The European electricity market

Alignment of system and market operations

Tomasz Sikorski

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Polskie Sieci Elektroenergetyczne S.A.

Challenges ahead of us

Full integration of national markets (increased volume of cross-border trade)

Large scale RES integration (high volatility of power flows)

Fostering generation adequacy (missing money problem)

Growing penetration of DER

Flexibility activation

Grid development

New roles – active consumers, *prosumers, smart grids …*

Increasing digital dimension

Incentives for smart grid innovations

Efficient electricity market

Expected outcome of market-based electrical system operation

Open access & Non-discrimination

- Efficient utilization of the existing generation resources and transmission infrastructure for energy delivery (providing good short-run operating incentives)
- Efficient development of generation and transmission infrastructure from viewpoint of long-term consumers requirements (supporting forward markets and long-run investments)

Key requirements for efficient market/system operation

- **System Security** – ensure secure operation of the power systems by including detailed representation of both transmission and generation unit constraints directly in the market clearing processes (forward, day-head, intra-day and balancing market)
- **Economic Efficiency** – ensure comprehensive maximization of total social welfare by including all energy delivery cost components in the market clearing processes (costs of energy, reserves, congestions and losses)
- **Incentive Compatibility** – ensure coherency between market participants behaviors strategies and secure and costs effective use of the grid by applying correct price signals
- **Transparency** – ensure that market participants get access to the full set of market data, allowing to understand both power system and market outcomes

Challenges with current EU market design

Suboptimal market results

- **Disrupted competition** – (i) not all capacity offered to the market; (ii) socializing a significant part of energy delivery cost since system operation costs are not properly reflected in the electricity prices, i.e. reserves, congestions, losses
- **High risk of insecure system operation** – significant TSO measures conducted out of the market in order to make the market outcome technically feasible

Distortion of price formation

- Wholesale prices in EU countries are determined based on „approximated" cross-zonal capacities (significant share of the cross-border trade is in fact technically not feasible), giving incorrect signals to generation dispatch and mid-to-long-term generation investments
- Generous subsidies for RES exercise downward pressure on wholesale prices

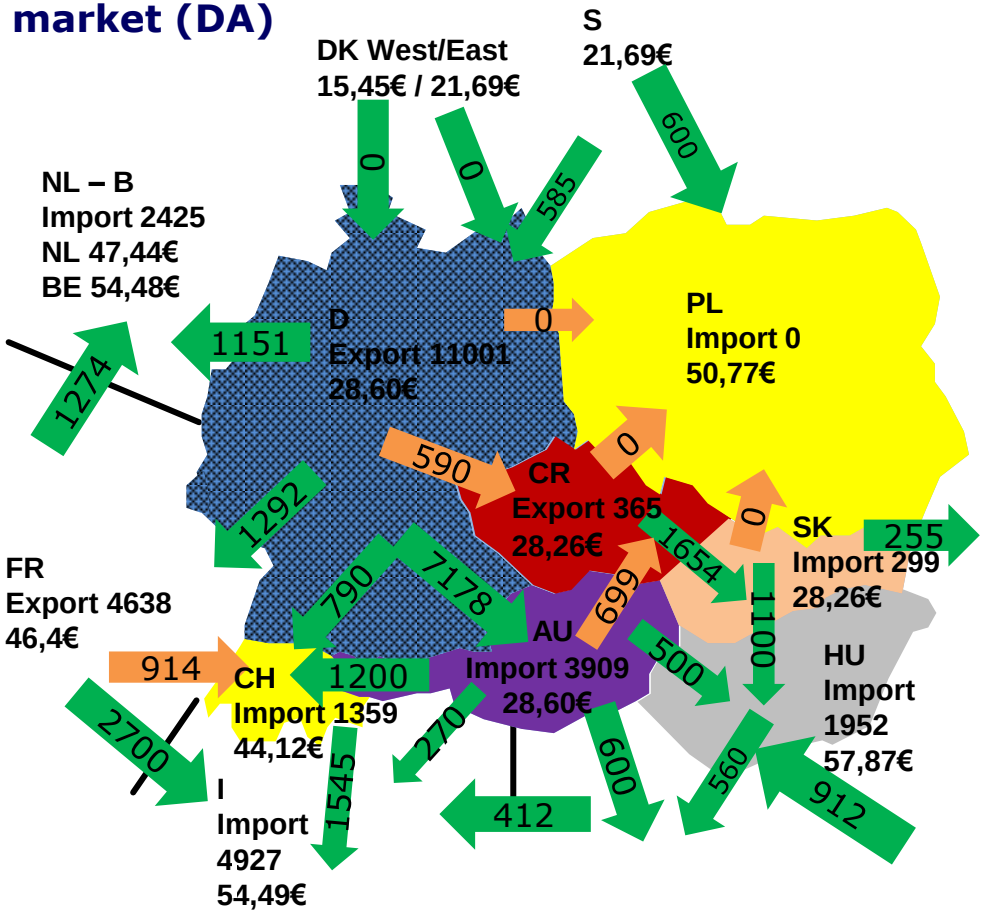
Energy-only market is insufficient to create incentives for required generation investments

- Scarcity pricing is not implemented
- Support systems for particular technologies (RES) reduce competitive market, creating downward pressure on prices
- Regulatory risk creates unstable conditions to invest in new resources (changes of law, implementation of the European Energy Market)

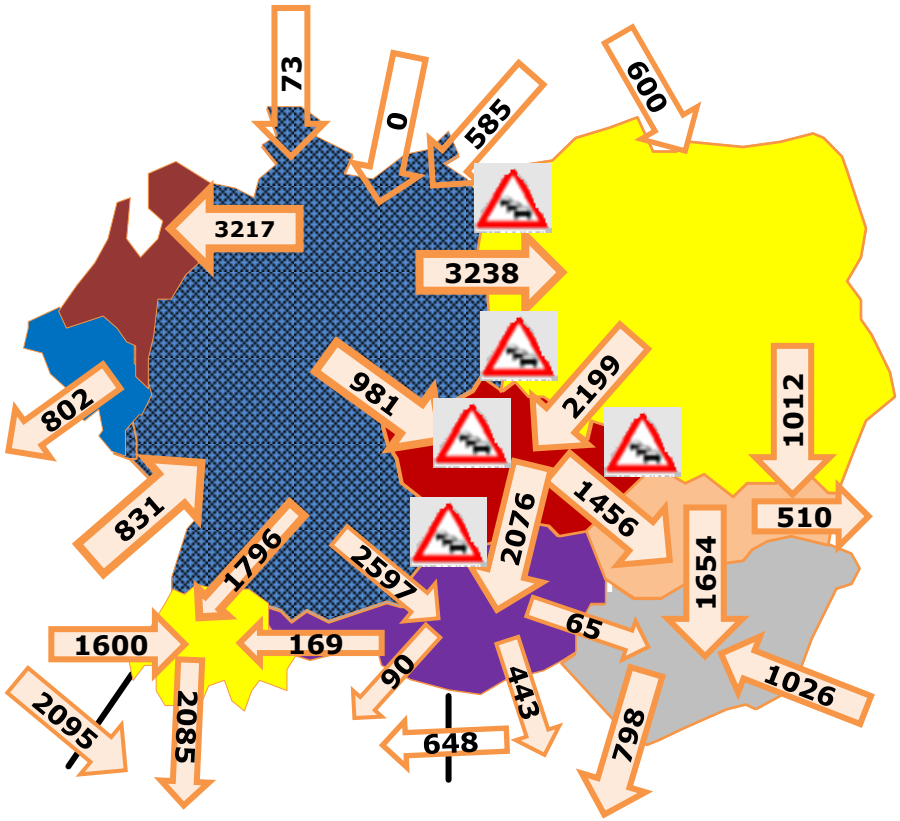
Market and System operations are currently disintegrated

Example of mismatch between commercial and physical flows: 15.09.2015, 11:30am (day ahead market schedules vs related physical flows)

schedules of day ahead market (DA)



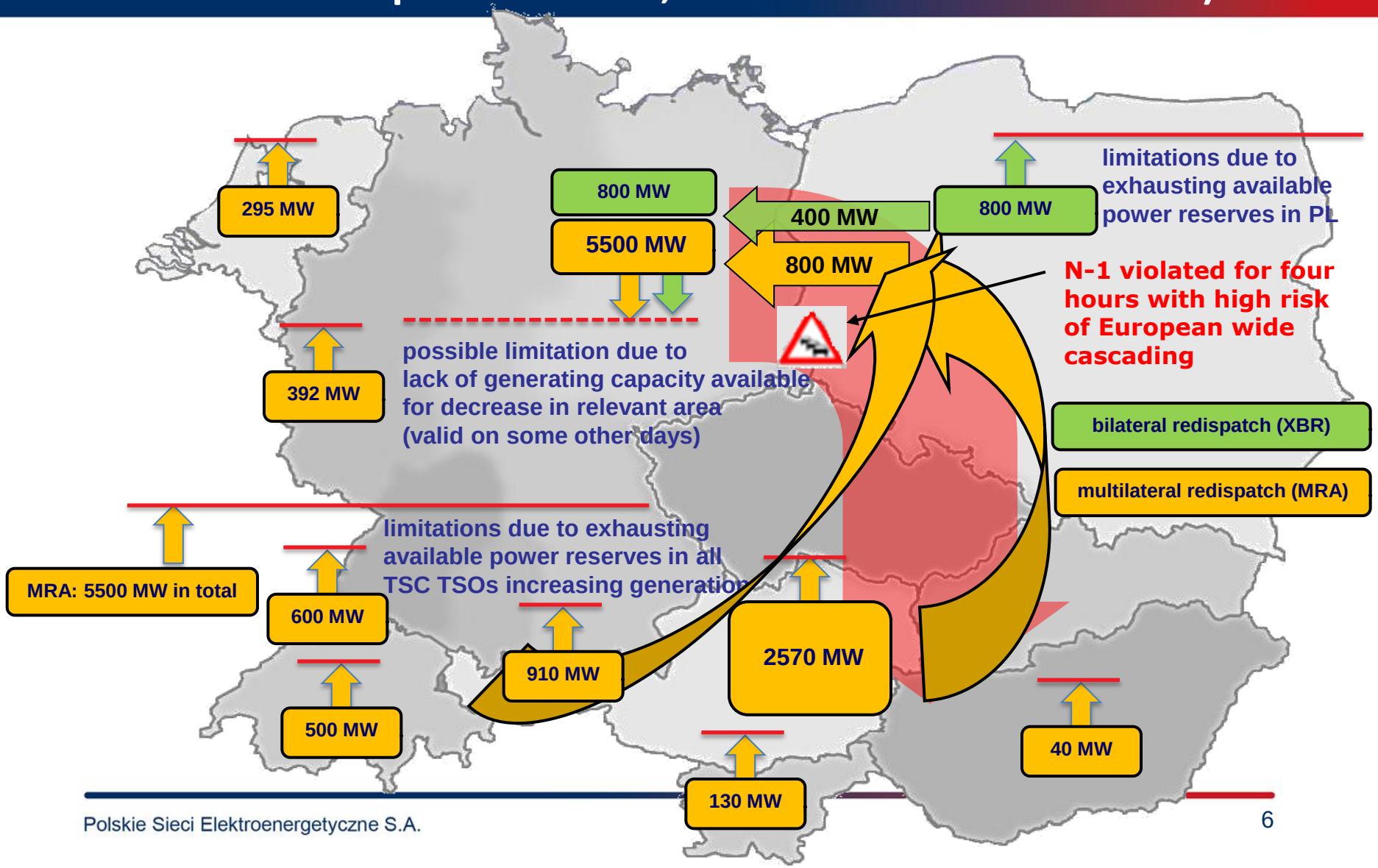
calculated flows DA; second run of DACF



Schedule in line with price difference

Schedule not in line with price difference

Example of remedial measures to cope with congestions on DE/PL border (the same day as on the previous slide, remedial action exhausted)



Necessity to (re)design EU Electricity Market

- **It is often claimed that development of the transmission and distribution network is an ultimate solution to all problems related to inefficiencies of current electricity market**
- **However, this message is not correct due to the following reasons**
  - Development of the network to the copper plate equivalent is economically unjustified - some congestion is economic
  - Rapid development of distributed generation, usually subsidized RES with variable output, brings uncertainty not only to electricity market but also to power systems operation and development
  - Development and management of elastic demand (DSR) requires appropriate price signals
  - Increase of cross-border trade across EU requires appropriate market mechanisms to ensure adequate level of coordination for long-distance power trades and level playing field for market participants from all countries
- **Therefore, appropriate market design, including congestion management mechanism, is a cornerstone of efficient management and development of a power system, giving correct incentives to all system users**

Q: What must be improved?
A: Market and System operations must be integrated

- **Locational price signals shall steer market participants decisions**
  - Real-time prices are the main means to coordinate the behavior of market participants, directly affecting both the market efficiency and system security
  - Real-time prices are the key driver for pricing in wholesale market segments
- **Capacity offered to the market shall be maximized and out-of-market redispatching measures shall be minimized**
  - Market processes based on detailed network representation (Full Network Model) offer all available capacity (so called „thermal") to the market
  - Full Network Model involvement supports prices discovery reflecting energy delivery conditions in time and location, including scarcity periods
- **Local responsibility for system security implies that TSOs must be able to select efficient means for fulfilling these tasks**
  - Role of Regional Security Coordinators (RSC) is to support TSOs in these tasks, not replace
  - National power system specificities require different approach to detailed market design and operational procedures, e.g. reserve and risks sizing
- **Strong regional cooperation of TSOs shall be supported with strong regional cooperation of Member States and NRAs**
  - Important policy issues should be addressed at the Member States level

Instead of conclusions

- **Energy market is multitude of players with often conflicting goals**
  - **Generators:** make revenue from generation, allowing for new investments
  - **Traders:** exploit all arbitrage opportunities by trading different time frames and products
  - **Consumers:** satisfy their energy needs at most economical price and in a reliable way
  - **Suppliers:** sell energy in (long-term) retail contracts, managing the wholesale price risks

- **Prices coordinate the behavior of all these market participants and therefore directly affect both the market efficiency and system security**
  - If prices reflect grid and energy balance conditions, price signals are consistent
  - Behavior in line with system needs is remunerated
  - Behavior against the system needs is discouraged

Get the prices right, so that they provide correct incentives for all grid users, leading to efficient use of resources (transmission, generation, flexibility) while respecting system security

Thank you for your attention

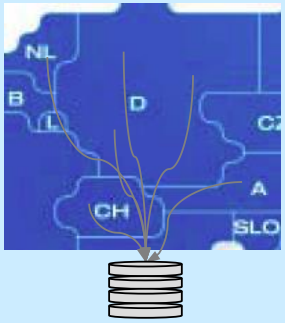
Key implementation tools
- Role of real-time energy prices [W. Hogan]

- All energy delivery takes place in the **real-time market**. Market participants will anticipate and make forward decisions based on expectations about real-time prices.
- **Day-Ahead/Intra-Day Prices:** Trade/Commitment decisions made day-ahead/intra-day will be affected by the design of day-ahead pricing rules, but the energy component of day-ahead prices will be dominated by expectations about real-time prices.
- **Forward Prices:** Forward prices will look ahead to the real-time, day-ahead and intra-day markets. Although forward prices are developed in advance, the last prices in real-time will drive the system.

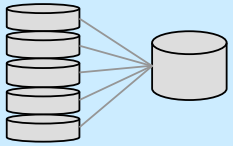
The last should be first. The most important focus should be on the models for real-time prices.

Regional operational planning

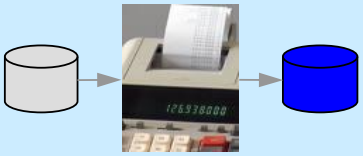
Input Data Processing



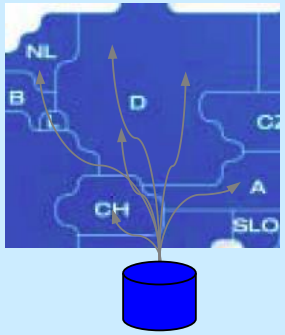
Creating common data set



N-1 security analysis



Distribution of results



CTDS

TSOs‘ experts analyze results

TSOs decide on counter measures

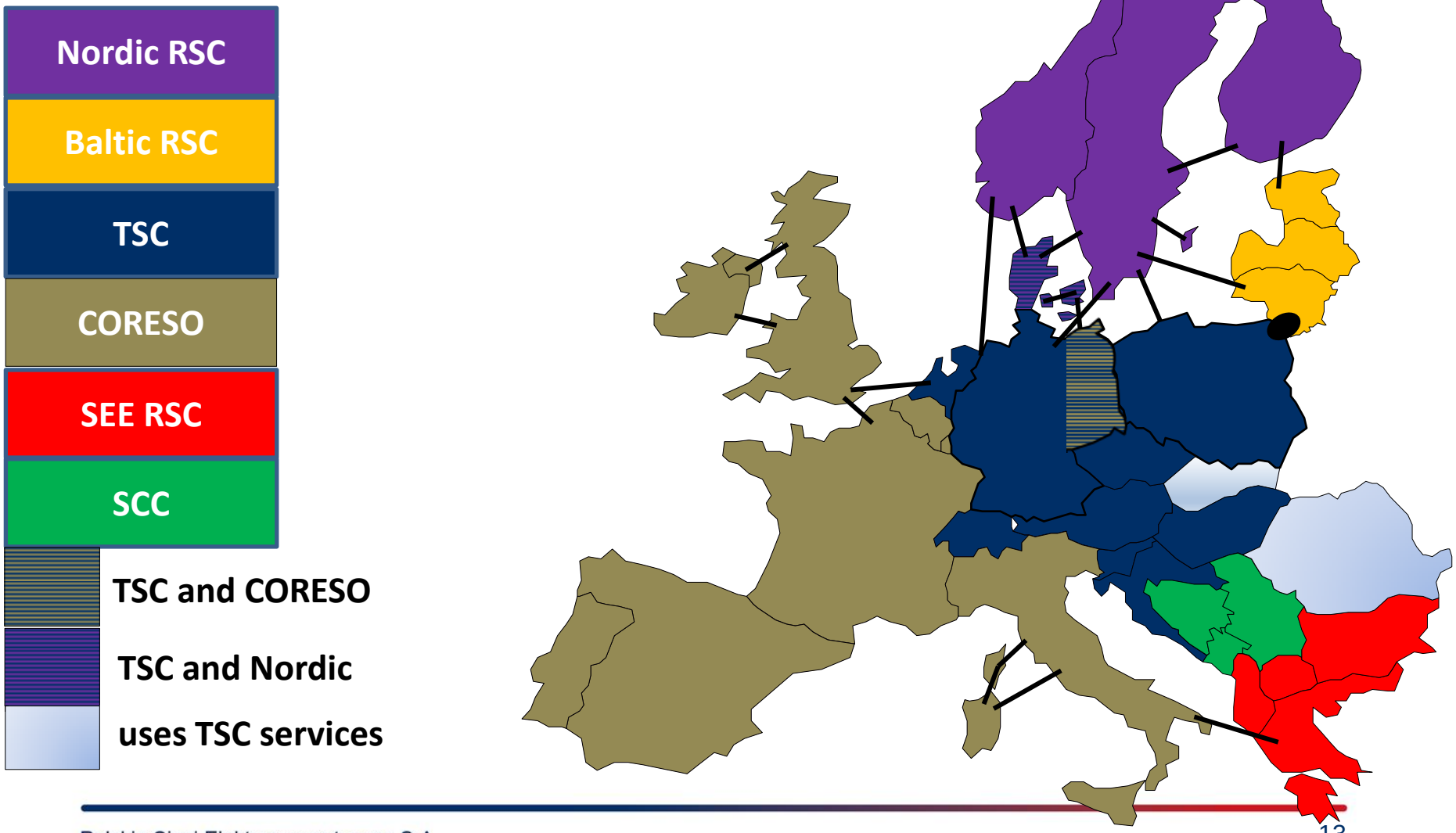
TSOs implement measures in control centres

Regional Cooperation

TSO System Security Cooperation

Taking place on D-1 around 17h-20h, i.e. after the market clearing, with the aim to correct non-feasible market outcome (if necessary)

Regional Security Coordinators



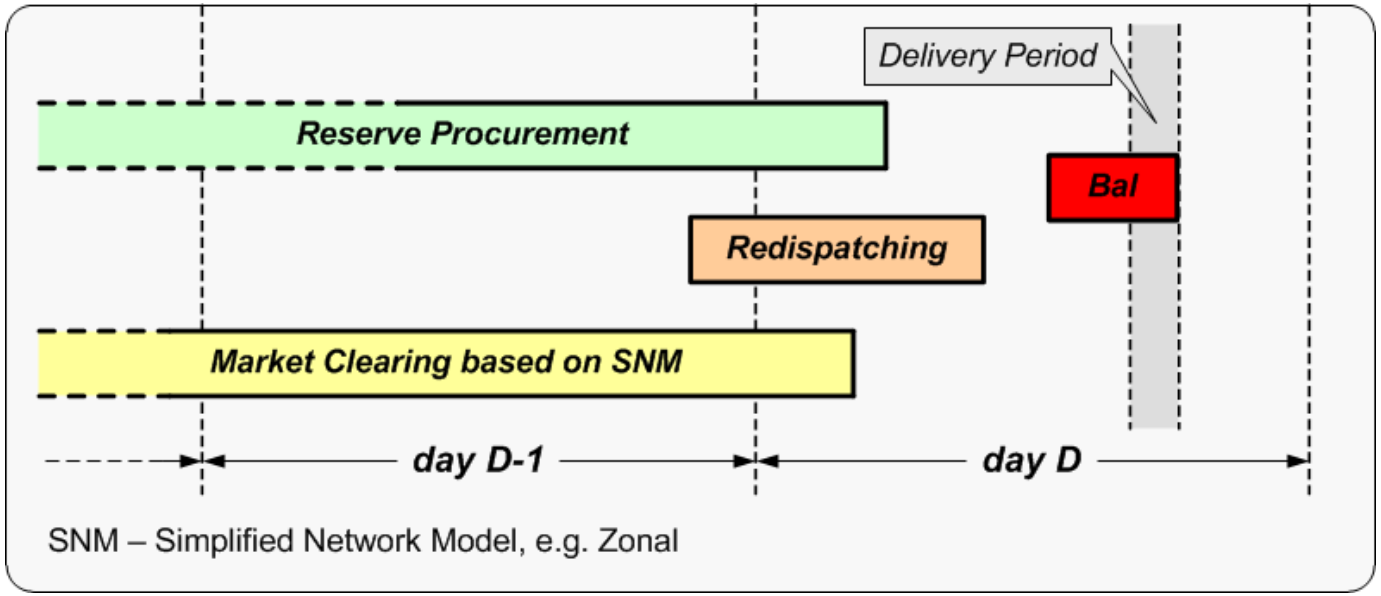
Key requirements for efficient market/system operation

- **Utilization of the transmission grid should be cost-effective while meeting all the transmission system constraints:**
  - Thermal limits
  - Voltage limits
  - Stability limits
- **When the transactions that parties wish to schedule would result in the violation of constraints, the system is congested and the TSO must take action to relieve the constraints violations - this is congestion management**
- **The options the TSO has:**

  Option 1: solve constraints outside the markets and socialize related cost

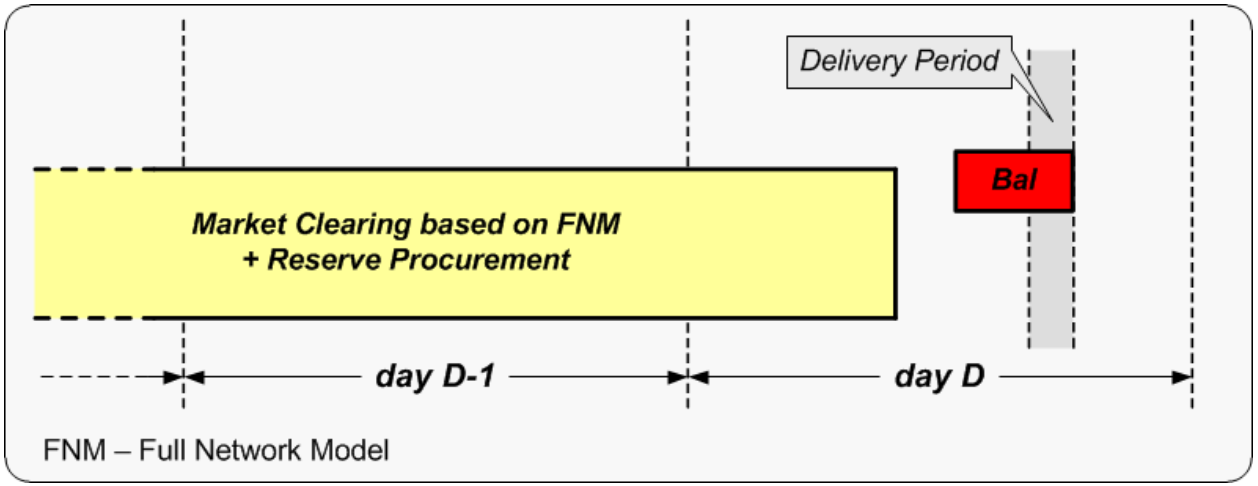
  Option 2: solve these scarce resources through market mechanisms

Option 1:
Market/System operation based on two-step approach - Market Clearing & Redispatching



- **Main advantages**
  - Easy to understand and analyse
  - Simple solution algorithms
- **Main challenges**
  - Market processes run in parallel compete for the same resources (valid also for non market based redispatching)
  - A large part of the energy delivery cost is socialized (tariff charges)
  - Timing conflicts (between trading and redispatching processes)

Option 2: Market/System operation based on Integrated Process



- **Main advantages**
  - Co-optimization of all resources and transmission capacity utilization (e.g. reserves and energy schedules can compete for transmission capacity)
  - System security requirements are reflected in energy prices (e.g. scarce resources and services are priced)
  - There is no timing conflict
- **Main challenges**
  - Full Network Model
  - Greater data requirements
  - More sophisticated algorithms/less intuitive market outcome

Main Challenges in EU market development

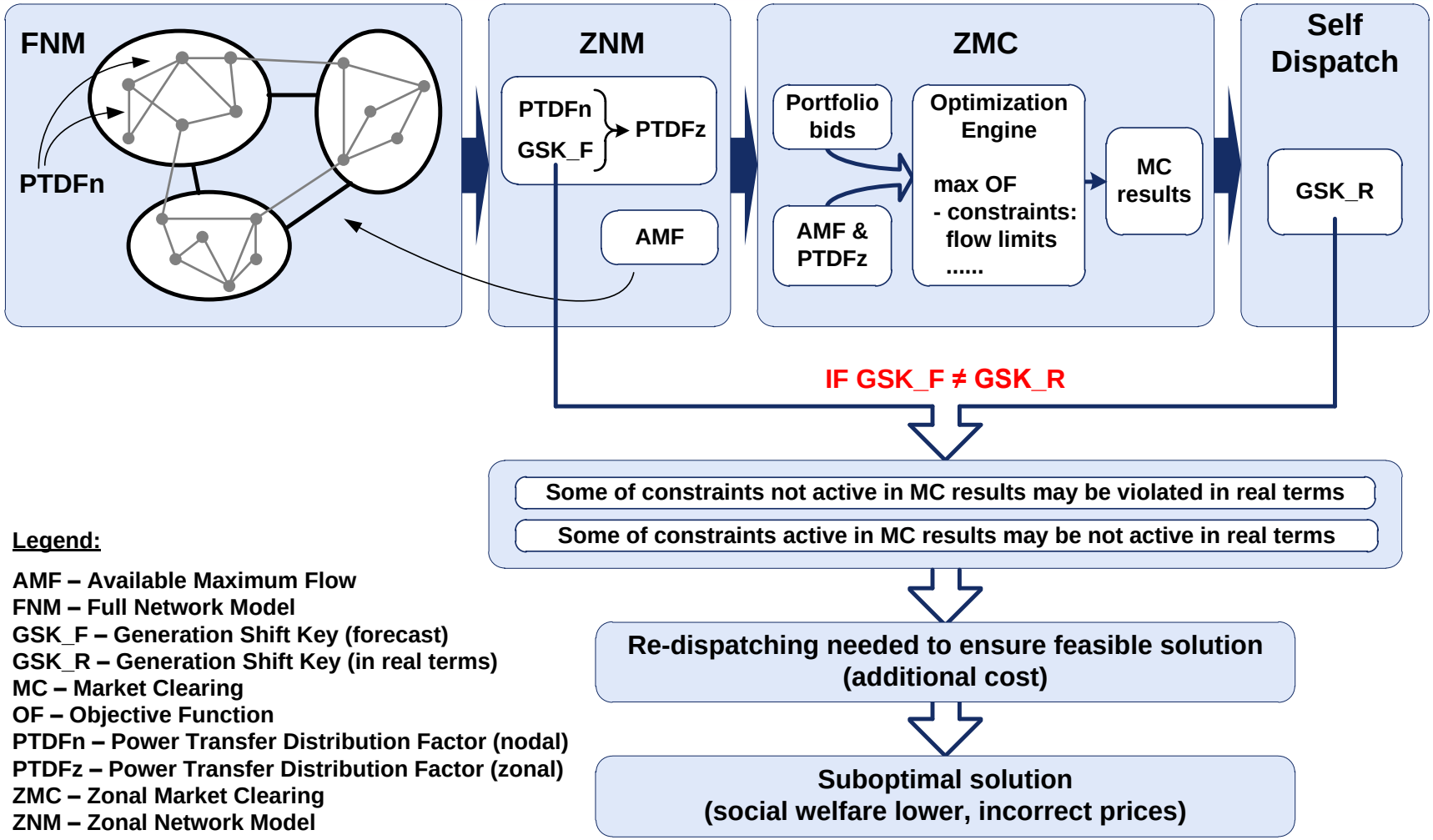
Appropriate Bidding Zones definition

- **Appropriate Biding Zones definition is a cornerstone of efficient Flow-Based capacity allocation**
  - Transactions within bidding zone are not controlled by the FBA mechanism
  - Biding Zones structure shall reflect grid structure, allowing FBA to manage the impact of commercial transitions on power flows in critical network elements
  - Market transactions within Bidding Zones shall not result in significant flows outside this Bidding Zone
- **Delimitation of biding zones vs market liquidity**
  - Liquidity provided by trading hubs: *vide* Nordpool, trading hubs in US nodal markets, etc.
  - Correct definition of Bidding Zones will maximize use of transmission infrastructure, demand inside Bidding Zones could be satisfied from internal resources and via cross-border lines thanks to efficient Market Coupling (*kind of* LMP mechanism)
  - Load pockets will remain an issue, whatever the size of zones

Why zonal model is not the first best solution

- **Problems with Zonal Markets**
  - Intra-zonal congestion must be infrequent, inexpensive and non-predictable, to avoid:
    - Infeasible market schedules
    - Excessive need for real-time dispatch corrections
    - Gaming (i.e. DEC game)
  - Zone definition requires studies and constant monitoring
  - Challenging in highly meshed grids
  - Difficulties with Zonal PTDF calculation
  - Inefficient transmission loss allocation (losses are ignored)
  - Different treatment of intra-zonal and inter-zonal transactions
- **Market consequences**
  - Risk of infeasible schedules
  - Market prices not reflecting the real costs of electricity delivery
  - Lower social welfare

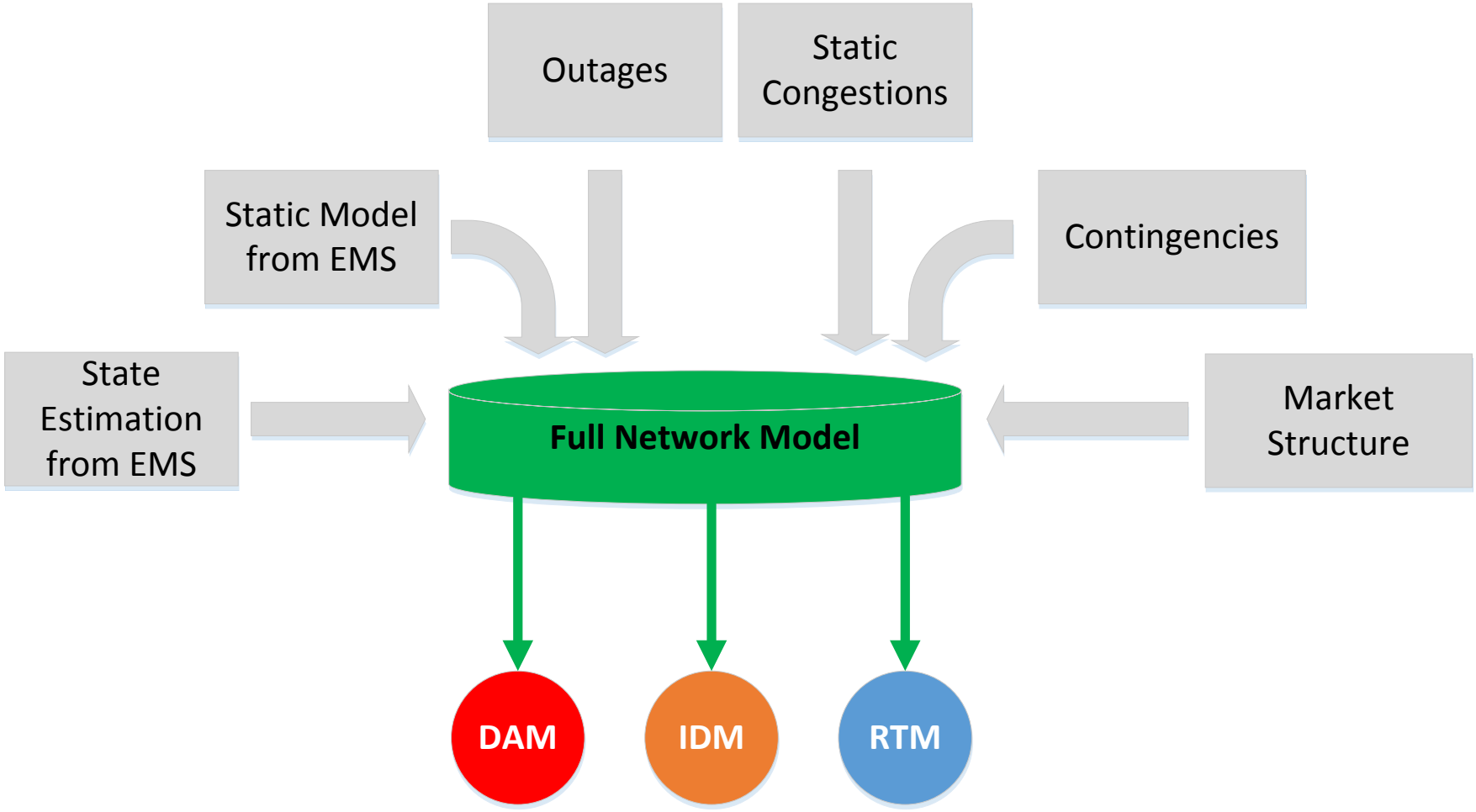
Problems with the Zonal market model



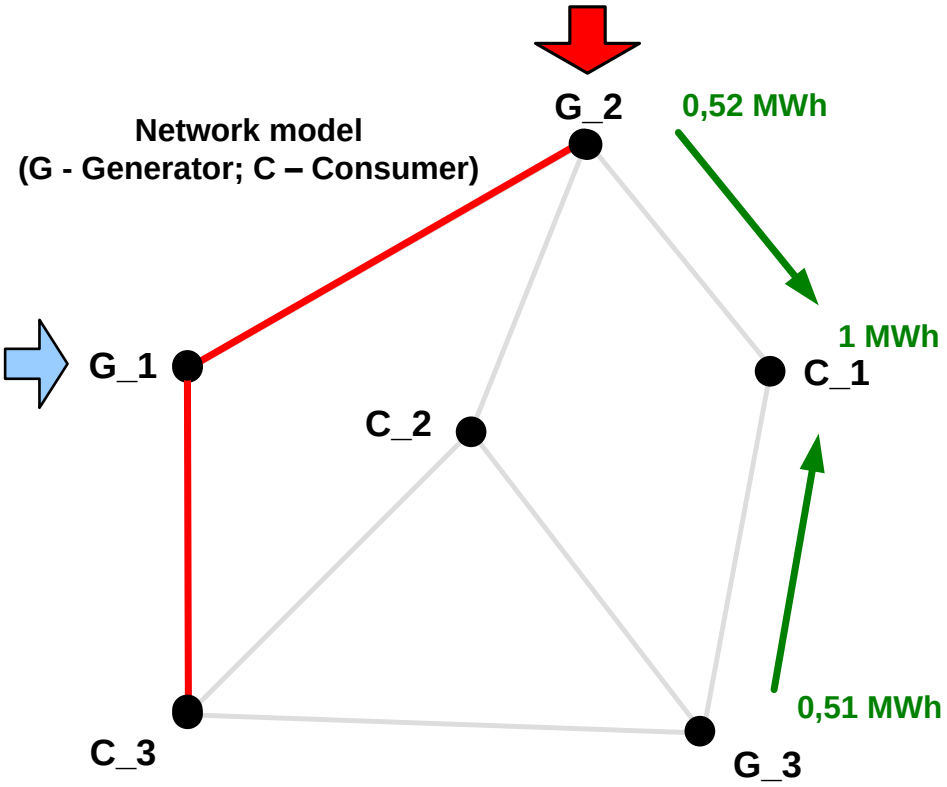
Legend:

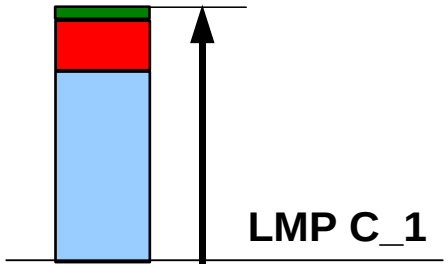
AMF – Available Maximum Flow
FNM – Full Network Model
GSK_F – Generation Shift Key (forecast)
GSK_R – Generation Shift Key (in real terms)
MC – Market Clearing
OF – Objective Function
PTDFn – Power Transfer Distribution Factor (nodal)
PTDFz – Power Transfer Distribution Factor (zonal)
ZMC – Zonal Market Clearing
ZNM – Zonal Network Model

Key implementation tools
- Full Network Model



Scheme of LMP's calculation





Components of LMP:

1. Marginal Cost of Energy
2. Marginal Cost of Congestions
3. Marginal Cost of Transmission Losses