TECHNICAL ASPECTS TO SUPPORT REGIONAL MARKET OPERATION

CAREM WORKSHOP ON REGIONAL ELECTRICITY MARKET CONCEPT AND PROSPECTIVE

TASHKENT, UZBEKISTAN
OCTOBER 23-24, 2019
CONTENTS

- Electricity Exchanges
- Interconnection Capacity (Congestion management)
- Ancillary services and balancing mechanisms
- Resource Adequacy of the system and security of supply
ELECTRICITY EXCHANGES
• Example of SFRJ (Former Jugoslavia)
  – Internal country trade (8 Power Utilities, Power plants as independent generation companies, Distribution companies as suppliers)
  – Generation companies were selling energy to Power Utilities, and Power Utilities were re-selling energy to final customers (copy of similar principal in USA)
  – Process was monitored and regulated by JUGEL
  – Import/Export was done by JUGEL

• Example of Europe (before EU)
  – Power Utilities (state owned) (country by country) exported energy between each other

• EU Market development initiative:
  – Development of electricity market
  – Unbundling of Power Utilities and privatization
  – Integration of Renewables
  – Implementation of Traders and new „players“
ELECTRICITY EXCHANGES

• Before we had:
  – Power companies/utilities (vertically integrated)
  – Customers

• First stage of the Market development was „unbundling“
  – Vertically integrated state owned companies were unbundled to:
    • Generation Companies (energy providers)
    • Transmission System Operators - TSO
    • Distribution System Operators - DSO
    • Demand Companies (Supliers)

• TSOs provide service of transporting energy from Generation Companies to Demand Companies (this includes responsibility for system security and stability)
• DSOs, same as TSOs but on distribution level
• Idea was Generation Companies and Supliers to be privatized (profit run companies), and service providers will be non-profit organizations
ELECTRICITY EXCHANGES

• **Second stage of the Market development – new entities**
  – Privatized Generation Companies
  – Privatized Supply companies
  – Traders

• For any trade you need to define the „commodities“:
  – Electricity
  – Services (provided by TSOs) envisaged in the form of „transfer capacity“

• TSOs are non-profit companies that provide service – implementation of transmission tariffs (to cover the costs of operation) – regulated income companies

• Regulators – defining the tariffs for electricity (based on expenditures/revenues so TSOs is not profitable

• Market operators – controlling the financial part of the electricity trade
EXAMPLE – DEVELOPMENT IN SERBIA

- **2004**
  - Energy law

- **2005**
  - EMS (TSO)
  - AERS (Regulator)
  - EPS established

- **2011**
  - Energy law
  - Transposition of the second package

- **2012**
  - Market Code

- **2013**
  - Electricity Market Opening
    - Balance responsibility concept
    - Balancing Market (energy)
    - Bilateral Electricity Market
    - Cross-border capacity allocation
    - Ancillary services (regulated framework)
    - Transmission losses (regulated framework)

- **2014**
  - Energy law
  - Transposition of the third package

- **2015**
  - SEEPEX (Market Operator) established

- **2016**
  - SEEPEX (organized day-ahead market)
    - Start of operation

- **2017**
  - Transparency Rules

- **2018**
  - Guarantees of origin Rules
New set of regulating principles was develop to preserve security of the system operation

A significant difference between network codes (NC) and guidelines (G) is that guidelines include processes whereby TSOs an/or NEMOs must develop methodologies

Similarities (NC and G):
- Both carry the same legal weight (both are Commission Regulations and are legally binding)
- Both are directly applicable – i.e. there is no requirement to transpose them into national law
- Both are subject to the same adoption procedure (Comitology procedure)
ELECTRICITY EXCHANGES

• Third stage of the Market development was „market expansion“
  – Transmission transferring capacity market
  – New commodities (like reserves, green certificates...) and therefore new markets

• All these activities had significant implications on parallel operation
INTERCONNECTION CAPACITY
(CONGESTION MANAGEMENT)
INTERCONNECTION CAPACITY - DEFINITIONS

- BCE - Base Case Exchange
- TTC - Total Transfer Capacity
- TRM - Transmission Reliability Margin
- NTC - Net Transfer Capacity
- AAC - Already Allocated Capacity
- ATC - Available Transmission Capacity

TTC = BCE + ΔE_{max}
NTC = TTC – TRM
ATC = NTC - AAC
MARKETS INTEGRATION AND CONGESTION MANAGEMENT

• A key challenge for market integration is to find ways of harmonizing regional rules and market platforms. Target Markets should be agreed by the Governance Body, Regulator Authorities, TSOs and stakeholders.

• Market integration also requires solutions to identify and effectively manage network congestion.

• Network congestion occurs when electricity is unable to flow where it is needed due to physical (e.g. not enough capacity) or contractual (all available capacity has been reserved) issues.

• Measures for solving congestion issues are:
  – investment in new network elements (cross-border transmission capacities)
  – rules for determining the amount of available cross-border capacity
  – cross-border capacity allocation on a non-discriminatory basis
  – equal conditions for all market participants
  – maximum utilization of transmission capacity
CONGESTION MANAGEMENT

• Congestion
  – **Physically**: when network element is overloaded (in full topology, or would be in case of outage (n-1))
  – **Commercially**: when more MW requests then capacity for the transfer at certain border (e.g. profile)

• **Cross-border transmission capacity allocation**: Process of in-advance allocation of transmission capacities (primarily at borders between systems/countries) to the electricity market players

• Cross-border transmission capacity allocation - essential part of Congestion Management process (which also considers load flow analyses such as Day Ahead Congestion Forecast and operational measures).
CONGESTION MANAGEMENT: CAPACITY CALCULATION (CC)

- For zonal markets, transmission network capacity calculation is typically ATC-based: which defines a unique constraint for the commercial exchange at certain border and direction.

- For nodal markets, per-branch limits are defined (e.g. PJM USA).

- Beside ATC-based, there are other hybrid forms of CC in zonal markets - such as flow-based capacity calculation (target model for capacity calculation on day-ahead and intraday timeframe in Europe).
CONGESTION MANAGEMENT: CAPACITY ALLOCATION

Explicit auctions

- Through a single interaction, capacity and electricity are traded at the same time, which is the main difference from the explicit auctions.
- Transmission capacity is "implicitly" allocated among the participants, based on the offered price of electricity.
- Implicit auctions are performed by Power Exchanges (PX)

Explicit auctions are performed by Auction Offices or TSOs.

Principles of capacity use:
- Use-it-or-loose-it
- Use-it-or-sell-it

Implicit auctions

- Use-it-or-lose-it
- Use-it-or-sell-it
CROSS-BORDER CAPACITY ALLOCATION

Why allocating transmission capacity?

- Transmission capacity is the deficient good of the electricity market.
- Transmission capacity is an important aim of the wholesale market design.
- Allocating transmission rights in the most efficient way is one of main issues of establishment of fair, transparent and non-discriminatory electricity market.
- Congestion revenues are meant to pay back investments in transmission development which are usually financed by consumers through tariffs.

Example of good practice: Establishment of common cross-border capacity market

TSOs need to collaborate in order to:

- create a common grid model
- define a common capacity calculation methodology
- jointly allocate capacity
- to split among themselves the cost borne to allocate capacity and the congestion income
## CASE STUDY: EUROPE

Cross border market efficiency assessment 2015-2017 (ACER report)

<table>
<thead>
<tr>
<th>Country</th>
<th>NTC vs. benchmark (average)</th>
<th>Physical flows due to cross-border exchanges vs. thermal capacity on interconnectors (average)</th>
<th>Physical flows due to cross-border exchanges vs. thermal capacity on interconnectors (worst border)</th>
<th>Loop Flows vs. thermal capacity on interconnectors (average)</th>
<th>Loop Flows vs. thermal capacity on interconnectors (worst border)</th>
<th>Cost of remedial actions per unit demand (average, euro/MWh demand)</th>
<th>Volume of costly remedial actions vs. demand (average, %)</th>
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ANCILLARY SERVICES AND BALANCING MECHANISMS
ANCILLARY SERVICES

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

• Ancillary services include:
  – black start capability (the ability to restart a grid following a full 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 (Voltage/Reactive control)

• Important aspect: approach of procuring ancillary services.

• Goal: access to a broad range of services from a wide range of providers: including generators and demand response
BALANCING SERVICES

• TSO is maintaining system security and covering system imbalances caused by balancing responsible parties (BRPs) by activating balancing reserves from balancing service providers (BSPs)

• Balancing services can be defined on two levels:
  – Balancing capacity (reserve) (in MW) – is available capacity for TSOs to balance power system in real-time
  – Balancing energy (in MWh) – is provided energy as a consequence of activated balancing capacity (reserve)
# TYPES OF BALANCING SERVICES

<table>
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<tr>
<th>Balancing service</th>
<th>Current terminology in Europe</th>
<th>Activation method</th>
<th>Time domain of response</th>
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<tbody>
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<td>Primary control reserve</td>
<td>Frequency Containment Reserve (FCR)</td>
<td>Automatic</td>
<td>Up to 30 seconds</td>
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<td>Secondary control reserve</td>
<td>Automatic Frequency Restoration Reserve (aFRR)</td>
<td>Automatic</td>
<td>Up to 15 minutes</td>
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<td>Directly activated tertiary control reserve (Fast)</td>
<td>Manual Frequency Restoration Reserve (mFRR)</td>
<td>Manual</td>
<td>Up to 15 minutes</td>
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<td>Schedule-activated tertiary control reserve (Slow)</td>
<td>Replacement Reserves (RR)</td>
<td>Manual</td>
<td>15 minutes – 1 hour</td>
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![Diagram showing power/frequency relationship and reserve activation processes](image)
BALANCING MECHANISM – MAIN PRINCIPLES
BALANCING SERVICES MARKET – MAIN PILLARS

• Definition of products (reserve products, energy products) and their characteristics:
  – mode of activation,
  – activation type,
  – full activation time,
  – granularity,
  – min/max quantity resolution,
  – validity period,
  – etc.

• Procurement process – mandatory provision or organized market

• Service providers – generation units and/or demand response

• Settlement – marginal pricing or pay as bid or regulated price

• Cost recovery scheme – balancing responsible parties and/or grid users

• Activation rules – pro rata or merit order list

• Contracting period (year, month, week, day ahead, intraday)
BALANCING MARKET: OFTEN OBSERVED CHALLENGES

• Non existing or in early development phase:
  − Concept of balancing responsibility of all parties not implemented
  − Regulated prices for balancing capacity
  − Partly regulated, partly market based prices for balancing energy – usually not directly linked with BSP offers

• Lack of competition:
  − Presence of dominant market player (service provider)
  − Imbalance settlement price often not market–based; no full incentive for BRPs to follow the schedule

• High costs of balancing at small national markets:
  − High level of balancing reserve (compared to overall size of generation portfolio)
  − No cross-border balancing except for the Emergency energy

Potential solution - in a form of regional cooperation that could:
- increase the competition (i.e. the number of BSPs)
- increase the technical possibilities
- lower the level of reserve
- lower the overall balancing costs
BALANCING SERVICES MARKET: REGIONAL COOPERATION

Common usage of balancing reserve (capacity)
- Common dimensioning of balancing reserve
- Exchange of balancing reserve
- Sharing of balancing reserve

Common usage of balancing energy
- Imbalance netting
- Exchange of balancing energy over Common Merit Order list (CMO)
BALANCING SERVICES MARKET: REGIONAL COOPERATION

**Model 1 (TSO – BSP)**

- Control Area 1
  - Imbalance Settlement Arrangements 1
  - TSO 1
  - BSP 1
  - BSP 2
- Control Area 2
  - Imbalance Settlement Arrangements 2
  - TSO 2
  - BSP 3
  - BSP 4

TSO can buy services directly from an external balancing service providers (BSP)

**Model 2 (TSO – TSO)**

- Control Area 1
  - Imbalance Settlement Arrangements 1
  - TSO 1
  - BSP 1
  - BSP 2
  - TSO 2
- Control Area 2
  - Imbalance Settlement Arrangements 2
  - TSO 3
  - BSP 3
  - BSP 4

TSO can only buy services from external balancing service providers (BSP) through the connecting TSO

**Recommended model**

Model 2 (TSO – TSO)
CASE STUDY EUROPE: BALANCING COOPERATION

Even in the mature national balancing markets (such as the ones in Europe), some of the problems persists, therefore increased cross border cooperation is recognized as a goal to be achieved in order to:

- Increase efficiency of power system regulation
- Decrease overall balancing costs and prices
- Avoid occurrence of extreme situations and price spikes

Typical day (October 2019) - wholesale VS upward secondary regulation energy prices [EUR/MWh]

Ongoing projects aiming the establishment of cross border balancing cooperation
RESOURCE ADEQUACY OF THE SYSTEM AND SECURITY OF SUPPLY
System Adequacy Assessment Objectives

- Assessment of the risk to security of supply at national/regional level
- Assessment of the needs for flexibility over the next decade
- Highlight the contribution of interconnectors to national adequacy
- Send signals to both market-players and decision makers of the need for generation fleet to evolve
ADEQUACY OF THE SYSTEM AND SECURITY OF SUPPLY

Usual Roles in System Adequacy Assessment

- **Ministry**: define strategic documents related to future net generating capacity (NGC), demand evolution, grid development

- **TSO**: provide the necessary technical analysis to determine threats to generation adequacy and its associated impacts on the security of supply.

- **Regulators**: Use Adequacy results as signals to establish counter measures in order to ensure the desired adequacy levels (e.g. capacity mechanisms)

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**Planning Horizons**

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<th>MID TERM</th>
<th>LONG TERM</th>
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<td>&gt; 1 week</td>
<td>Several years</td>
<td>&gt;10 years</td>
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<td>OPERATIONAL DECISIONS</td>
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**Uncertainty Increases**
ADEQUACY OF THE SYSTEM AND SECURITY OF SUPPLY

System Adequacy Assessment

Deterministic Approach

Probabilistic Approach

Main indicators

Remaining Capacity

Analyses of one hour per season/month as representatives of the whole year (the third Wednesday in January at 7 p.m. and the third Wednesday in July at 11 a.m.)

Analyses of ALL hours in a year

Several climatic years (temperature, hydro, wind, solar conditions)

LOLE [h/y] Loss Of Load Expectation

ENS [MWh/y] Energy Not Supplied
CASE STUDY EUROPE: MID TERM ADEQUACY ASSESSMENT (2018)
CASE STUDY EUROPE: CAPACITY MECHANISMS IN PLACE (2018)
• CENTRAL ASIA REGIONAL ELECTRICITY MARKET

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  • KUNAYEV STREET 77, OFFICE 520
  • ALMATY, KAZAKHSTAN, 050000

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