Markets Workshop 2.1

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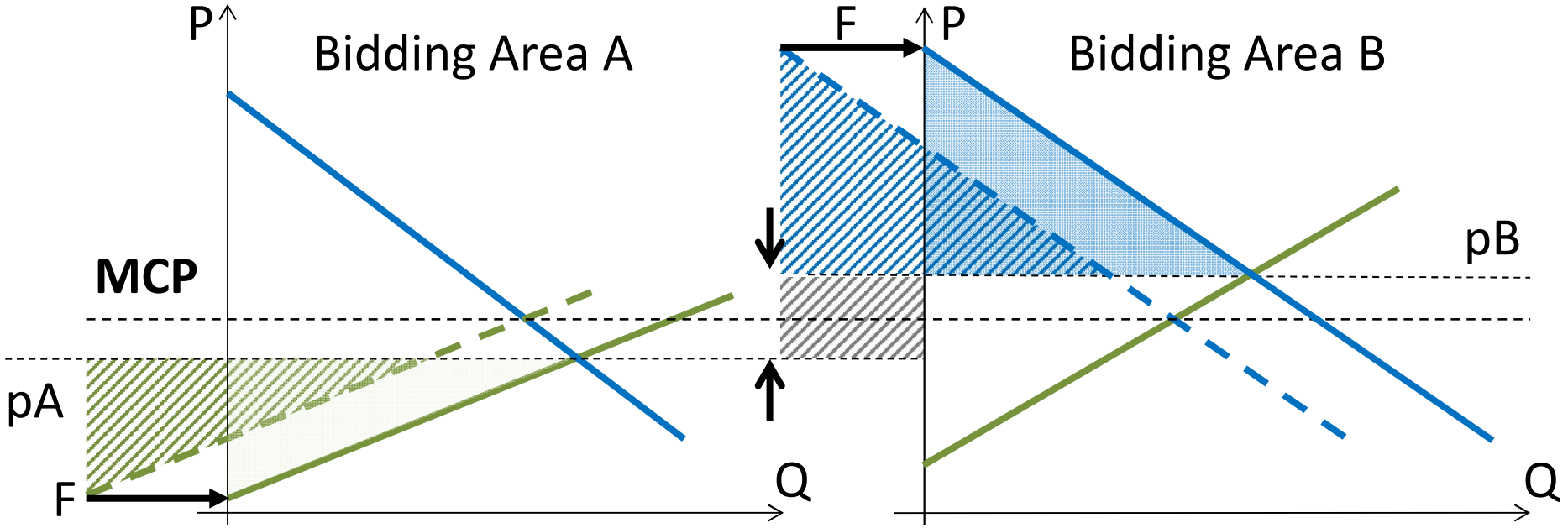
The presentation aims at giving a **high-level overview of the mechanism of day-ahead coupling**.

The presentation is structured as follows:

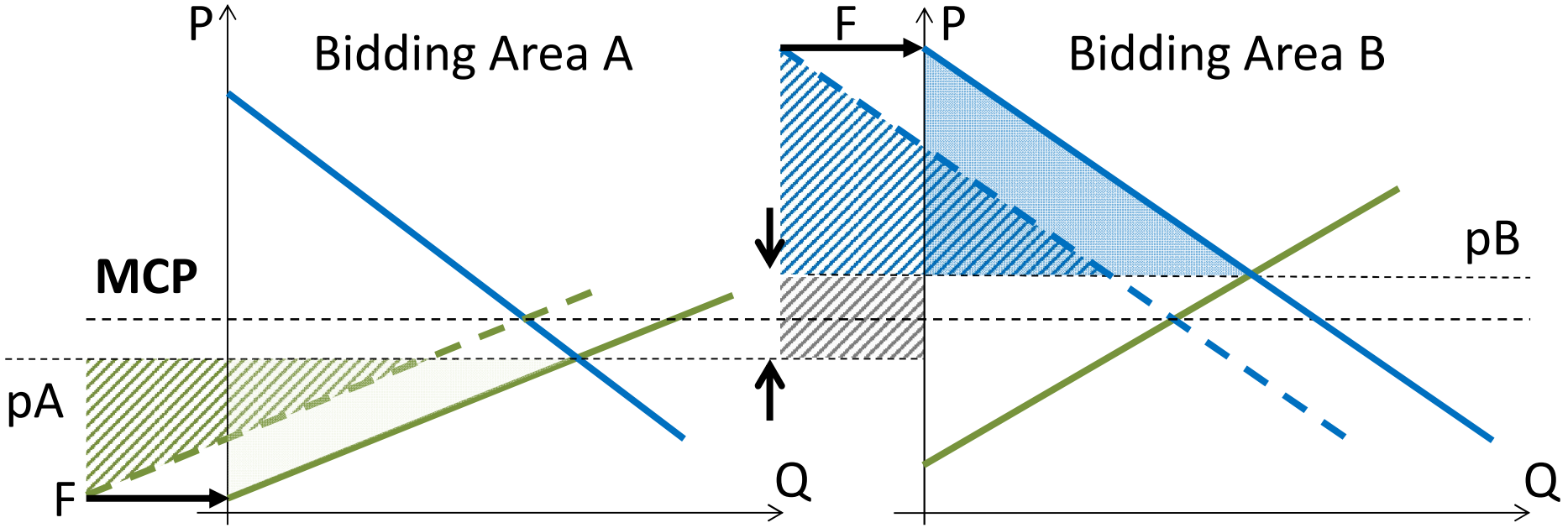
- Principles of auction-based and market coupling mechanism
- Order types currently available in Euphemia
- Modelling of network features
- Coupling architecture

Day-ahead power markets are **auction-based markets**

- **Day-ahead** is the term of delivery: products are traded in a day for delivery in the next day.
- **Auction-based** is the modality of the market, which has several implications:
  - Calculated prices are **market clearing prices** which apply to every executed order.
  - Orders are sent into Order Books at limit prices without knowing the prices and quantities of the other orders.
  - During the opening of Order Books (OBKs), no trade is executed. **Trade execution** is made **simultaneously for all trades** after gate closure: no change in OBK is possible before the starting of trade execution.
    In other words, the sequence of operations does not mix between OBK update and trade execution.



- Market coupling **increases welfare**.
- Supply in A matches with demand in B: price in A increases whereas price in B decreases.
- **Market coupling optimizes capacity allocation**, thus prevents both adverse flows and under-used capacity.
- Market coupling merges isolated bidding zones whereas market splitting splits country into smaller bidding zones. In both cases, coupling mechanism is the identical.



Coupling problem can be seen as a **welfare optimisation problem**:

- Maximise social welfare
  - **Welfare = Supplier surplus + Producer surplus + Congestion Rent**
- Subject to constraints:
  - Order execution rules
  - Network constraints (e.g. flows within the range of ATCs)

List of order types in Euphemia

- **Stepwise / piecewise hourly orders**
  - Must be executed if in-the-money
  - Must be non executed if out-of-the-money
  - Can be partially up to any acceptance ratio if at-the-money
- **Block orders**
  - **Regular** block orders link consecutive hours together with the same quantity - Execution rule: kill-or-fill.
  - **Profiled** block orders link non consecutive hours together with different quantities.
    Execution rule: can be partially accepted above minimum acceptance ration has been reached.
  - **Flexible** order: similar to one-hour regular block order; but the execution hour is determined by the optimisation process, not set beforehand.

List of order types in Euphemia

- **Block orders**
  - **Exclusive** block orders: a group of block orders for which the sum of accepted ratio cannot exceed 1.
    The combination of accepted blocks in the group is determined by the optimisation process.
  - **Linked** block orders link block orders together: “child can save parent” i.e. the surplus provided by the acceptance of the child block is higher than the loss due to the acceptance of the parent block: accepting them both is welfare beneficial.

List of order types in Euphemia

- **Spanish orders**
  - **Minimum Income Condition** (MIC) orders
    MIC orders represent the minimum cost to be covered by the execution of the order: the minimum cost is modelled by a fixed term and a linear variable cost.
    MIC orders can have a **Schedule Stop** condition which avoid the MIC to be fully rejected (if not executed) during the first hours in a day.
  - **Load Gradient** orders limit the variation of the executed quantity between consecutive hours.
- Italian orders: PUN orders guarantee some buyers to be executed at the same price everywhere in Italy although Italy is split into several bidding zones, so that sell orders can be executed at different clearing prices if they are located in different bidding zones.

- If block price in-the-money, then block quantity fully executed?

Demand

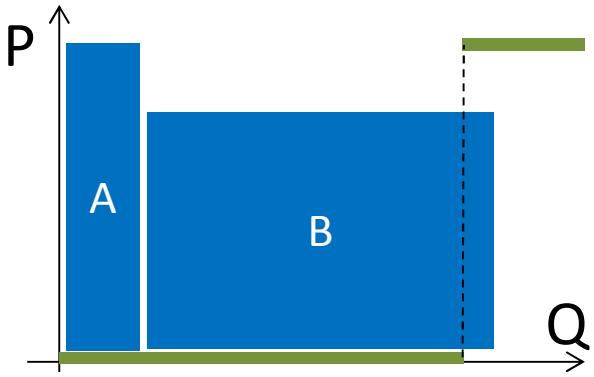
Block A: 10MWh@100€ /MWh

Block B: 100MWh@80€ /MWh

Supply

Stepwise 1: 105MWh@0€ /MWh

Stepwise 2: 20MWh@110€ /MWh



- Stepwise 2 cannot be executed (otherwise MCP >= 110€ and demand block out-of-the-money).
- Stepwise 1 can be partially executed but has no sufficient quantity to match block A and block B simultaneously.
  - If block A is matched, then Stepwise 1 is only partially executed up 10MWh and MCP = 0€.
    Welfare = 10MWh x 100€/MWh = 1 000€.
  - If block B is matched, then Stepwise 1 is only partially executed up to 100MWh and MCP = 0€.
    Welfare = 100MWh x 80€/MWh = 8 000€.
- Whatever the choice, MCP = 0€ and one block is rejected though in-the-money i.e. Paradoxically Rejected.
- Block execution rules must consider the possibility for a block to be Paradoxically Rejected.

Execution rule for block orders

- If block price in-the-money, then block quantity **can** be executed; if it actually is, then it is fully executed.
- If block price out-of-the-money, then no execution.

List of network features in Euphemia

- ATC

  Flow cannot exceed the Available Transmission Capacity. ATC is directional i.e. can be different “up” and “down”.

- Cumulative ATC

  Sum of flows over a set of interconnections cannot exceed a given value (this network feature is not directly implemented in Euphemia; however, it is possible to model the cumulative ATC requirement through a virtual bidding area).

- Flow-Based

  Constraints limiting flows are replaced by constraints limiting the exchanges between bidding areas, which better represents the critical branches of the network.

- Ramping

  Flow variation between two consecutive hours cannot exceed a given value (e.g. AC / DC converter).

- Cumulative ramping

  The sum of flow variation over a set of interconnections between two consecutive hours cannot exceed a given value.

- Hourly and daily net position ramping

  The variation of a bidding area net position can be limited between two consecutive hours or over a whole day.

- Tariff

  An interconnection has a tariff which creates a minimum price difference at the ends of the interconnection even when no congestion occurs.

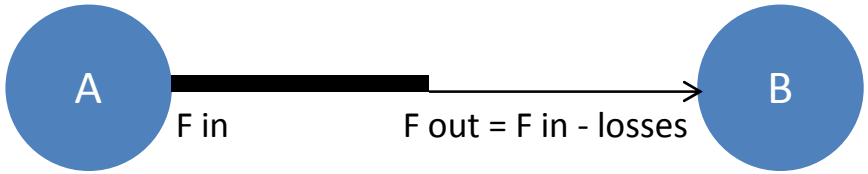
- Losses

  Flow at receiving end is lower than flow at sending end and prices are modified accordingly so that the amount paid by the buyer is equal to the amount received by the seller, which creates a price difference even when no congestion occurs (contrary to tariff, the price difference is not constant but depends on prices).

Price-network properties

- **Prices** are **in the direction of flows**
- Due to ramping constraints, flows can seem to be adverse in one hour but this is welfare maximising over the whole day.
- Losses create price difference even when flow does not reach ATC, which should not be interpreted as a congestion rent without congestion.

- Losses are paid at the price of the exporting bidding area, which is the cheaper price.



- Loss factor is a percentage: it corresponds to the energy share which is lost in the energy transmission through the interconnection.

  Although actual losses often have a quadratic profile of the load, loss factor is linear and independent from load.

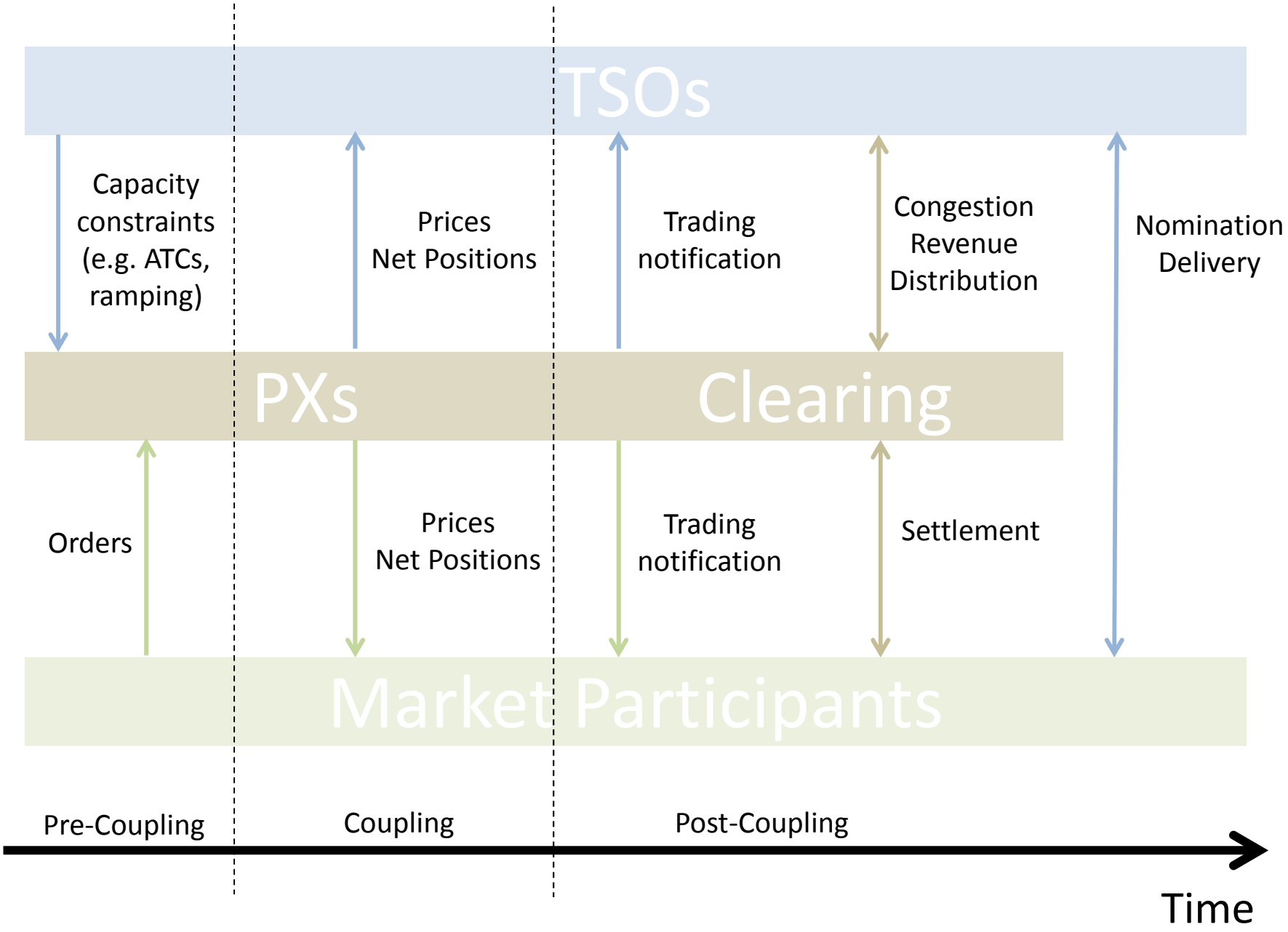
- Modification of total energy balance: Sum of net positions + Losses = 0.

Example

- Loss factor 2%
- Flow at sending end A = 50MWh
  Flow at receiving end B = 49MWh
- Price A = 100€
  Price B = 102.04€

Effect on welfare

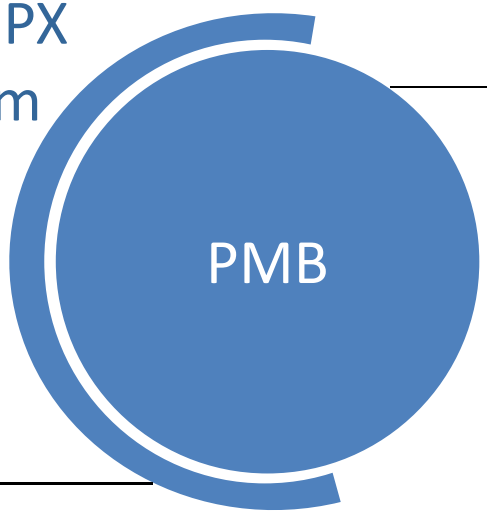
- Without losses included, TSO / Cable Operator explicitly purchases losses at a price which is not the market price (possibly higher; possibly lower, which deprives the market from lower prices).
- With losses included, **loss procurement is implicit at market price**, which maximises welfare.


TSOs
Capacity constraints (e.g. ATCs, ramping)
Prices Net Positions
Trading notification
Congestion Revenue Distribution
Nomination Delivery
PXs
Clearing
Orders
Prices Net Positions
Trading notification
Settlement
Market Participants
Pre-Coupling
Coupling
Post-Coupling
Time

TSO common system

- Performs common capacity calculation process
- Checks coupling results

Local PX System



- Aggregates coupling data
- Performs coupling calculation

TSO local system

- Calculates capacity constraints
- Checks congestion income
- Nomination system

- Aggregates coupling local data
- Checks coupling results
- Clearing and settlement systems

Main steps preceding price publication

- Calculation and sending of capacity constraints
- Aggregation of orders in OBKs
- Calculation of prices and net positions (welfare optimisation)
- Sending of coupling results

➡ **Each of this step is crucial and needs to be robust**

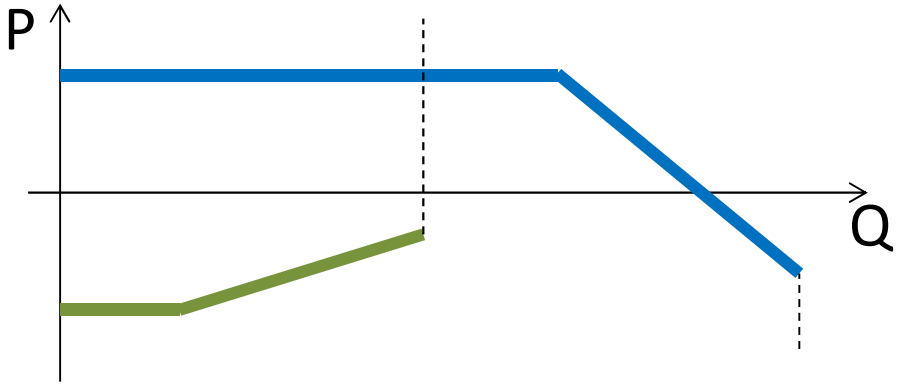
Fallback and mitigation solutions

- Decentralized Calculation aims at preventing the failure of one system.
- Checking results process (PXs side and TSOs side).
- Second Auction when price threshold has been reached.
- Partial Decoupling / Full Decoupling procedures maintain part of coupling process as much as possible.

Annex

- Purchase orders at maximum price and sell orders at minimum price are Price Taking Orders (PTOs) i.e. should always be executed.
- It can happen that **no sufficient supply** is offered to be matched against purchase PTOs (or conversely: **no sufficient demand** is offered to be matched against sell PTOs). This configuration is called **curtailment**.
- Rules define how to share scarce supply between demand PTOs, e.g.:

- Scarce supply can be shared between PTOs in all bidding areas;
- Some bidding areas can avoid the sharing of scarce supply;
- Scarce supply is shared between PTOs locally in each bidding area;



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