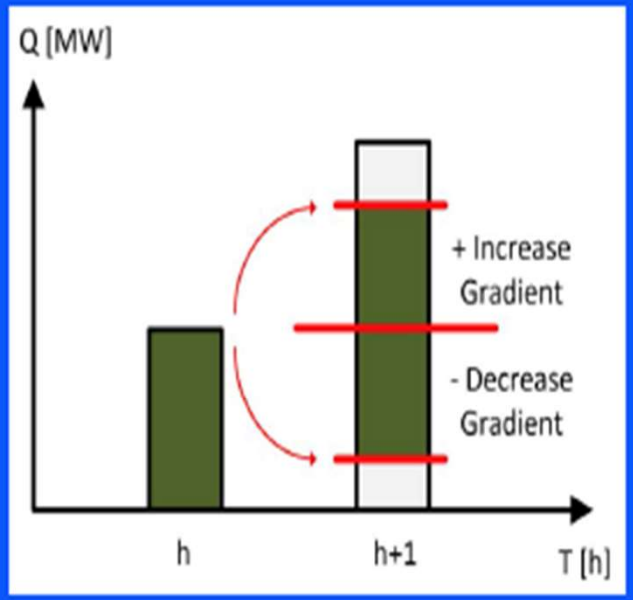
Mixed Curve



Complex Orders

✓ EUPHEMIA supports a variety of orders currently submitted in CWE, Nordpool, **MIBEL** and GME

1. Load Gradient



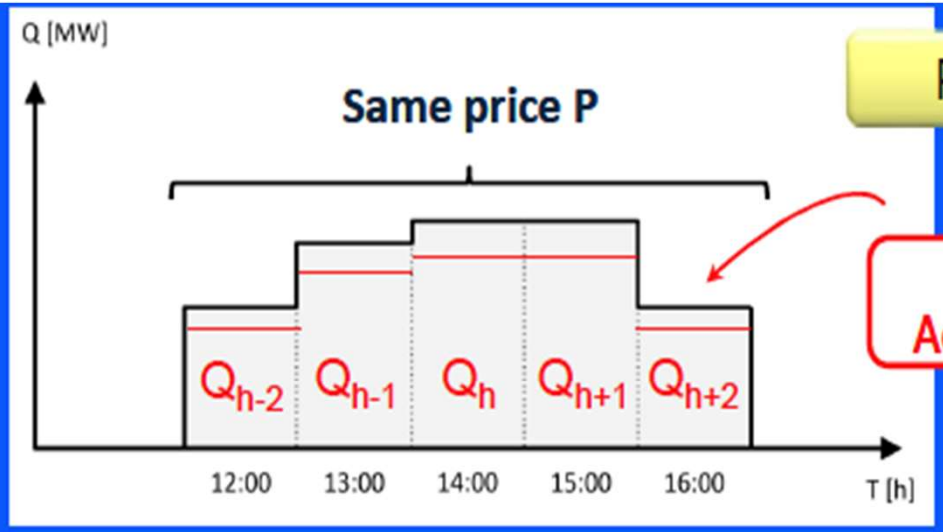
Maximum/minimum clearing in period *h+1* depends on the clearing in period *h*

2. Minimum Income

Total daily revenue (TR) of an activated MIC order with cleared daily quantity *q* must cover a fixed (FT) and a variable (VT) cost term

$$TR \geq VT * q + FT$$

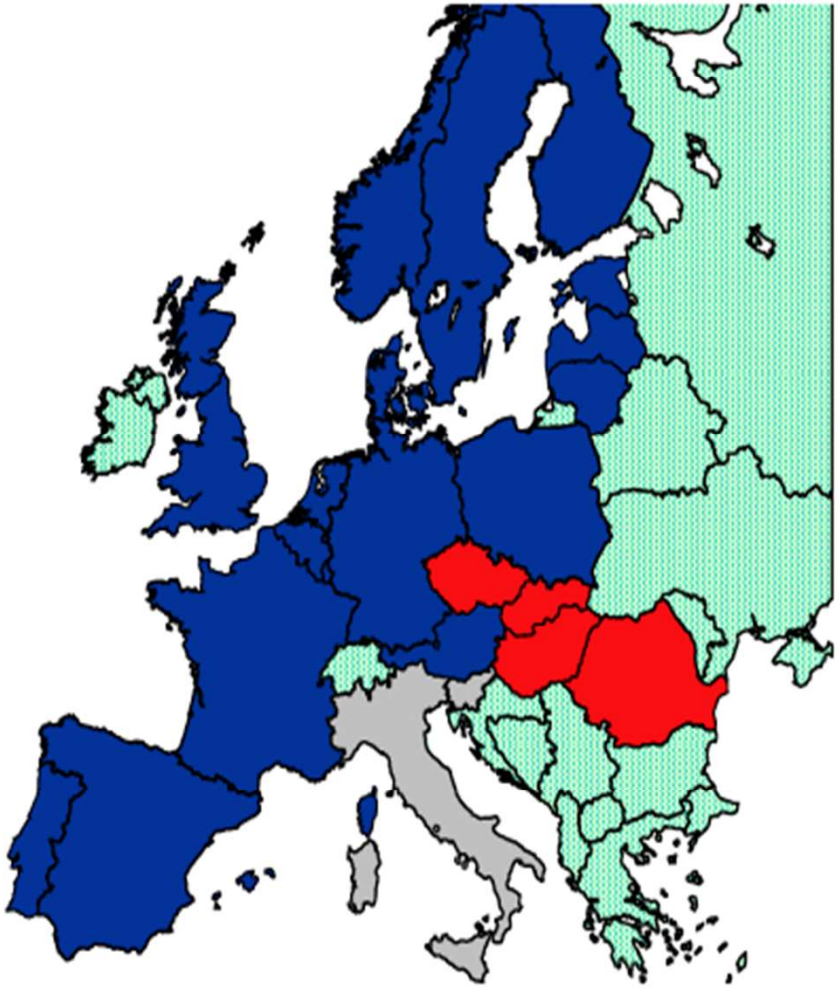
Block Orders



- ✓ Different quantity Q_h in each period *h*
- ✓ Acceptance based on **volume weighted average** market clearing price (**Average MCP**)
- ✓ **Partial** acceptance → **0 or Minimum Acceptance Ratio ≤ Cleared Quantity ≤ 1**

Accept order if it is "in-the-money":	**P < Average MCP** (supply)
Reject order if it is "out-the-money":	**P > Average MCP** (supply)
(Partially) **Accept/Reject** order if it is "at-the-money":	**P = Average MCP** (supply)

Currently, in Europe we have market coupling between the countries marked with blue colour (PCR Price Coupling Regions)



And the countries marked with red and grey colour have their own market coupling

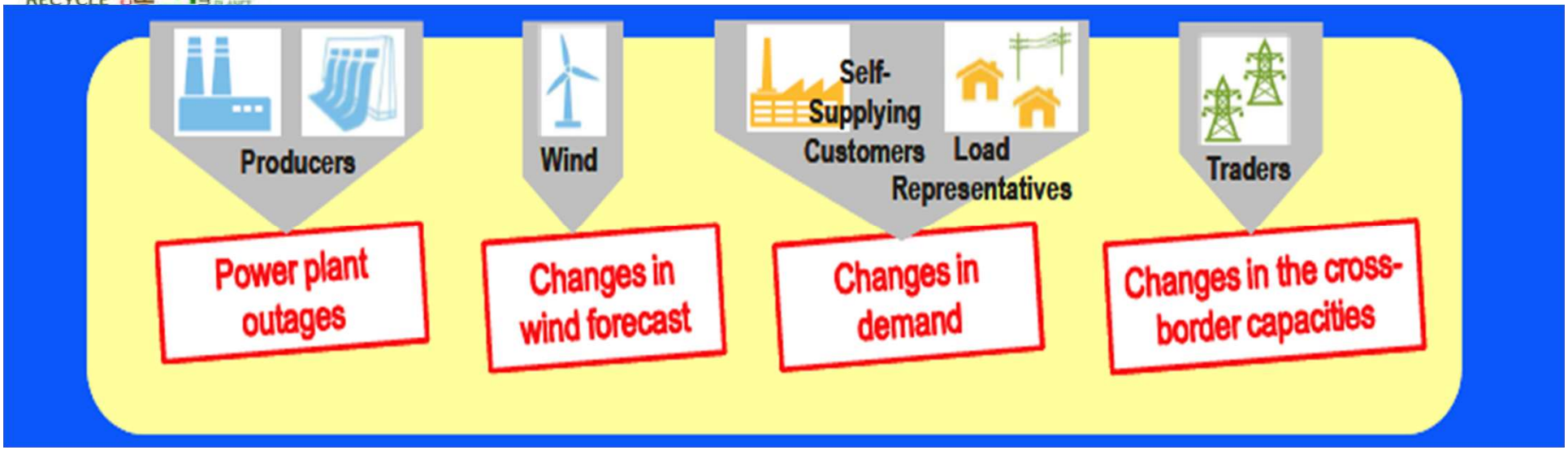
Intra-day market

Intra-day market

Why is the intra-day electricity market useful?

Because they can happen:

- **Faults (power outages)** in production plants
- Change in **wind forecast or sunshine**
- **Changes in demand** (eg due to heatwave or change of production line of an industry
- Change to interconnections (eg failure on an interconnection, also for position correction when auctions are not implicit)

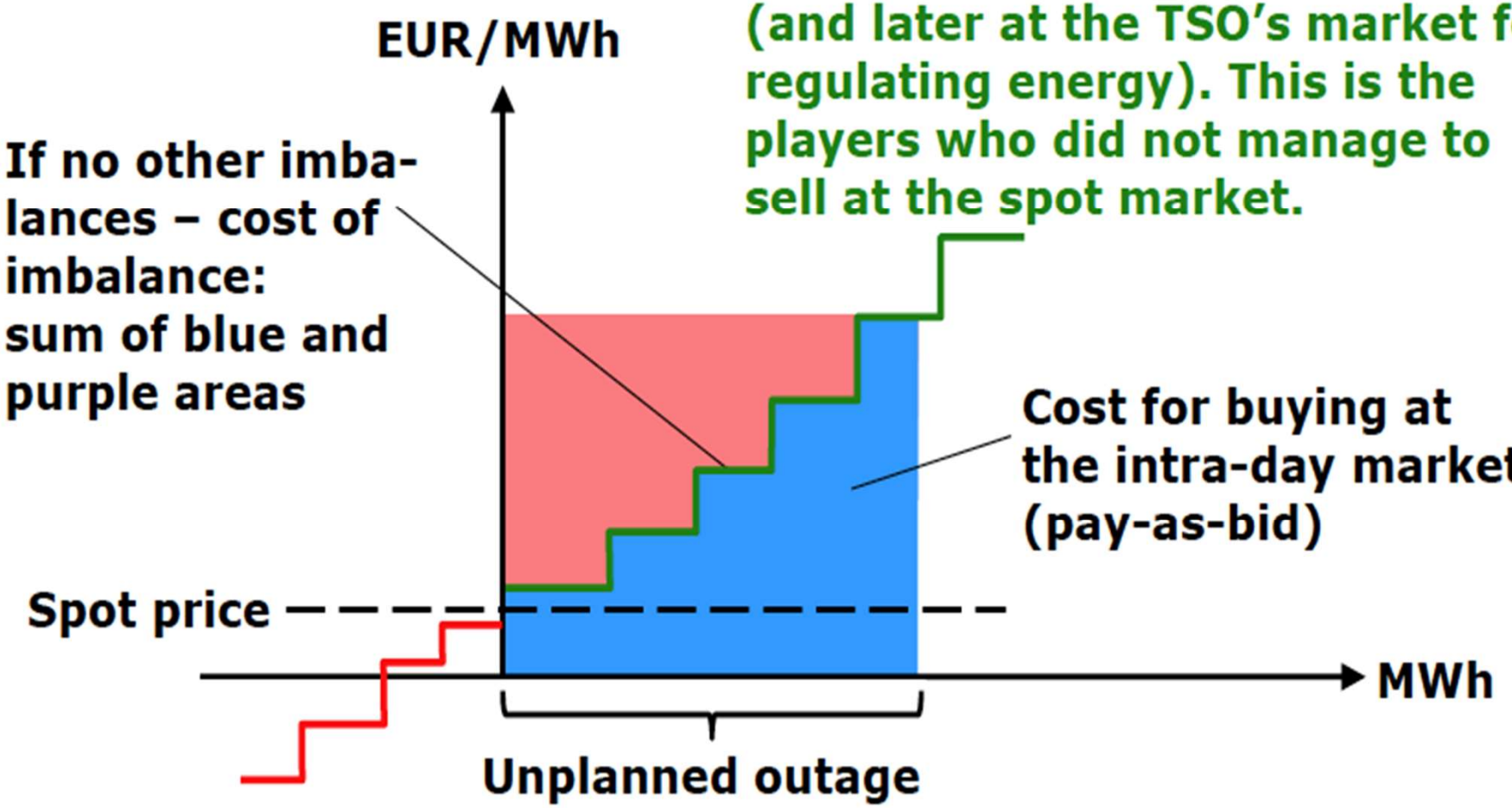


Intra-day trading and spot trading

- The turnover at the intra-day market is very small.
- As cases – turn-over for the year 2013 (numbers in TWh):
  - ✓ EPEX Spot (Austria, France, Germany, Switzerland)
    - Spot turnover 323
    - Intra-day turnover 23
  - ✓ Nord Pool Spot
    - Spot turnover (Baltic-Nordic area) 349
    - Intra-day turnover (Baltic-Nordic, Germany) 4
  - ✓ APX (Belgium, the Netherlands)
    - Spot turnover 64
    - Intra-day turnover 1
  - ✓ As can be seen: the turnover at the intra-day markets is paltry. It cannot finance the intra-day trading platforms
    - Hence the intra-day trading platforms only survive due to heavy cross-subsidizing from the spot trading.

Unplanned outages

Sales offers at the intra-day market (and later at the TSO's market for regulating energy). This is the players who did not manage to sell at the spot market.



For a big player, the imbalance will normally be expensive! Hence, a big player will use the intra-day market in case of an unplanned outage.

For a small player, it's normally better to settle the imbalance (the total imbalance my be in the small player's favour)

Three Phase Approach

1st Phase

Intra-day auction sessions shall be implemented in Greece,

consistent with the timing of the corresponding Italian XB and internal intra-day sessions

Alternatively: **local continuous Intra-Day Market** open for all local Market Participants, where:
participation of cross-border Traders
→ via successive explicit Cross-Zonal Capacity allocation auctions

2nd Phase

Continuous intra-day trading, both internally and at the border with the Italian electricity market

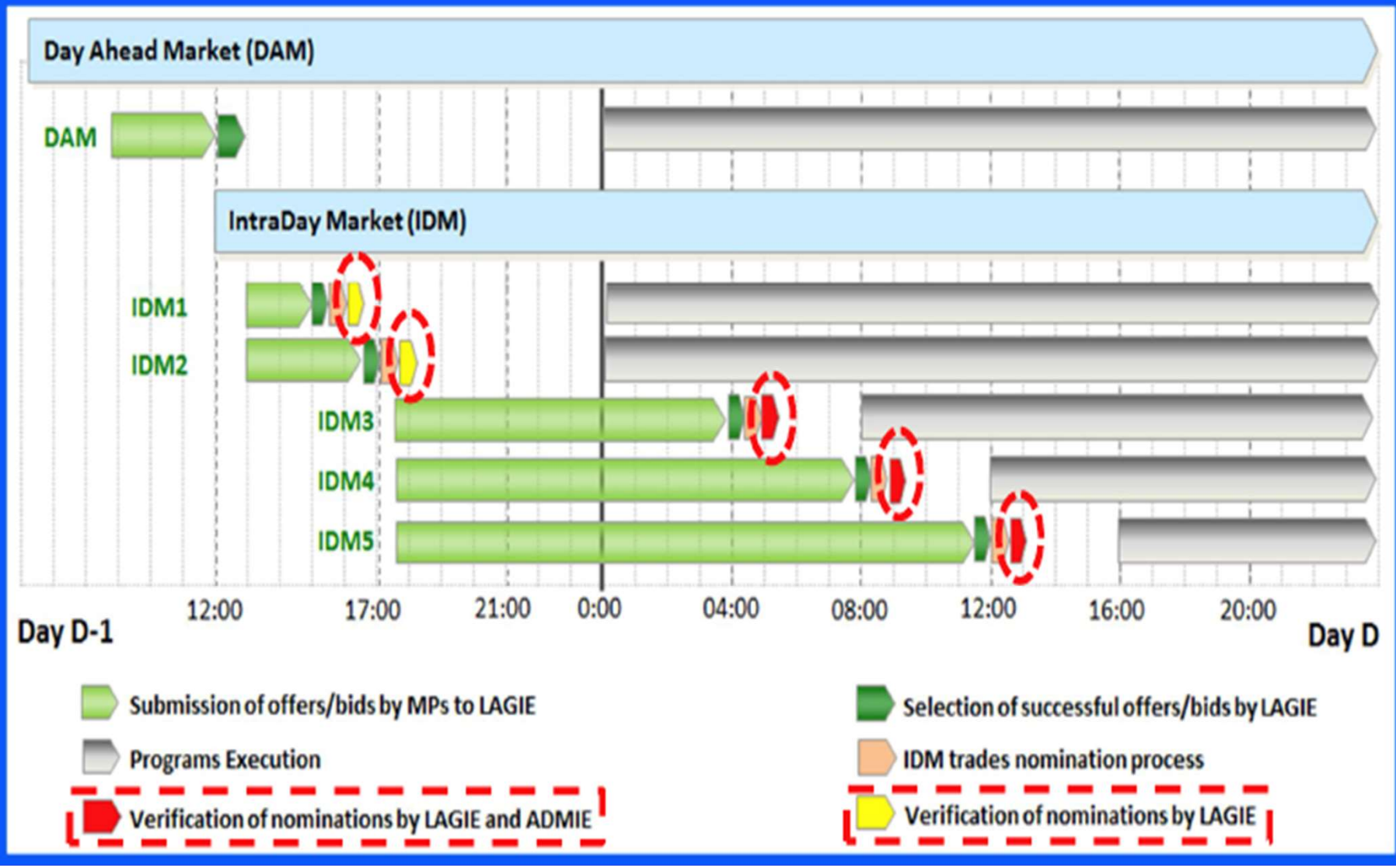
(based on procedures that will have been obtained by the NWE markets)
Cross border intra-day sessions, shall only be retained at the northern borders

3rd Phase

Only continuous intra-day trading, internally and at all borders

Operating cross-border sessions at the northern borders shall be abolished

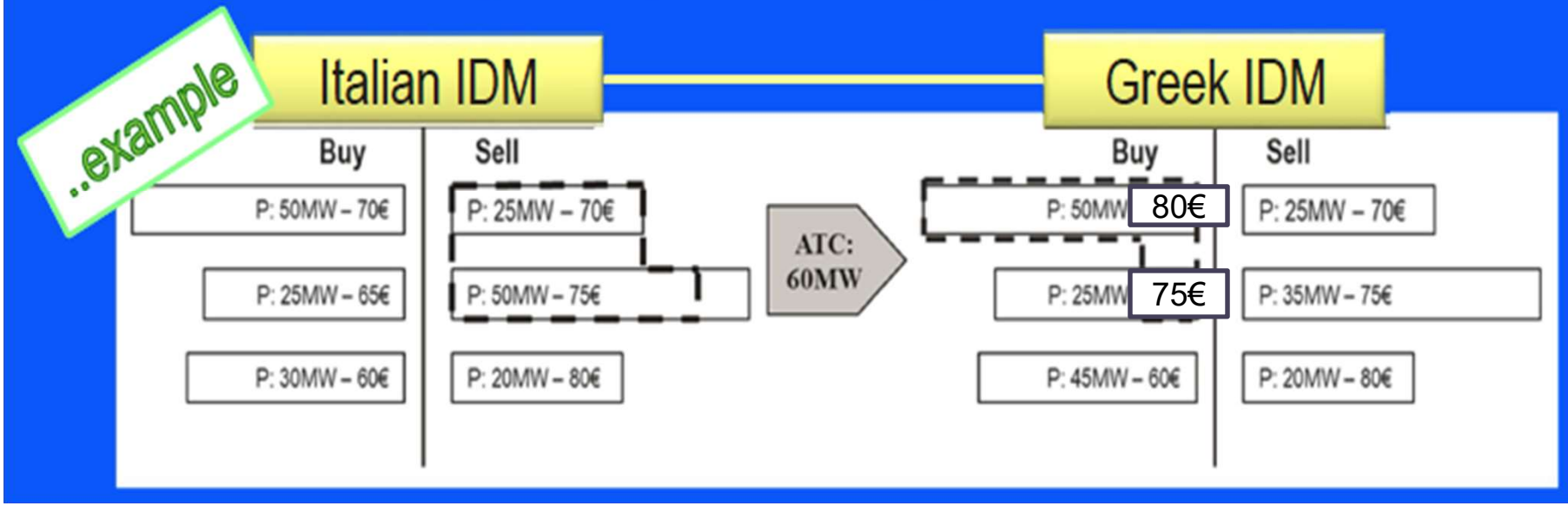
Internal Intra-Day Auctions (1st Phase)



Continuous Intra-Day Trading (2nd & 3rd Phase)

Promoted **Cross Border Intra-day Model**:

- ✓ Collaboration between Market Operators to allow their respective intra-day Bids and Offers to **continuously match** between them, **irrespectively to which Market Operator and Bidding Zone they are submitted to**
- ✓ This assumes that **sufficient Cross Zonal Capacity** is available (implicit capacity allocation method) and the transmission system security is not jeopardized
- ✓ The continuous matching can take place until a **final gate closure** before the start of the delivery

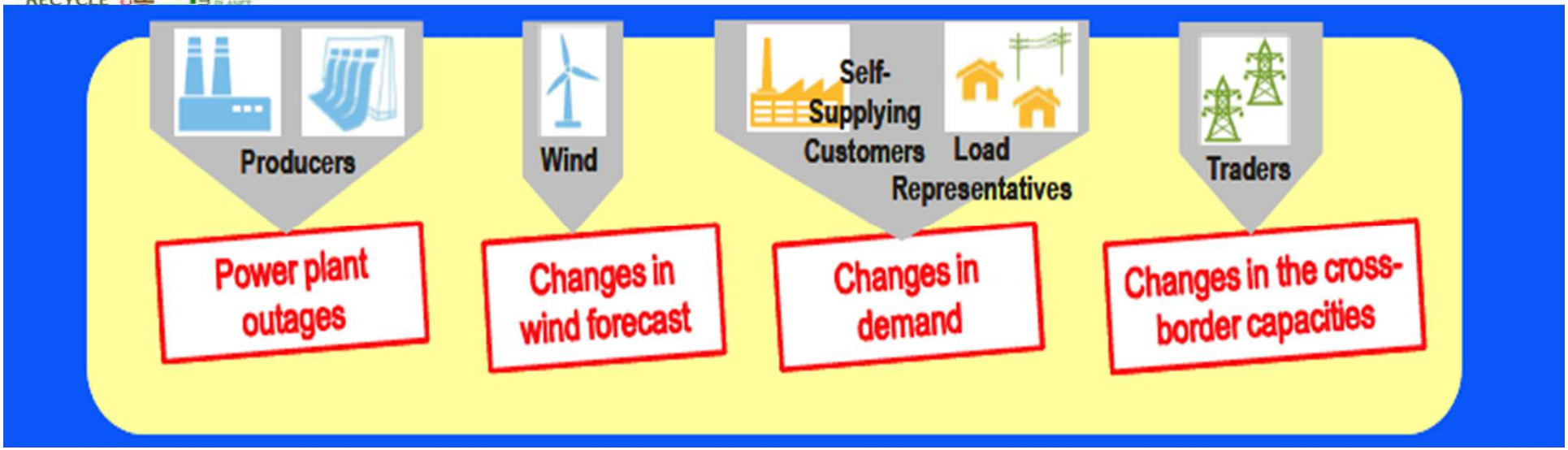


Intra-day market

Why is the intra-day electricity market useful?

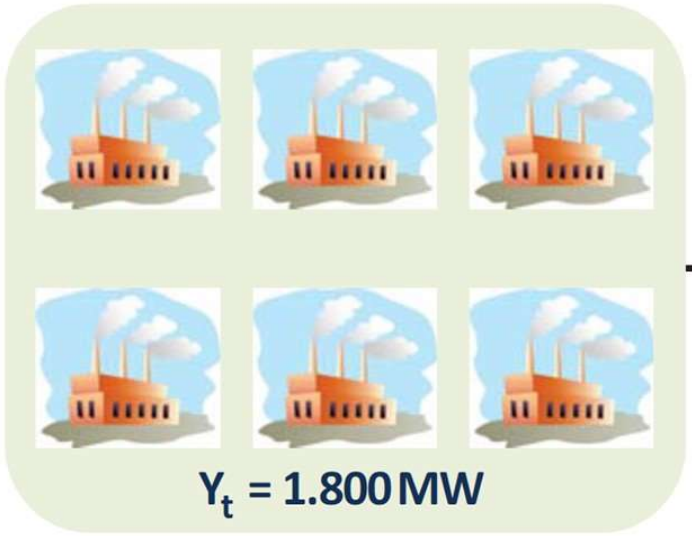
Because they can happen:

- **Faults (power outages)** in production plants
- Change in **wind forecast or sunshine**
- **Changes in demand** (eg due to heatwave or change of production line of an industry
- Change to interconnections (eg failure on an interconnection, also for position correction when auctions are not implicit)



Balancing market

Transmission System Operator (TSO) operates in real-time the power system so as production meets demand, otherwise we have local or total black-out



$Y_t = 1.800\,MW$

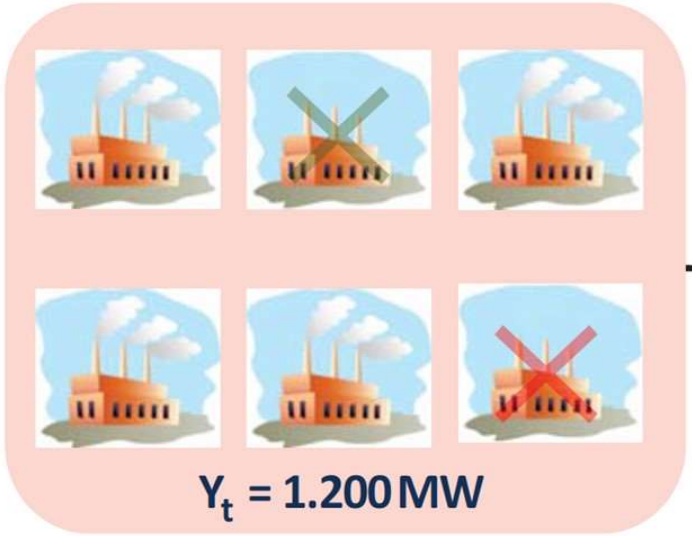
Total available capacity

$$Y_t = \sum_{i=1}^{N} X_t^i$$

$L_t = 1.500\,MW$

$Y_t > L_t$

OK



$Y_t = 1.200\,MW$

$L_t = 1.500\,MW$

$Y_t < L_t$

Black out

Balancing market

Why do we need the balancing market?

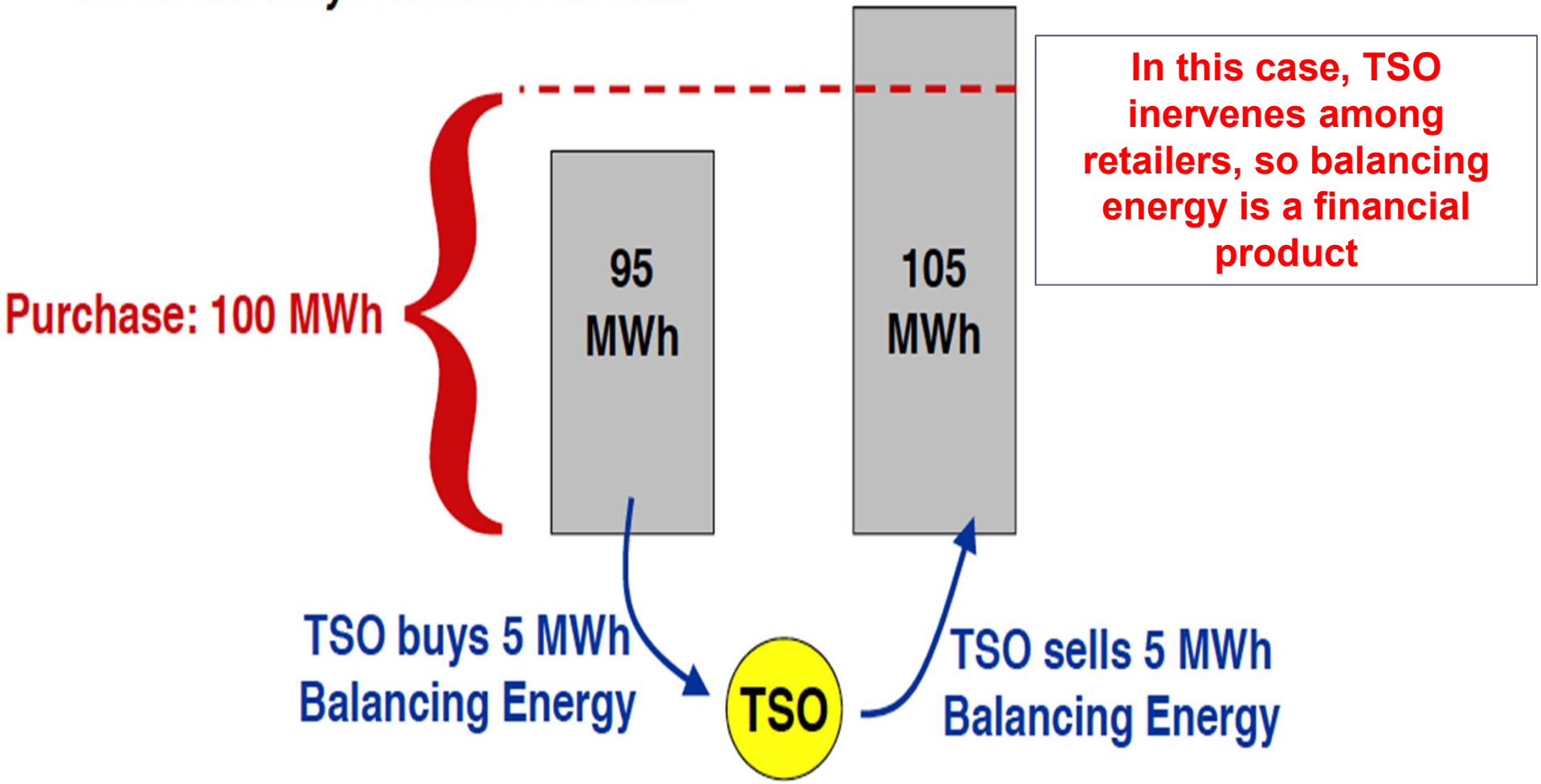
Balancing refers to the situation **after markets have closed** (gate closure) in which a **TSO** acts to **ensure** that **demand is equal to supply**, in and near real time.

Because actual energy production / consumption differs from the energy transactions from market mechanisms (day-ahead and intra-day markets):

- **Different production** (e.g., failure, non-compliance with distribution orders, we calculate it in imbalance settlement)
- Wrong **forecasting wind or sunshine**
- **Different demand** (eg due to a heat loss or change in an industry's production line, the deviation of actual consumption and the quantity cleared on the market from tolerance limits - we calculate it in the clearance of discrepancies)
- Power flow differences in **interconnections** (eg failure)

What is balancing energy? - 1

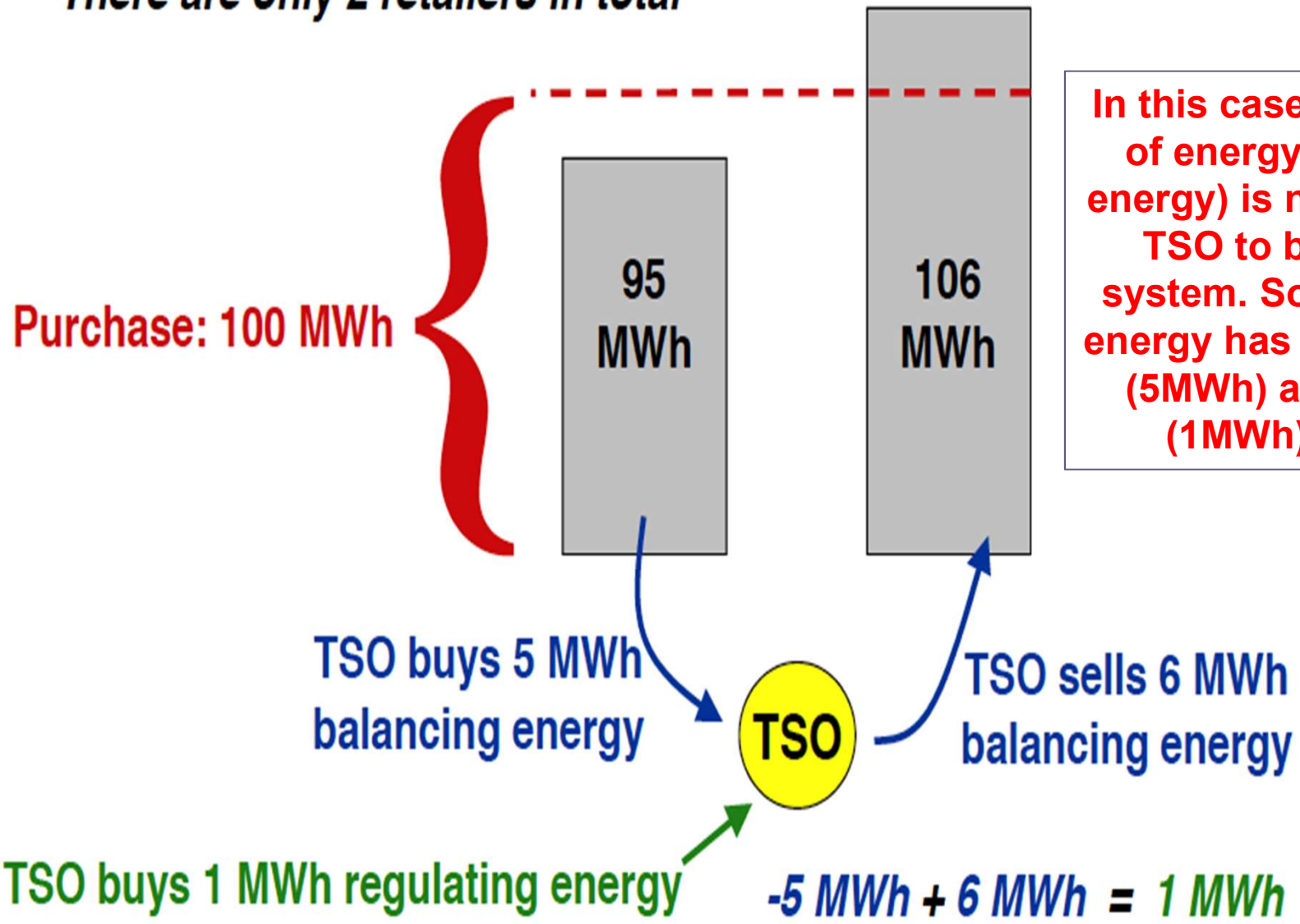
Let's look at a small electricity market:
There are only 2 retailers in total



Answer: balancing energy is a financial product

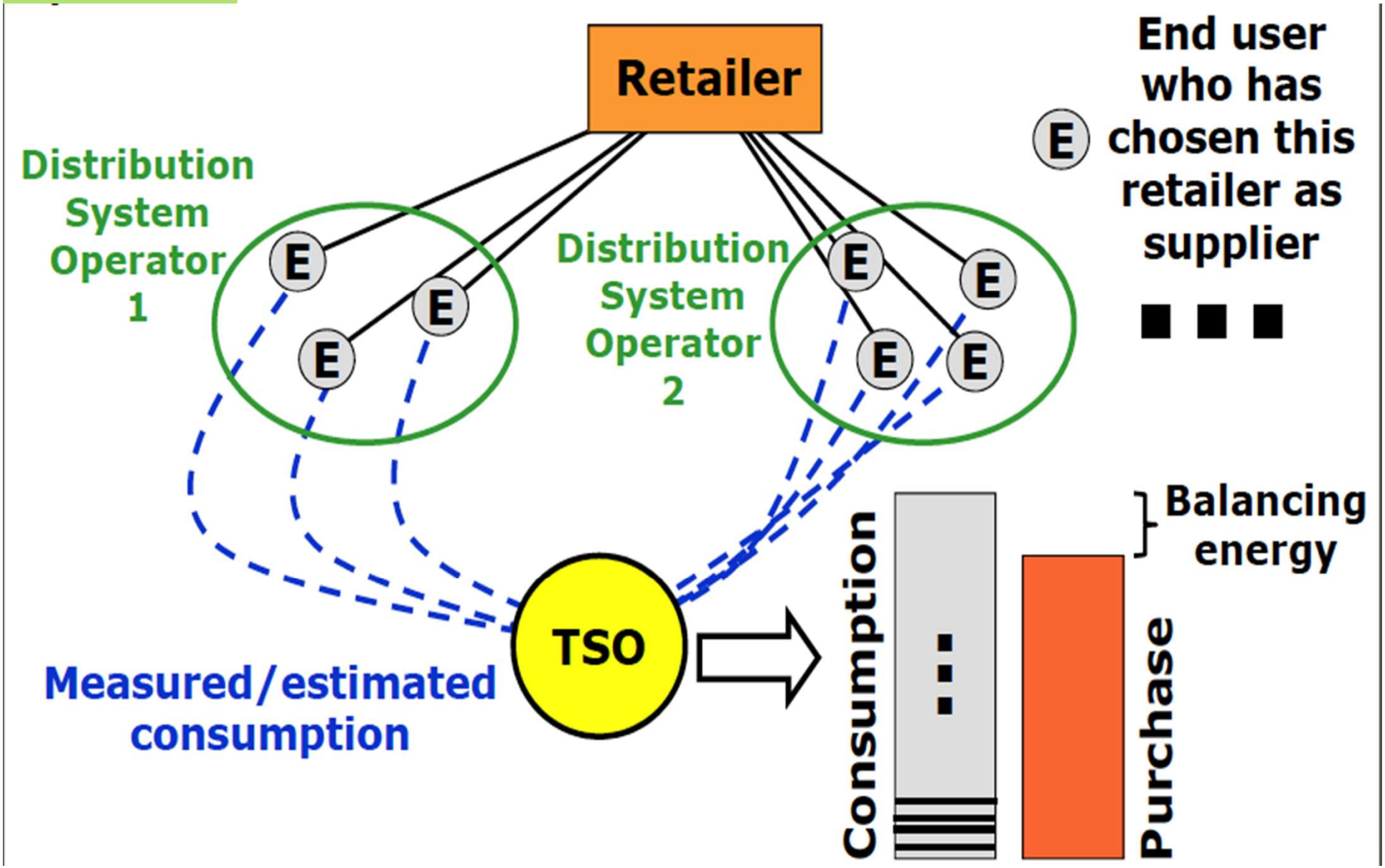
What is balancing energy? - 2

Let's look at a small energy market:
There are only 2 retailers in total



In this case, extra 1MWh of energy (regulating energy) is needed for the TSO to balance the system. Som balancing energy has both financial (5MWh) and physical (1MWh) product.

Practically the Distribution System Operators (DSOs) inform the Transmission System Operator (TSO), in order to estimate the total volumes of energy required to balance the system for every hour



Balancing energy - 3

- What is balancing energy?
- Answer: balancing energy is a financial product
  - ✓ Regulating energy is a physical product.
- If you for one given hour of operation add up all the balancing energy, you will get the regulating energy needed during this hour (provided you remember to include the sign in the balancing energy):
  - ✓ $B_1 + B_2 + B_3 + \ldots = R$

Balancing energy

In addition to determining the volume of balancing energy, an important issue is how this energy is priced.

There is a market where all **Balancing Responsible Parties** are involved, namely

- retailers
- producers,
- traders &
- large consumers.

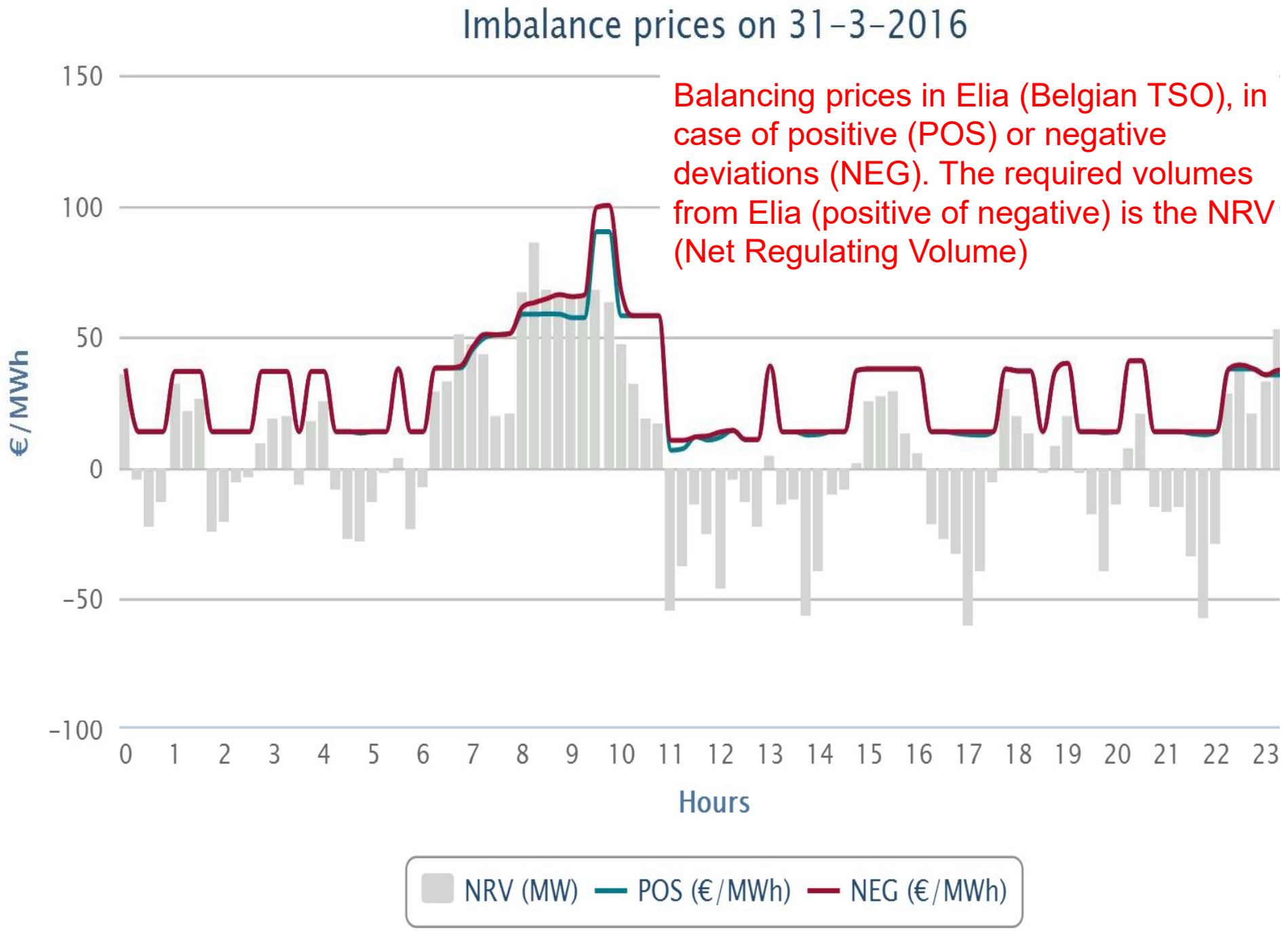
and sign a relevant agreement with the TSO.

Submit offers for balancing energy

- **upwards**
- **downwards**

(ie more or less than what their futures / day-ahead / intraday market has determined to absorb/produce)

Retailers can act as coordinators of balancing groups.


Imbalance prices on 31-3-2016
Balancing prices in Elia (Belgian TSO), in case of positive (POS) or negative deviations (NEG). The required volumes from Elia (positive of negative) is the NRV (Net Regulating Volume)
€/MWh
150
100
50
0
-50
-100
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hours
NRV (MW)
POS (€/MWh)
NEG (€/MWh)

Example of volumes and prices in Belgian system (Belpex και Elia)

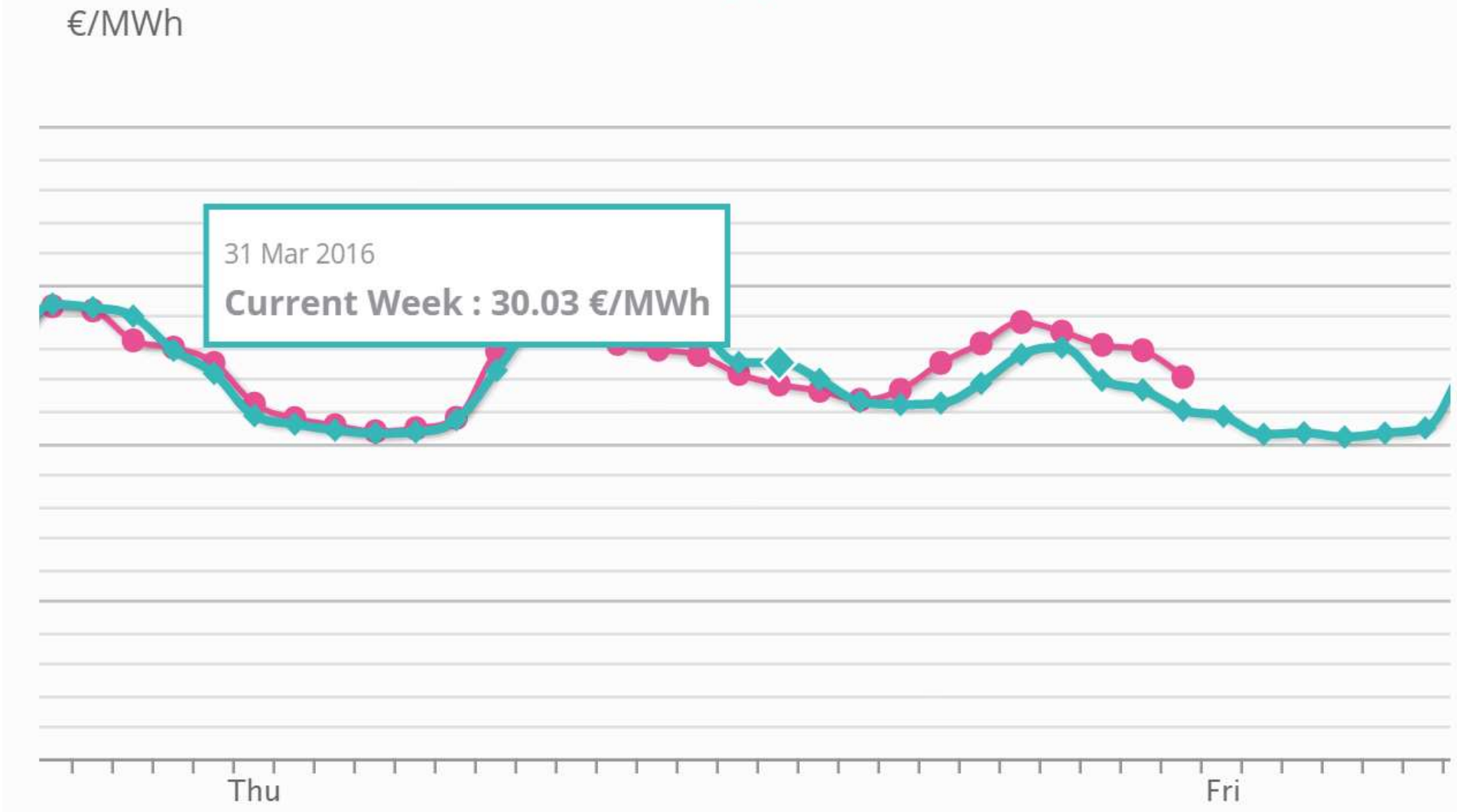
Day Ahead Market indices

Week Month Year

Belgian Hub **Hourly prices** Hourly volumes

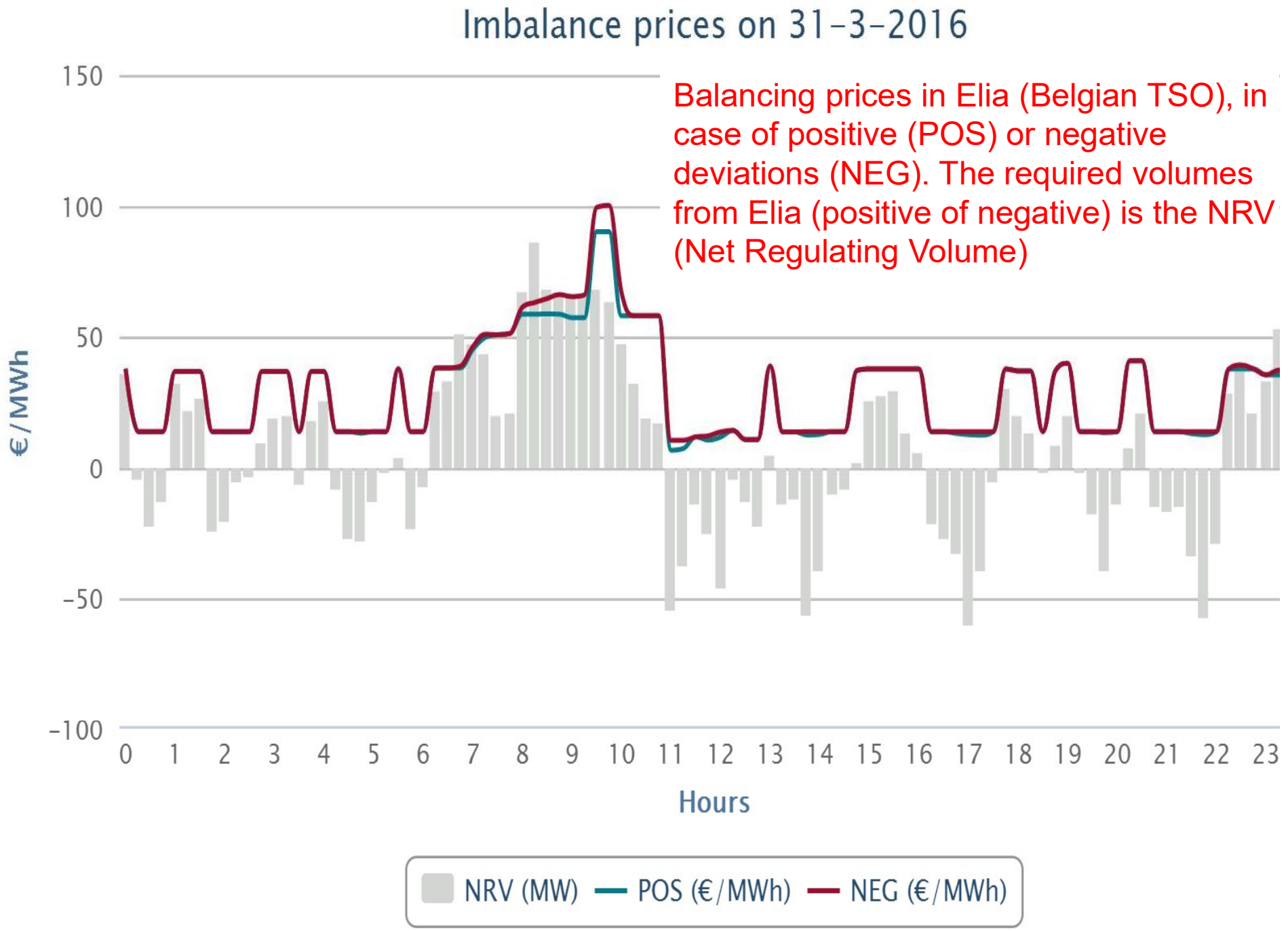
CWE Prices

Hourly prices



Belpex Continuous Intraday Market

Week Month Year


Imbalance prices on 31-3-2016
Balancing prices in Elia (Belgian TSO), in case of positive (POS) or negative deviations (NEG). The required volumes from Elia (positive of negative) is the NRV (Net Regulating Volume)
€/MWh
150
100
50
0
-50
-100
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hours
NRV (MW)
POS (€/MWh)
NEG (€/MWh)

Volumes and prices

The volume of **Intraday transactions** is very small compared to the Day-ahead Market (**2-3%).**

Intra-day prices are usually slightly higher than Day-ahead prices

The volume of transactions in the **balancing market** is again small but usually slightly higher than the Intraday market.

However, **prices are most likely to fluctuate**, <u>especially at the times when the load and renewable energy forecasts have a large deviation</u>. Therefore, a producer can enhance his profitability at these times.

In addition, the producer has an **ancillary services market** and a power market to enhance revenue.

Volumes and prices

Ancillary services for 2016 in Elia

Auctions are made in the previous month and concern the next month. However, the auctioned volume is determined on an annual basis.

Service	Volume (MW)	Price €/MWh
R1 Symmetric200	73,0	18,75
R2 Upward	140,0	8,28
R2 Downward	140,0	8,28
R3 Production	62,0	7,46
R3 DP (demand/production)	8,0	4,83

The services are mainly for producers, but some of them also for consumers (demand-side flexibility).

Supplementary markets

The Transmission System Operator may also create a capacity market. This market includes some of the following categories:

- **capacity availability**
- **flexibility**
- **strategic reserves**
- **Demand-side response (interuptibility)**

In Belgium, the results from the purchase of strategic reserves for the winter months (usually uncompetitive old units paid to be available in the critical months, and eventually their operating costs will also be paid).

Contracted volumes and prices for strategic reserve:

Delivery period	Strategic Reserve Type	Total Contracted Volume [MW]	Average Price [€/MW/h]	Average activation price [€/MWh](3)	Generation Load type
Winter period 2015-2016	SGR	1 177,1(1)	10,62	62,44(4)	Generation
Winter period 2015-2016	SDR	358,4(2)	9,76	736,73	Load

(1) These volumes were constituted in two call for tenders (first one organized in 2014 in which 750 MW were procured for 3 winter periods and the second one organized in 2015 in which 427,1 MW were procured for the 2015-2016 winter period).
(2) Volume contracted in the tender for the winter period 2015-2016, valid for this period only.
(3) Weighted average MWh price for an activation of 4 hours.
(4) The SGR activation price is the result of a formula, described in the Functioning Rules of Strategic Reserve, which includes the daily fuel and CO2 prices. The calculation of average variable costs represented here is made based on the fuel and CO2 prices of January 25th, 2016. Moreover the cold activation prices are considered.

Capacity Mechanism Reform

Table 6: Basic form of the proposed CRM reform

Pillars	*Resource adequacy purpose*	*Mechanism of remuneration*
Capacity Availability	Meeting peak load (with adequate reserve margin at a probability below a threshold – LOLP)	Remunerate true capacity availability of dispatchable plants using a unit capacity payment approach
Flexibility	Meeting ramping system requirements and avoiding over-generation or renewables curtailment (at a probability below a threshold – LORP)	Remunerate capability of dispatchable plants to perform ramping at rates beyond a certain threshold using a mixed system which combines a fixed payment and a variable payment component
Strategic Reserve	Meeting peak load in rare cases of extreme events involving simultaneously high demand and very low availability of renewable resources	Conclude contracts with plants remaining in cold reserve for strategic reserve purposes, following a procurement procedure
Demand Side Response	Meeting peak load at times of high demand on a daily and seasonal basis through interruption of load by large industries	Remunerate energy demand reduction at system marginal price levels or at prices determined after a tender for a limited collection of times of high demand

Ancillary services

Ancillary services

An important aspect of balancing is the approach to **procuring ancillary services**.

'Ancillary services' refers to a range of functions which TSOs contract so that they can guarantee system security.

These include:

- **black start capability** (the ability to restart a grid following a blackout);
- **frequency response** (to maintain system frequency with automatic and very fast responses);
- **fast reserve** (which can provide additional energy when needed);
- the provision of **reactive power** and various other services.

Ancillary services

Ancillary services are the services required to transport electricity through the Transmission System from injection points to points of consumption and to ensure the **quality of electricity supply to consumers.**

The types of ancillary services are:

- **Primary reserve**
- **Secondary reserve**
- **Tertiary spinning and non-spinning reserve**
- Standing Reserve
- Voltage control
- Black-start capability

The first four are referred to as Ancillary Frequency and Active Power Services

Ancillary services

Primary reserve

Frequency stabilization within 30 seconds of frequency disturbance

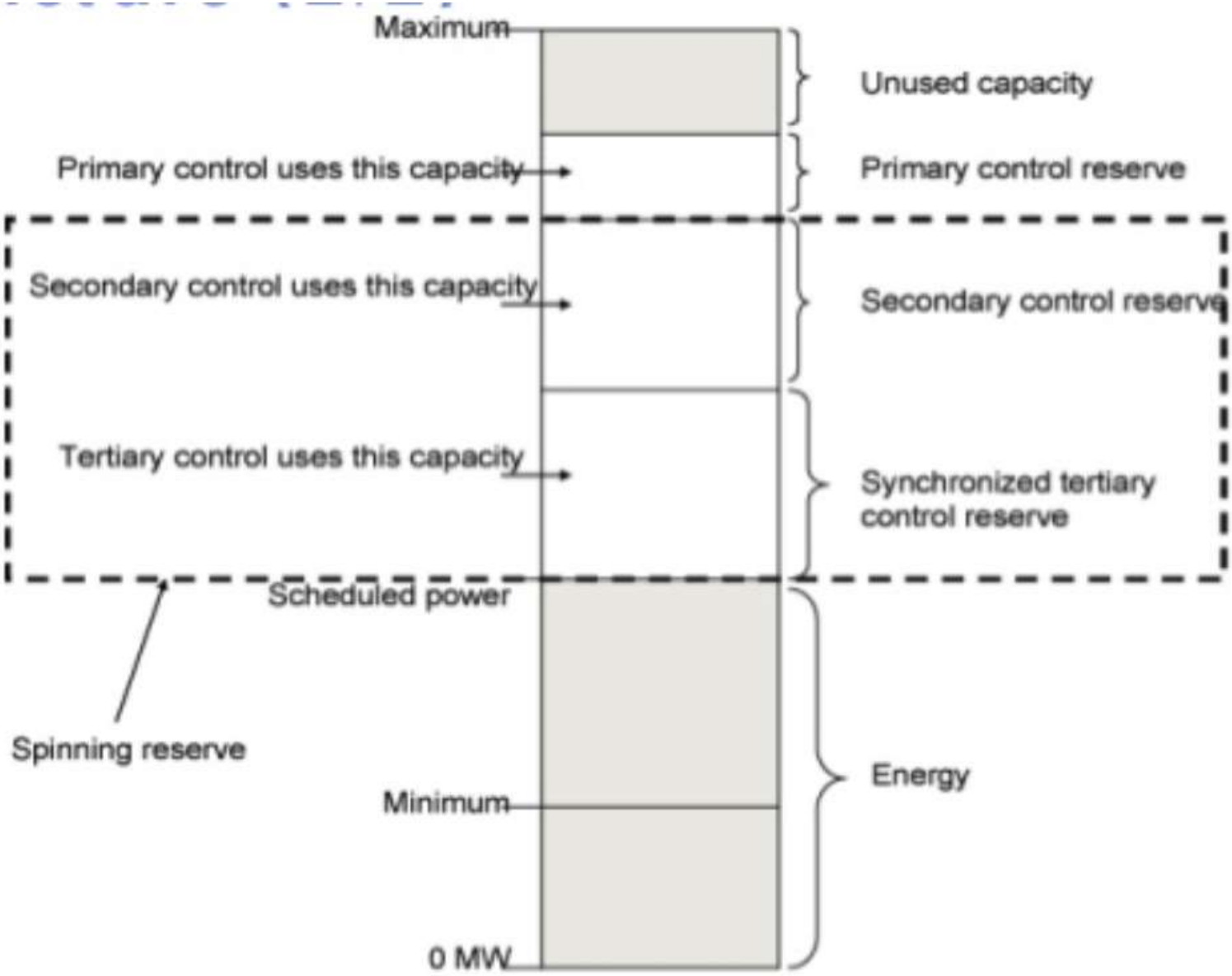
Secondary Reserve

Corrects Productivity and Consumption Deviations of a Control Box as well as Frequency Deviations of the System.

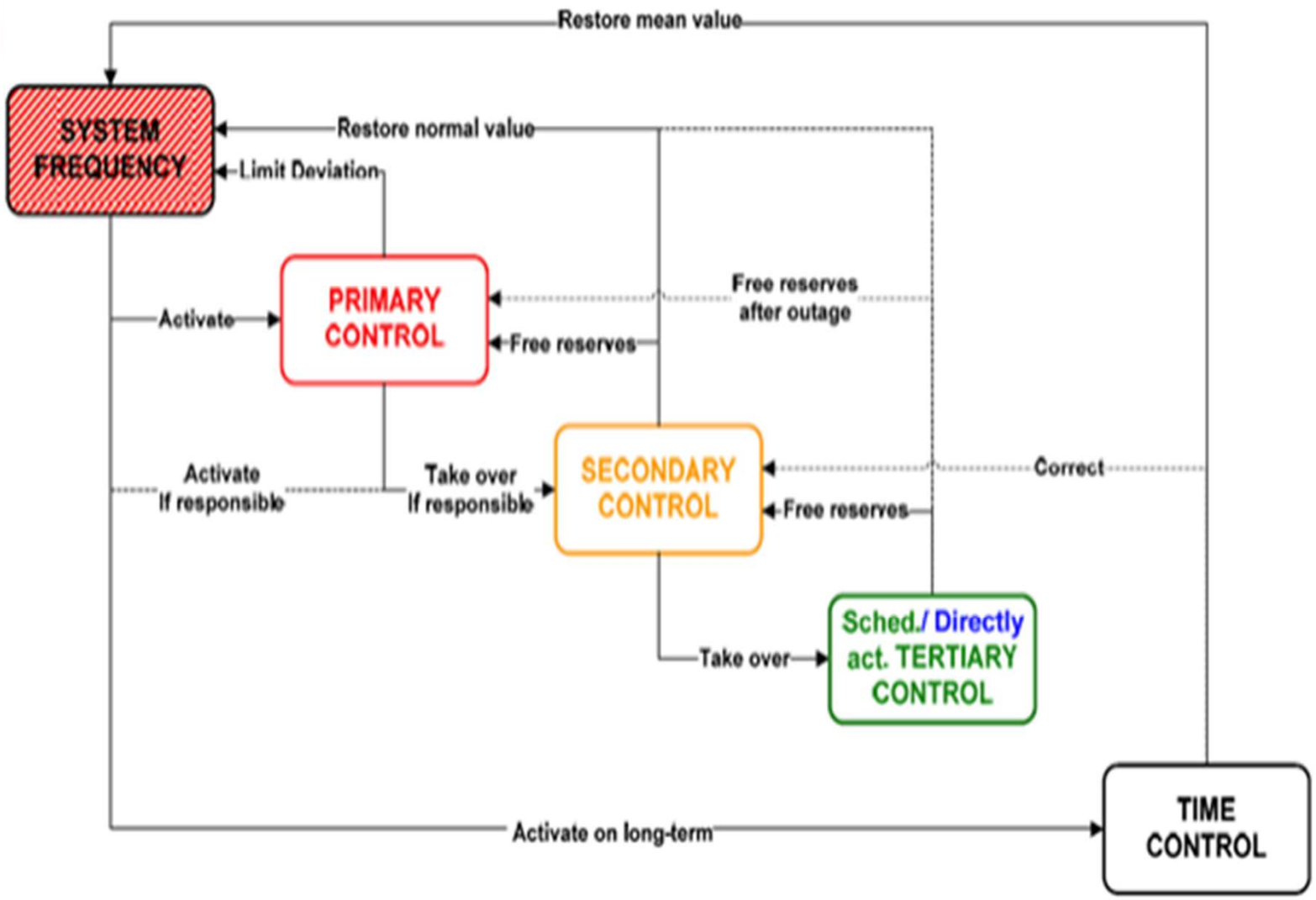
Uses centrally installed AGC, which adjusts the power output of the units between 10 seconds and 15 minutes from activation

The Tertiary Reserve is the power reserve of one unit between 90 seconds and 15 minutes of a dispatch instruction

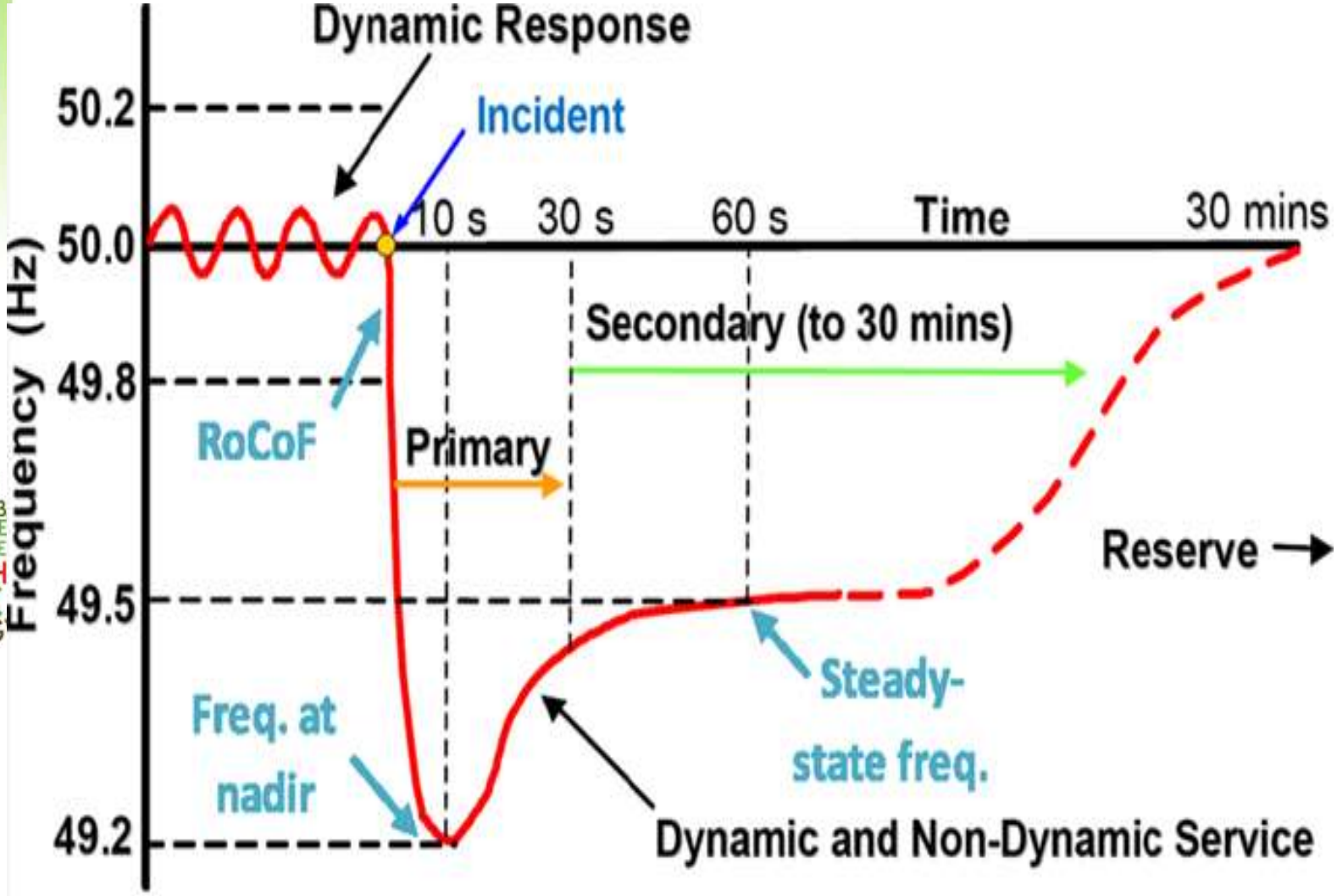
Activation of reserves in AGC



Activation of reserves for frequency control



Activation of reserves



New services

The penetration of RES creates the need for new services / markets.

Such as **flexibility**, which can be divided into 2 markets.

1. Be part of the capacity market, so flexibility is organized at the level of long-term planning.
This practically gives a price signal for the construction of flexible units, similar to how a market availability of power gives a signal for the need to build new units (just in the case of flexibility, these units must be flexible).

In this case, an auction is made for a minimum requirement of flexible power, depending on the estimated mix eg. the penetration of RES. The auction is organized at year level.

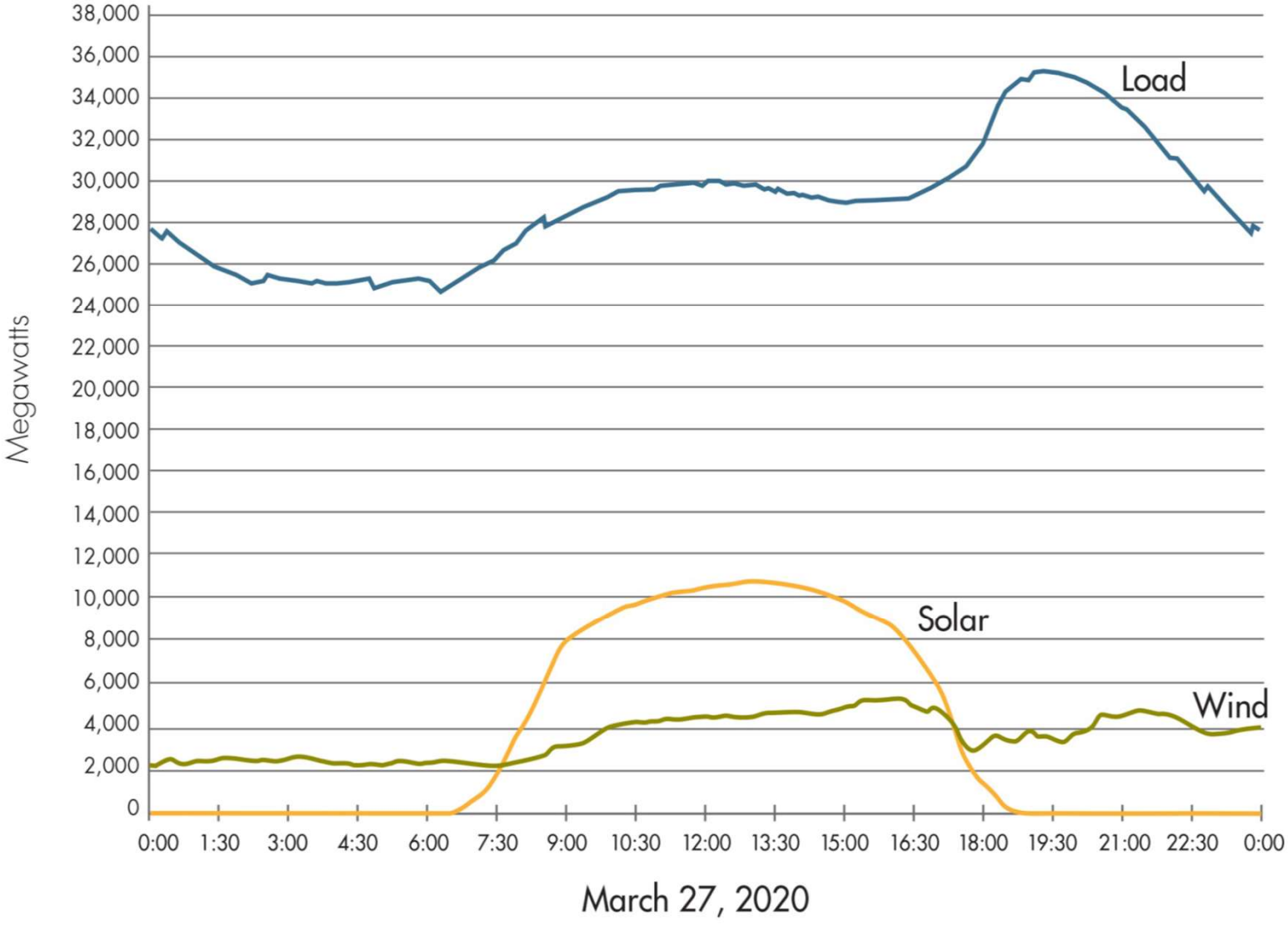
New services

2. Be part of the **day-to-day operation** of the system by the Operator, so flexibility is similar to other ancillary services markets.

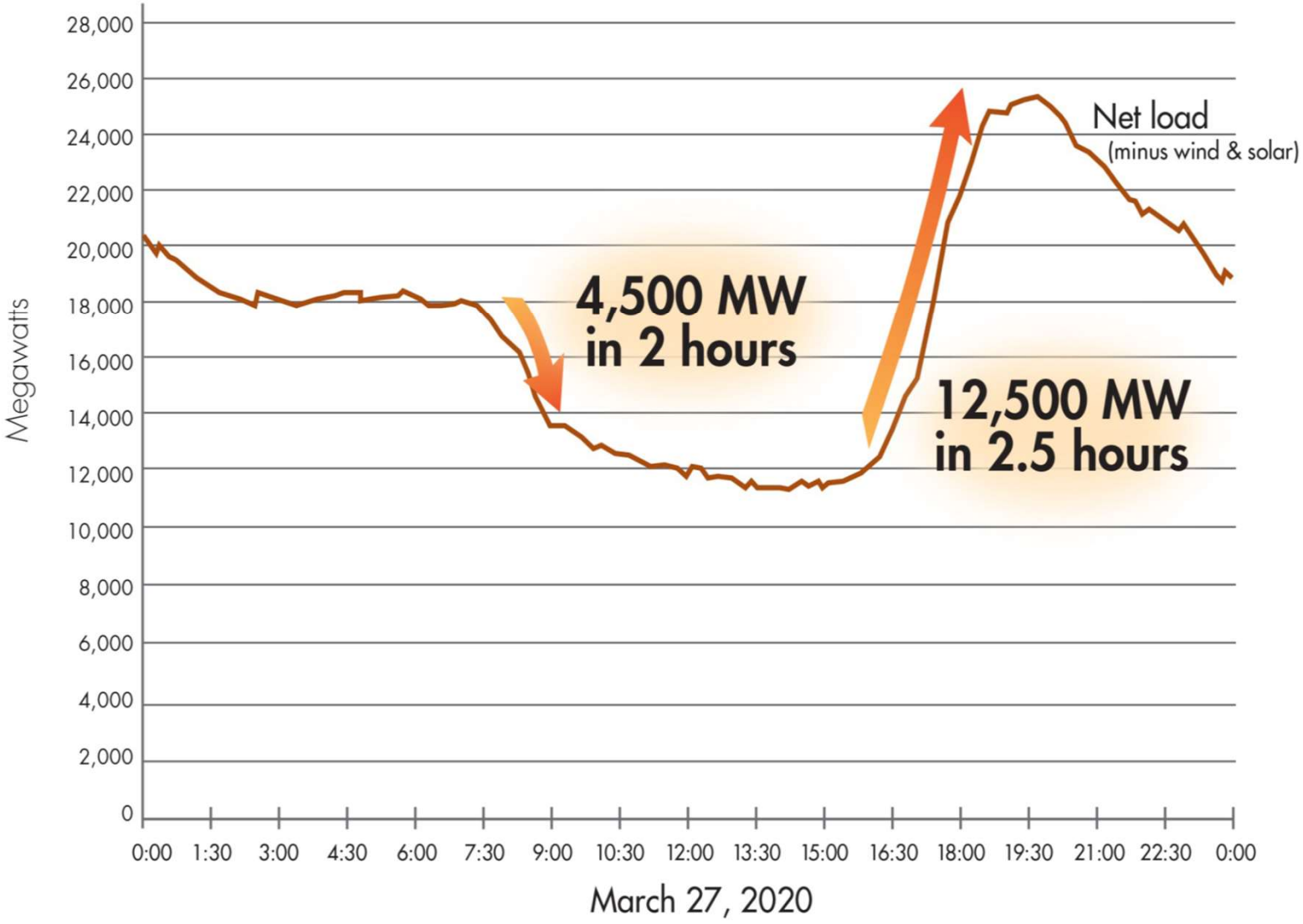
In this case, the Transmission System Operator determines flexibility requirements for each hour and day and a relevant auction is made for a minimum requirement of flexible power, depending on the estimated mix eg. the penetration of RES on that day. The auction is logically organized at day level.

A criterion for flexibility will be **ramping capacity**, that is, the rate at which a unit increases/decreases its output over a period of time. So it is estimated that this type of service will mainly be provided by large hydropower units (with a water storage reservoir) and natural gas units.

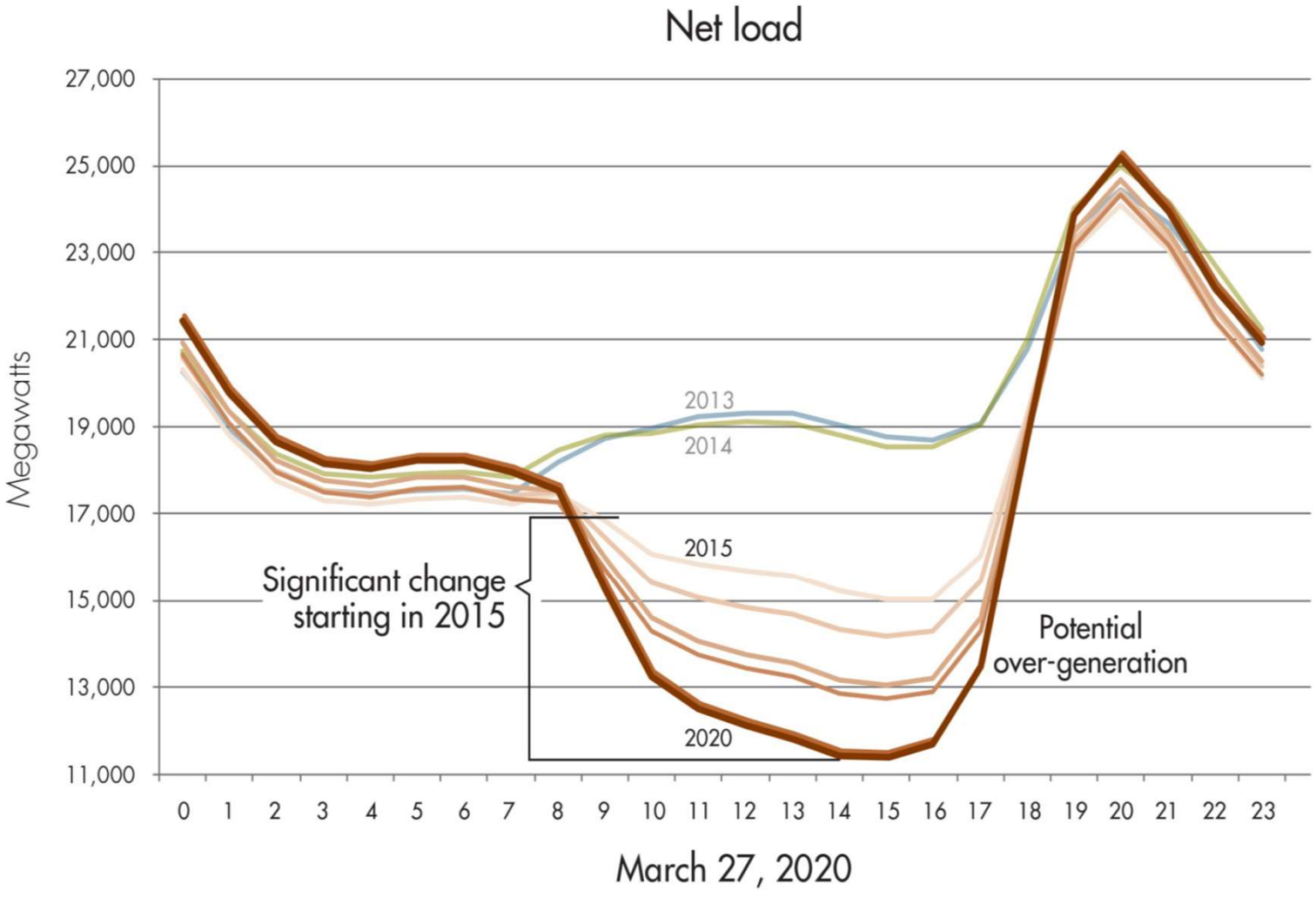
Estimated curves for Load, Solar and Wind generation for the California ISO for a specific date 27th March 2020



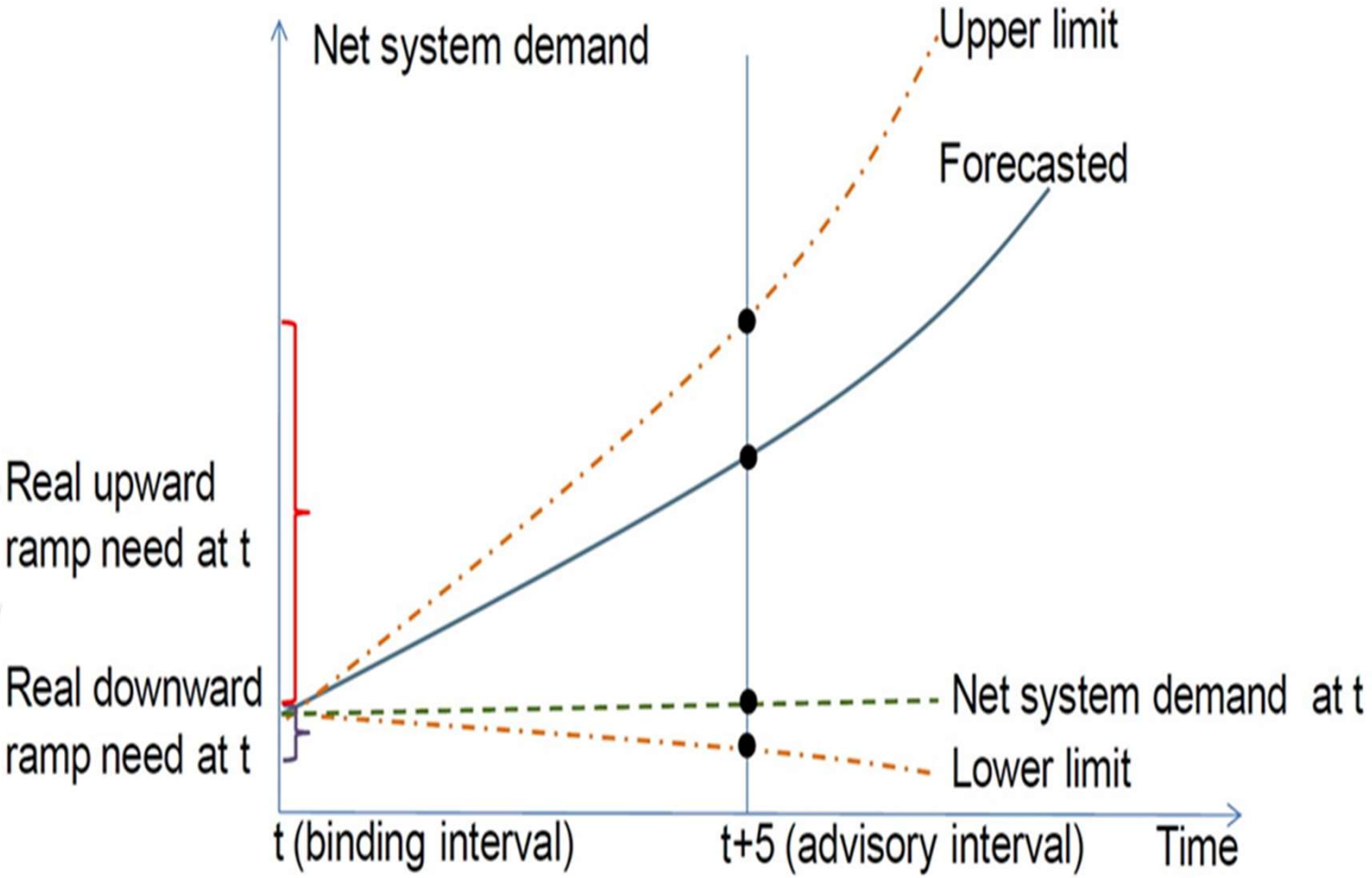
Estimated flexibility needs for the California ISO for a specific date 27th March 2020



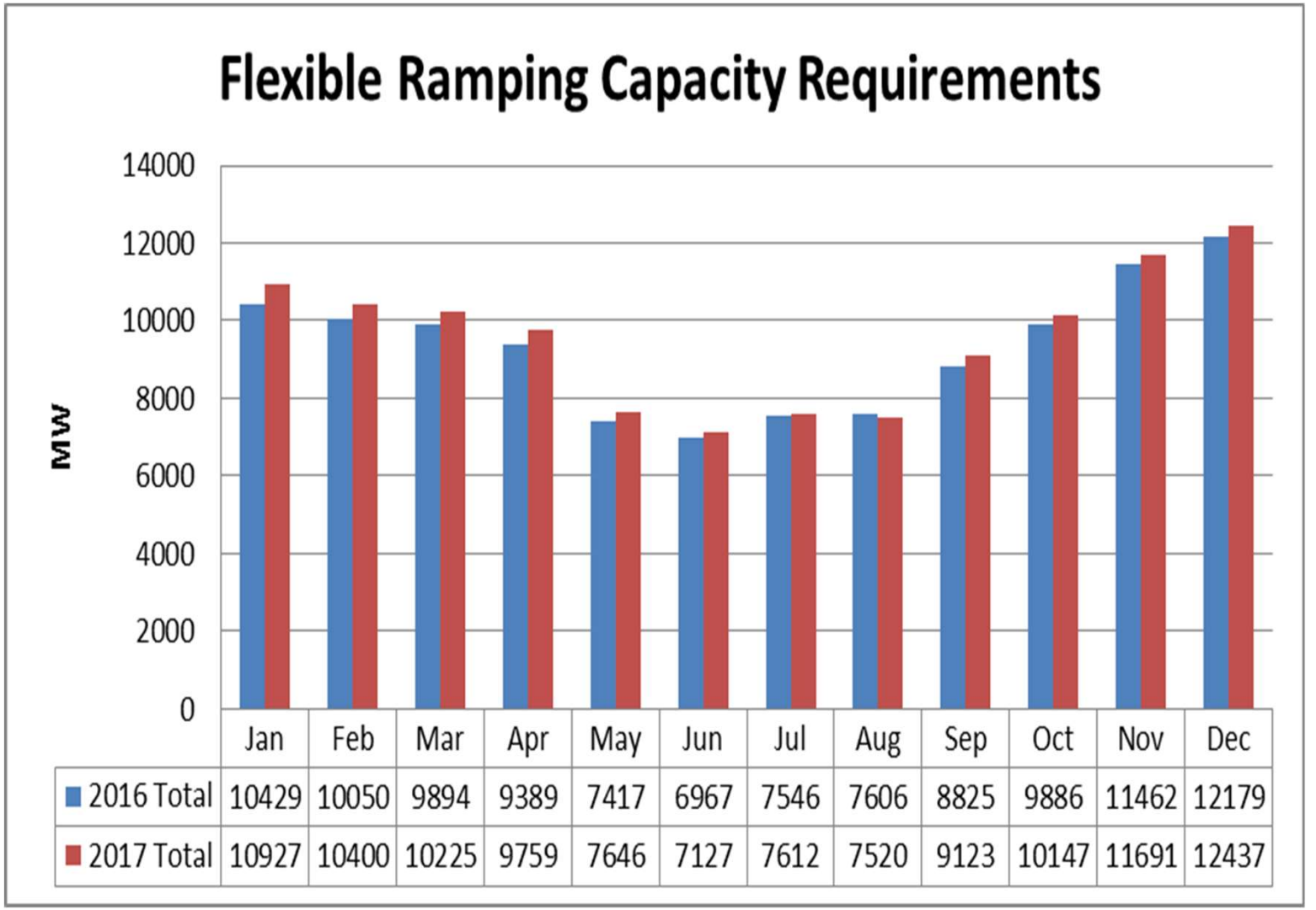
Evolution of net load and of the flexibility needs over the period 2013-2020 for the California ISO



Real ramping need between times t and t + 5 minutes, source: California ISO



Evolution of estimated Flexible Ramping Capacity Requirements per month over the period 2016-2017 for the California ISO



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016 Total	10429	10050	9894	9389	7417	6967	7546	7606	8825	9886	11462	12179
2017 Total	10927	10400	10225	9759	7646	7127	7612	7520	9123	10147	11691	12437

Demand response and demand flexibility

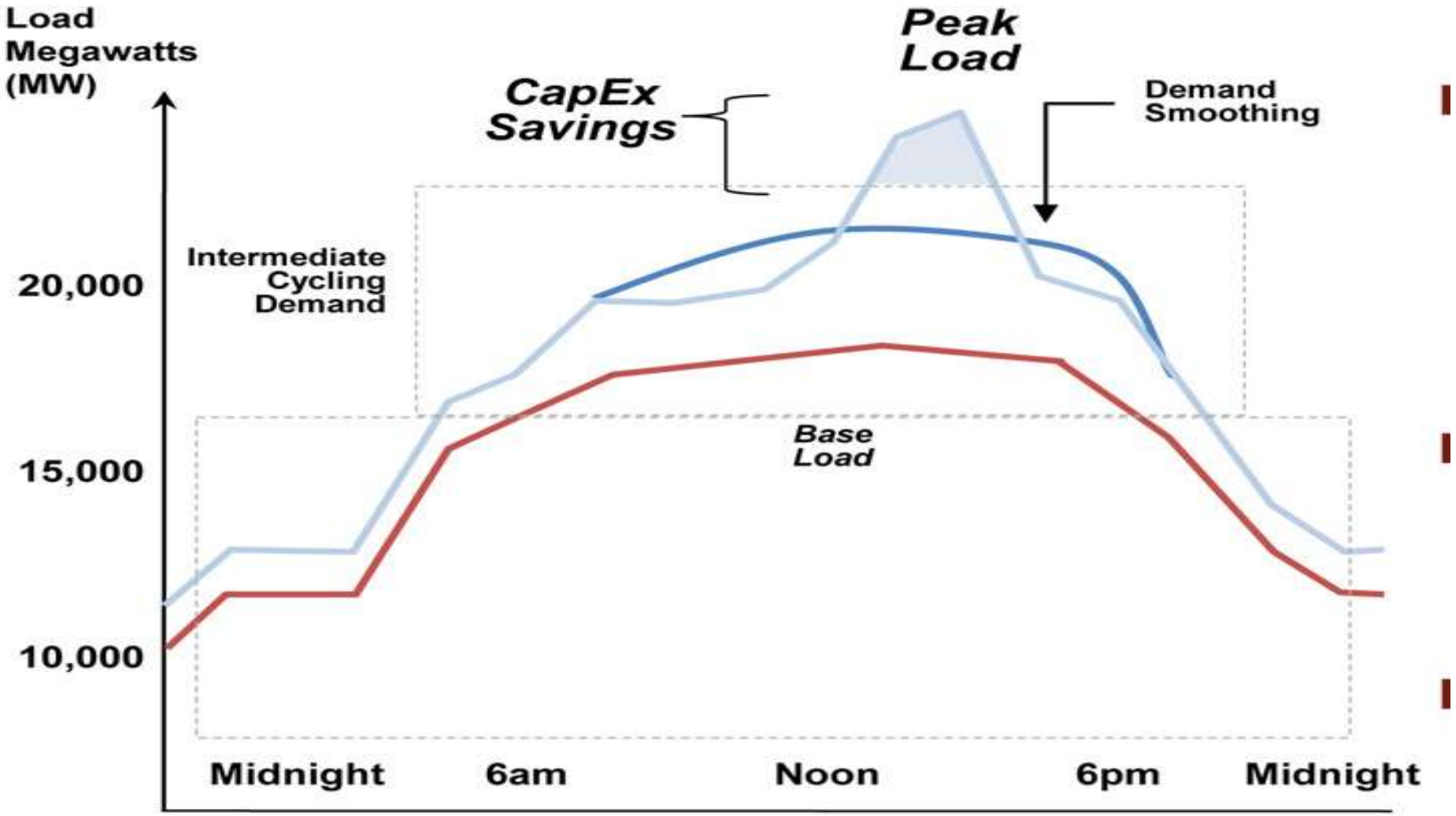
Demand response and demand flexibility

If a consumer has an **intelligent consumption measurement** and **remote control system**, he can participate in the real-time market by providing a number of benefits:

- **Reduction of peak demand**, and the need to invest in major infrastructure projects (Capital Expenditure)
- **Smoothing / shedding of load demand**, contributing to the stability and economy of the system
  - Ideally, the load curve would eliminate the load peaks and limit the intermediate load level so that the total load resembles the base load.

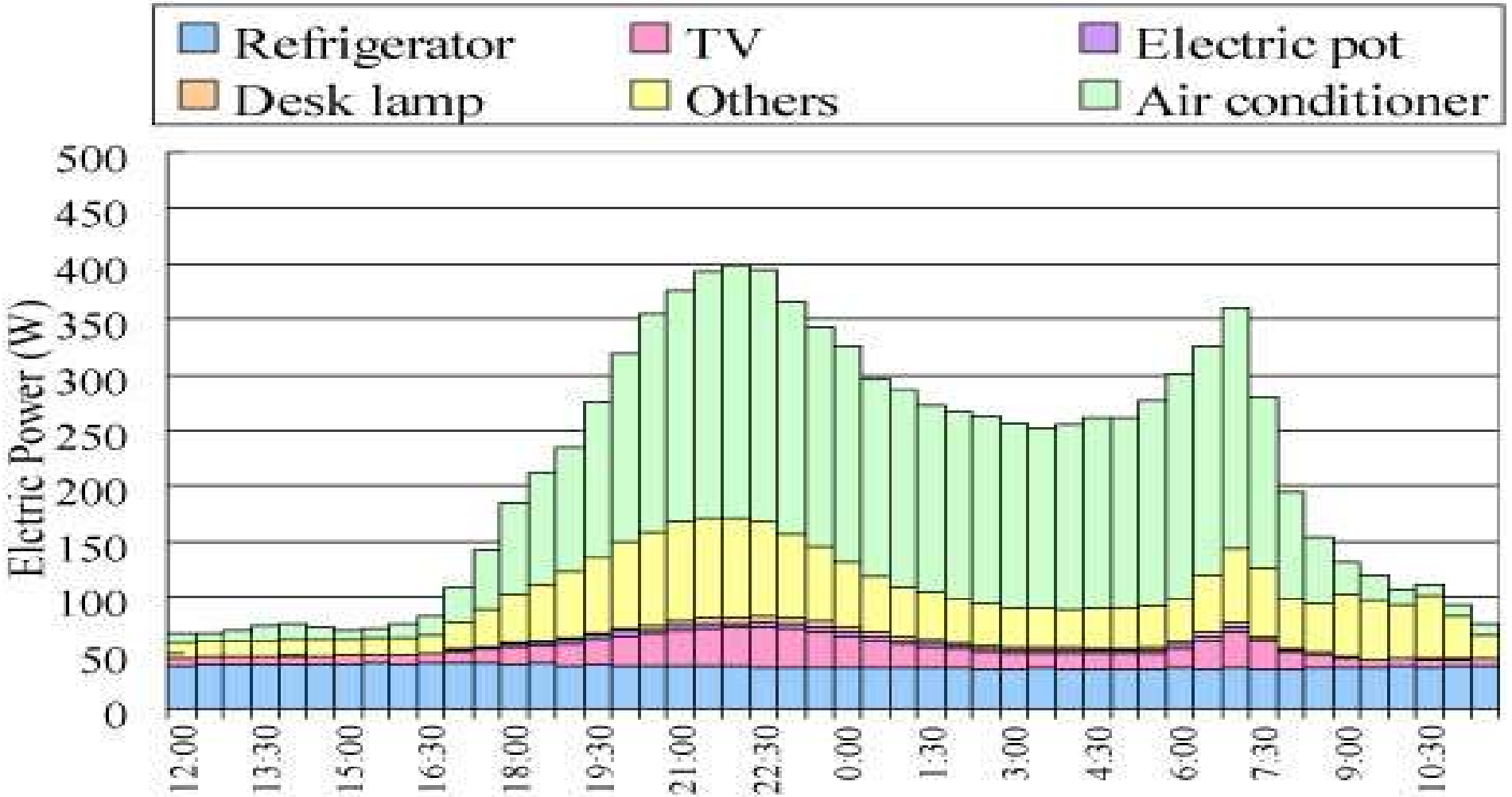
In addition, **energy savings** lead to an reduction of total energy system costs (no regret options)

Demand Response and Demand flexibility



Demand Response and Demand flexibility

Even households can participate, in case of smart meters & flexible tariffs



Summary


FLORA
NATURE
LEAF
GREEN
WORLD
GROWTH
GLOBAL
LIFE
ECO
PROTECT
RECYCLE
TREE
PLANET
NATURAL
FLORA
GLOBA
ORGANIC
PROTECT
RECYCLE
PLANET
PLANT
TREE
ENVIRONMENTAL
RECYCLING
GREEN
TREE
EARTH
ECO
EARTH
PLANET
TREE
ECOLOGY
VEGETATION
GREEN
ALTERNATIVE
GREEN
NATURAL
GROWTH
ORGANIC
LEAF
ECO

Conclusions

A contemporary energy (power) market consists of:

- **Bilateral contracts**
- **Futures)**
  - **OTCof in energy excange**
- **Day-ahead market**
- **Intra-day market**
- **Ancillary services market**
- **Balancing market**

Prices in power markets are in €/MWh

Supplementary markets:

- **Capacity market**
  - **Flexibility**
  - **Demand response**

Prices in capacity markets are in €/MW

Conclusions – simplified case

One power plant, for one hour, is required (directly or through a retailer) to sell energy into a consumer where the transaction is consumed

- on an **energy exchange** and / or,
- through a **bilateral contract**

The power plant, in the case of a bilateral contract, is paid for the energy it produces at the agreed price with the consumer / supplier.

In the case of an energy exchange, transactions and cash flows are done through clearing houses.

The consumer is charged with the regulated transmission system usage costs and any other regulated charges.

Conclusions – simplified case

In practice, however, there may be **deviations** between scheduled and measured volumes.

That is why there exist <u>different markets</u>:

The intraday market allows the participants (producer, supplier, consumer) to correct their design (production / consumption)

The market for **ancillary services** is essential for the System Operator for the stability of the system

Similarly, the **balancing market**, which defines their deviations and prices to clear them.

Also, for reasons of system stability, attracting investment, tackling the problem of missing money, there may be a market for capacity availability and flexible power.

Sources

- *ENTSOE, 2011, EU Target Model for Market integration*
  https://www.energy-community.org/pls/portal/docs/914180.PDF
- *ACER, 2013, Electricity Target Model and its early implementation.*
  https://www.energy-community.org/portal/page/portal/ENC_HOME/DOCS/2104182/Electricty_Target_Model_-_Mr_Cesson.pdf
- ECCO International Inc., 2014, *Analysis of the High level Design for Reorganizing the Whole Sale Electricity Market in Greece*,
  http://www.rae.gr/site/file/system/docs/consultations/30092014/10112014
- Houmoller Consulting ApS, 2014
  www.houmollerconsulting.dk
- *Evolution of Global Electricity Markets: New Paradigms, New Challenges, New Approaches,* Fereidoon P. Sioshansi (eds.), Elsevier Inc., 2013