Lessons Learned from the Development of the Regional Power Market in the Balkans

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Overview of Balkans interconnected systems

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Balkans (South East Europe) Power System

Synchronous zones in Europe →

Balkans: Peninsula at the South-East of Europe

Usually considering 9 present countries & European part of Turkey

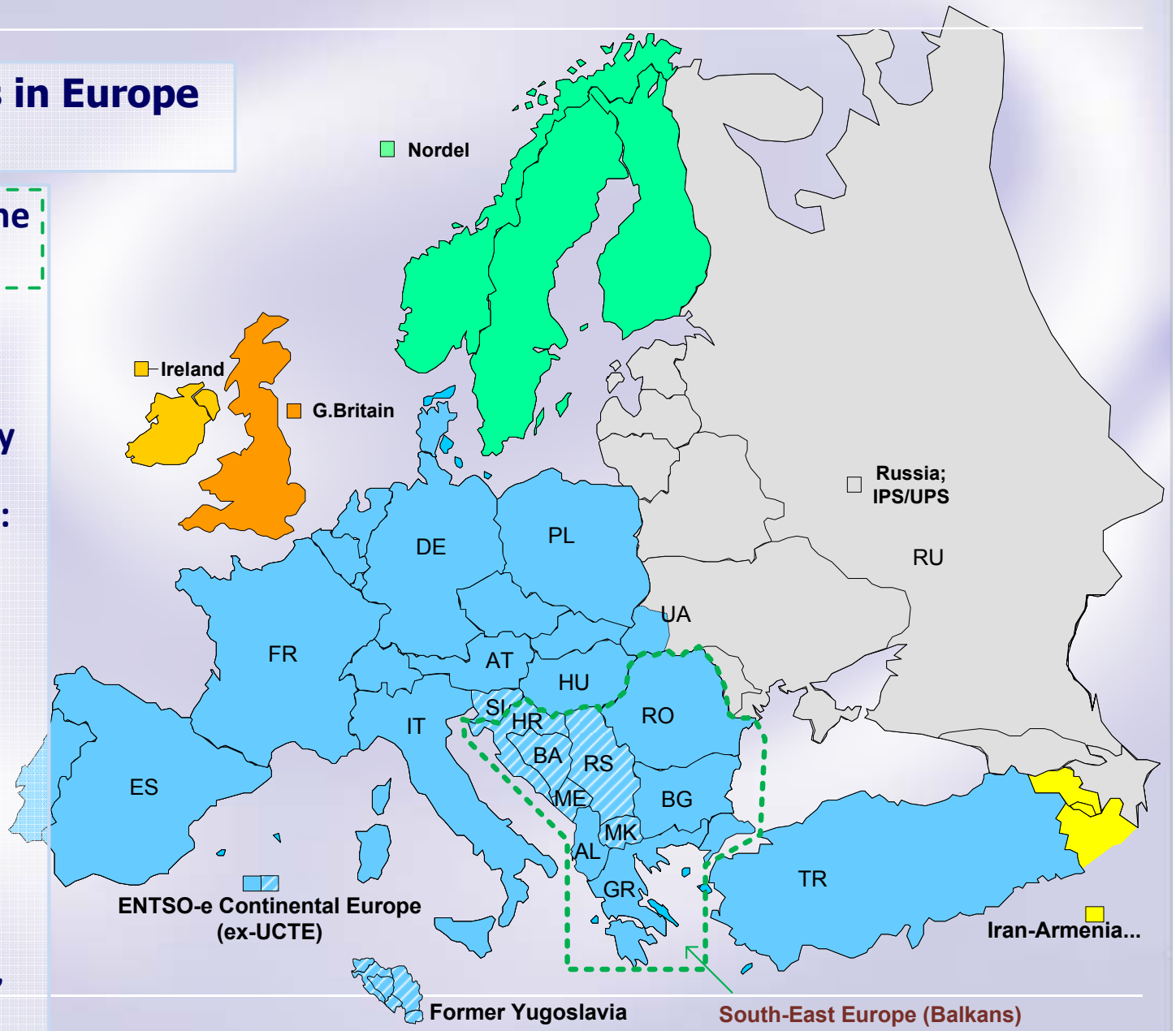
Balkans power systems: Nowadays entirely interconnected within Continental Europe

~50 mil. people

~30 GW, 230 TWh

3500 kWh/capita

hydrology dependence, old facilities



Balkans & ex-Yugoslavia power system

Early 90-ies: in the Balkans there were Yugoslav united power system and Greek power system operation in synchronous parallel operation together with other western European countries (UCTE interconnection).

From political point of view Yugoslavia was one federal country consisted of six republics.

Six republic and one join electric power utility for whole Yugoslavia

Republic electric power utilities - vertically organized

Today in brief:

- **entire Balkans belongs to a single synchronous zone of Continental Europe**
- **six Yugoslav republics are independent states now**

  (Slovenia-SI, Croatia-HR, Bosnia&Herzegovina-BA, Serbia-RS, Montenegro-ME, Macedonia-MK),

  with unresolved status of Serbian southern province Kosovo

90's

During 90-ties: dramatic changes and different political and economic challenges.

Transition from previous socialistic to capitalistic systems

Disintegration of country

Wars: **in Croatia: 1991-1995**

in Bosnia-Herzegovina: 1992-1995

in Kosovo and war Serbia-NATO: 1999

- **Disintegration, damaged facilities, turbulences in operation of power system**
- **Forming of temporary separation of 1st and 2nd UCTE synchronous zones (1991-2004)**
  - Serbia, Montenegro, Macedonia, part of BiH, Greece, Albania
  - Joined by Romania (1994) and Bulgaria (1996)
- **Negative effects:**
  - Abnormal operational conditions (serious blackouts happened)
  - Often power imbalance and disturbances (frequency deviation was huge, deviations)
  - Infrastructure devastation and major absence of investments in development
  - Lack of consistent energy strategy due to the political turbulences

Regional Electricity Market

Most of Balkans countries are/were not the members of European Union, however

All have European agenda

- **in the meantime Bulgaria, Romania and Croatia joined EU**
- **Serbia, Montenegro, BiH, Macedonia, Albania are candidates**

EU made a parallel process of Regional Electricity Market (REM) in line with EU one, and the related Regional institutions: ENERGY COMMUNITY

The committed REM process required:

- **improvement of operation, rehabilitation of existing power plants, network equipment**
- **reforms in all counties, even though part of them are in the advanced process**
- **cooperation for implementation of regional functions and harmonization of the approach in the internal market solutions**
- **implementing unbundling (separation of generation&distribution from the transmission);**
  - implementing independent Transmission System Operators (TSOs);
- **necessary legal framework and coordination of the implementation programs.**

Power system characteristics
- Today-

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Precondition for Regional market - Development in last two decades (1)

Electric power sector: restructured on different level of unbundling per countries

- independent Transmission system operator (TSO) established in all countries
- unbundling between generation and distribution done in some countries (Romania, Bulgaria, Macedonia, Albania, Greece)
- Different level of privatization in power sector - in some distribution or generation utilities were privatized (Romania, Bulgaria, Macedonia, Albania, Greece)

Improvements of operational conditions:

- **Telecommunication links (OPGW) between networks and modern SCADA**
  - exchange of operational data TSO Dispatching Centers
  - High-speed protection relays at tie-lines
- **All tie-lines are equipped with metering devices**
- **Energy meter readings are transmitted in real time to Dispatching Centers**
- **Common scheduling methodology regarding operation of the power systems**
- **Network operators regularly apply software for transfer capability calculations and allocation at the interconnections**

Development in last two decades (2)

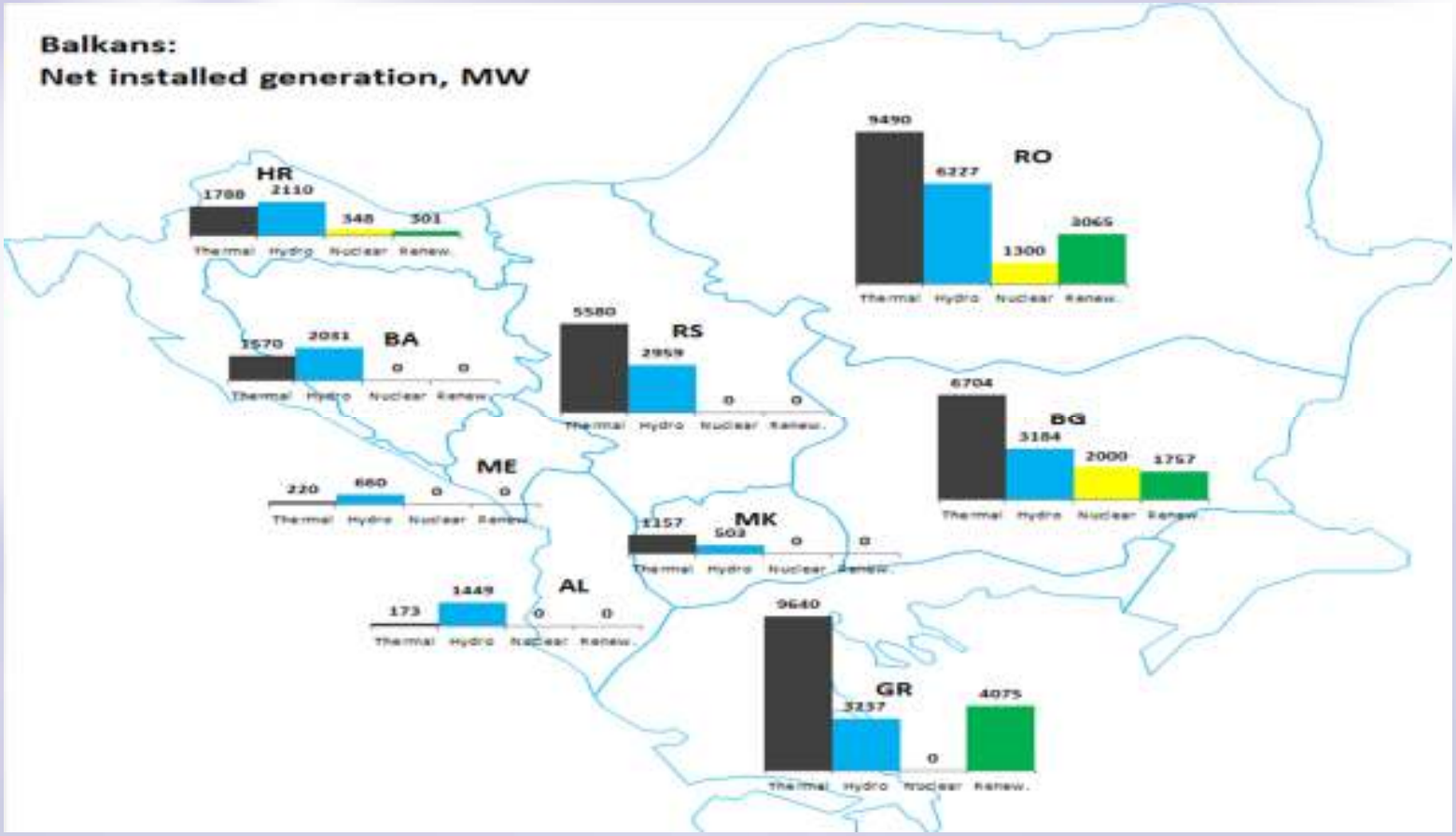
- Rehabilitation and modernization of existing power plants and coal mines with increasing their production possibilities
- Except in Romania, Bulgaria and to some extent Greece, there is no new power plants with significant installed capacities.
- Bulgaria had to meet EUs request to close four aggregates of NPP Kozloduy in 2003 and 2004 (1800 MW shutdown).

- Many new internal and interconnection lines have been built in region in order to improve security
- World crisis 2008- resulted in overal load decrease in almost all countries (roughly -2%).
- Countries are taking actions regarding decrease of non-technical losses in certain countries of the region (especially in Albania, but in other countries as well).

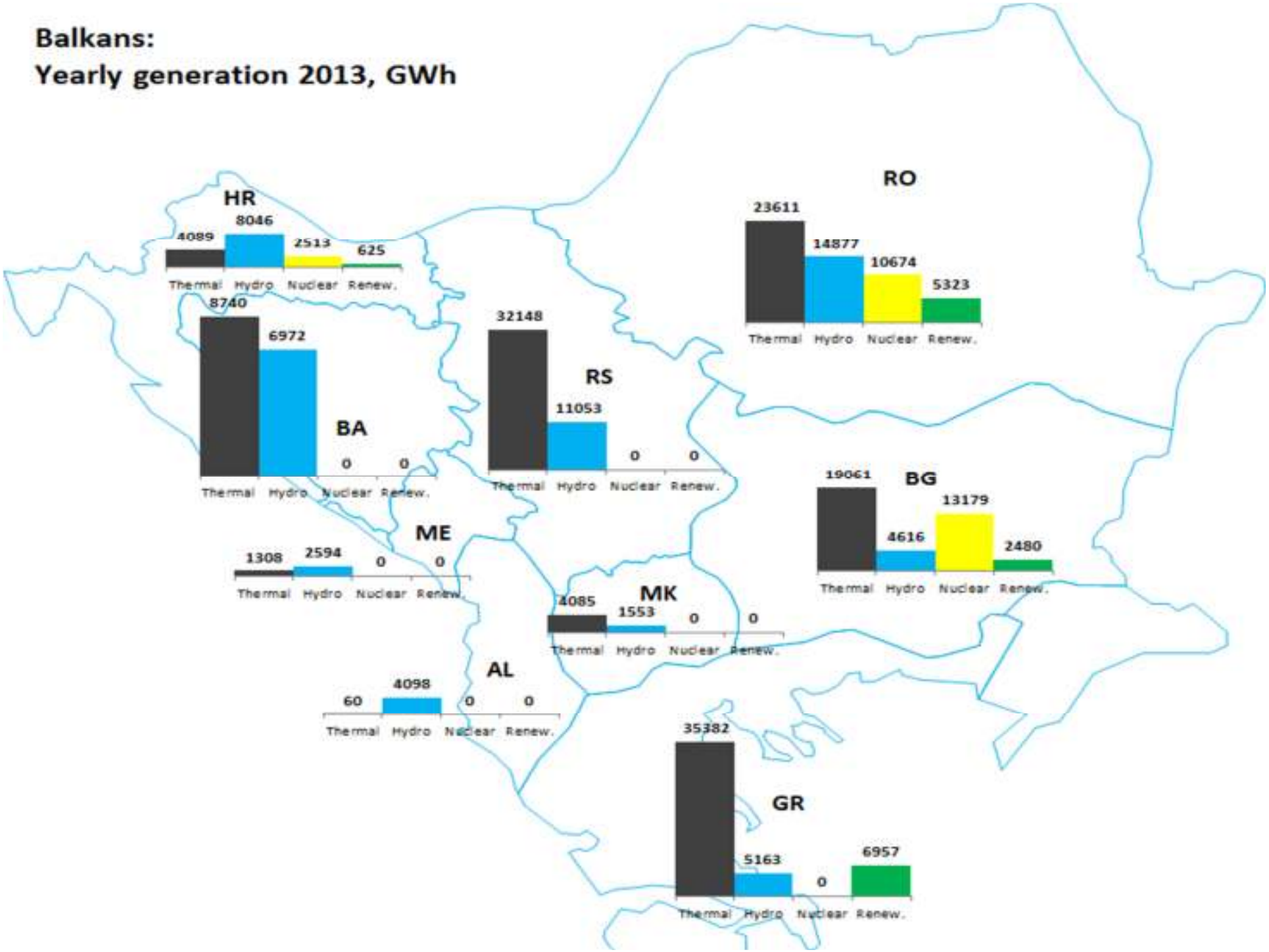
- Bilateral market (OTC) for the electricity trade is the main trading tool in general, power exchange (stock market for day ahead electricity trade) exists only in Romania

Basic data; net installed generation

	AL	BA	BG	GR	HR	ME	MK	RO	RS
	Albania	Bosnia-H.	Bulgaria	Greece	Croatia	Montenegro	Macedonia	Romania	Serbia
Population, mil.	3.161	3.766	7.510	11.321	4.450	0.620	2.047	21.425	9.116
GDP/capita, EUR	2,854	3,461	5,084	21,661	10,799	4,997	3,475	5,937	4,081
Consumption, GWh	7,272	12,016	32,210	49,568	17,065	4,505	8,049	52,303	39,444
Cons/capita, GWh/mil.	2,301	3,191	4,289	4,378	3,835	7,266	3,932	2,441	4,327

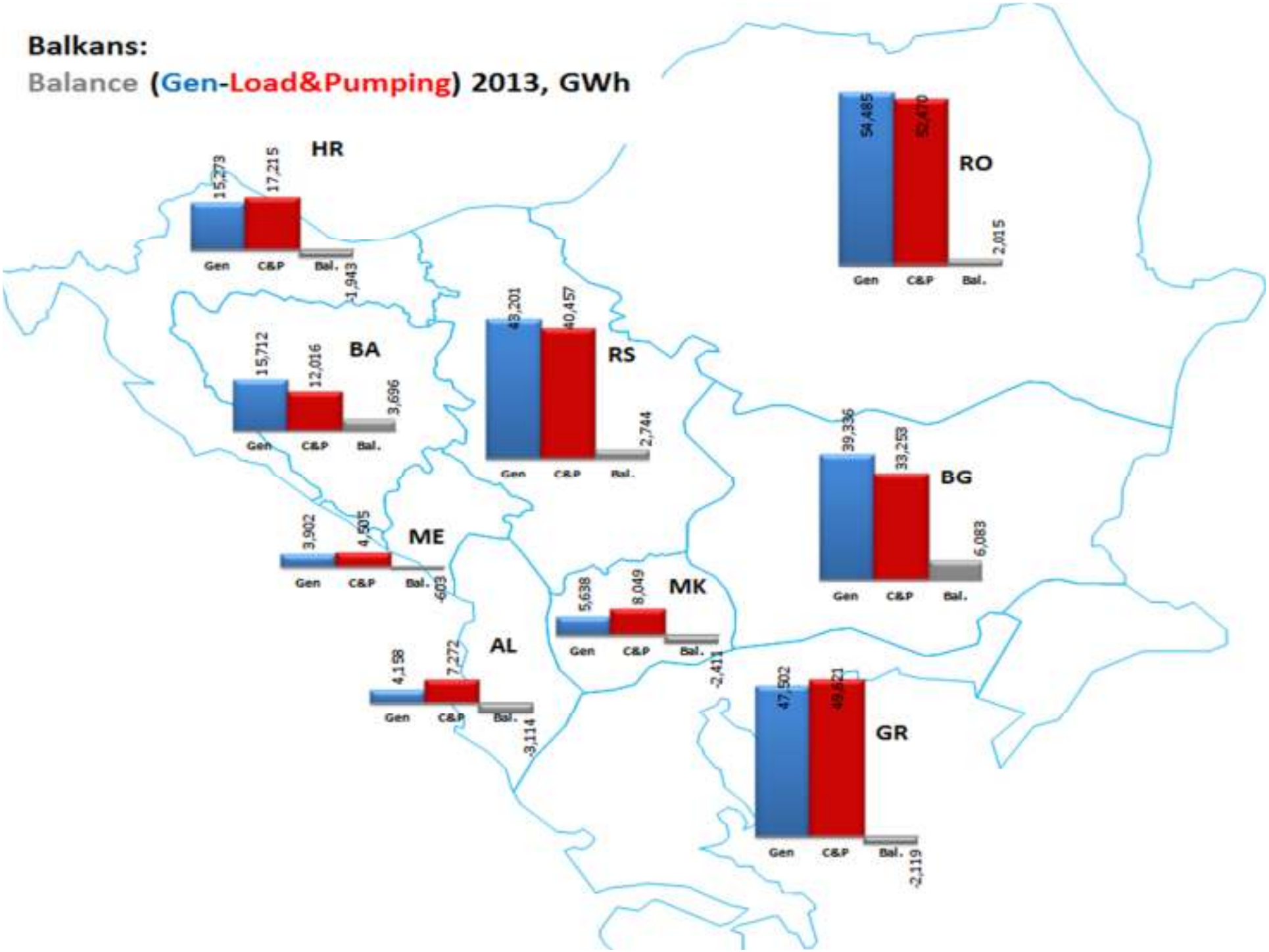


Balkans:
Yearly generation 2013, GWh



Balkans:

Balance (Gen-Load&Pumping) 2013, GWh



System operation, market and planning

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Rules and procedures on the country level

Operational, market and planning rules are based on national Grid and Market Code(s):

- **Managing the electric power system in real time**
- **Provision of ancillary services:**
  - Primary, Secondary and Tertiary control and Voltage control
  - Compensations for unintentional deviations in the control area
- **Preparation of the Electric Power System Defense Plans:**
  - Under frequency protection plan and Load shedding plan
  - Power system restoration plan
- **Planning of the electric power system operations:**
  - Annual plan of operations and daily schedules
- **Power system control:**
  - Control at normal conditions (LF and voltage control, operation monitoring, data collection)
  - Control during disturbances (removal of disturbance, load shedding, system restoration)
- **Protection system operations:**
  - Pre-setting, replacement and maintenance
  - Functioning in real-time
  - Overload protection settings plan
- **Communication and Reporting**

Collaboration on the regional level

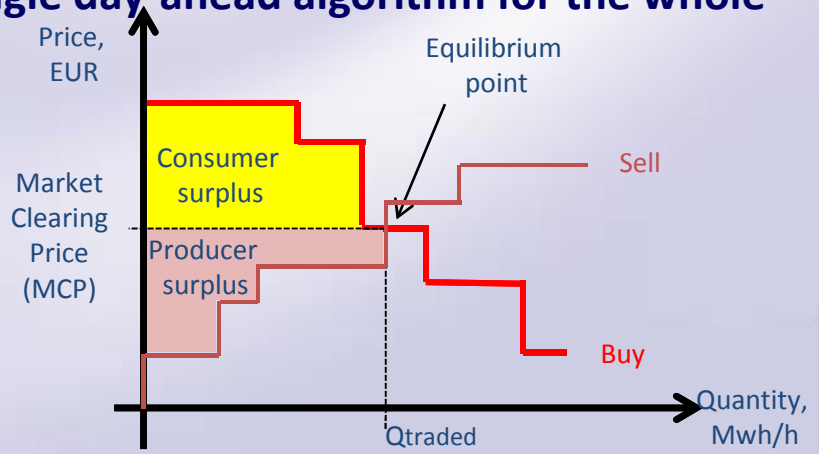
- **Three levels of data exchange:**
  - On line SCADA and tele-measurement information exchange
  - System network simulation models:
    - Day ahead – for checking network security
    - Planning models (month, or 1-5-10 years ahead)
- **National Dispatch Centers coordination:**
  - Compliance monitoring and enforcement (exchanging visits and checking TSO performances)
  - Observing and enhancing the system performance and dynamics
  - Unplanned outages
- **Cross border exchanges scheduling**
- **Maintenance coordination:**
  - Regional disconnection plan
  - Generation and network maintenance plan
- **Regional transmission network planning**
- **Protecting critical systems**
- **Developing and maintaining the Electronic Highway** (high speed communication link)
- **Promotion and enhancement of coordinated system operation and services**

Organizing the electricity exchanges

Trading	Scheduling	Real Time	Accounting
• Year/month ahead • Day ahead, intra-day • Involves capacity allocation • Bilateral, or over Power Exchanges (PX)	• Scheduling is organized at day-ahead and intra-day level • Passing the commercial schedules to the TSOs, for the physical realization	• TSO is managing real-time operation • Power & frequency regulation • System security	• Accounting is post-festum process for settling imbalances, transit costs …
On the national level: Market Operators are organizing the trade MO can be part of TSO or, separate company (can be PX also) On the regional level: PX jointly, where there is Market Coupling (in development)	On the national level: National TSO is responsible for scheduling On the regional level: Control blocks & Two coordination centers for the whole Continental Europe (Swiss and Germany)	On the national level: National TSO is responsible for real time operation On the regional level: Three security centers for the whole Continental Europe (Brussels, Munich, Belgrade - (in development))	On the national level: National TSO is responsible for accounting On the regional level: Imbalances: two centers for Europe (Swiss and Germany) Transits: ENTSOE association

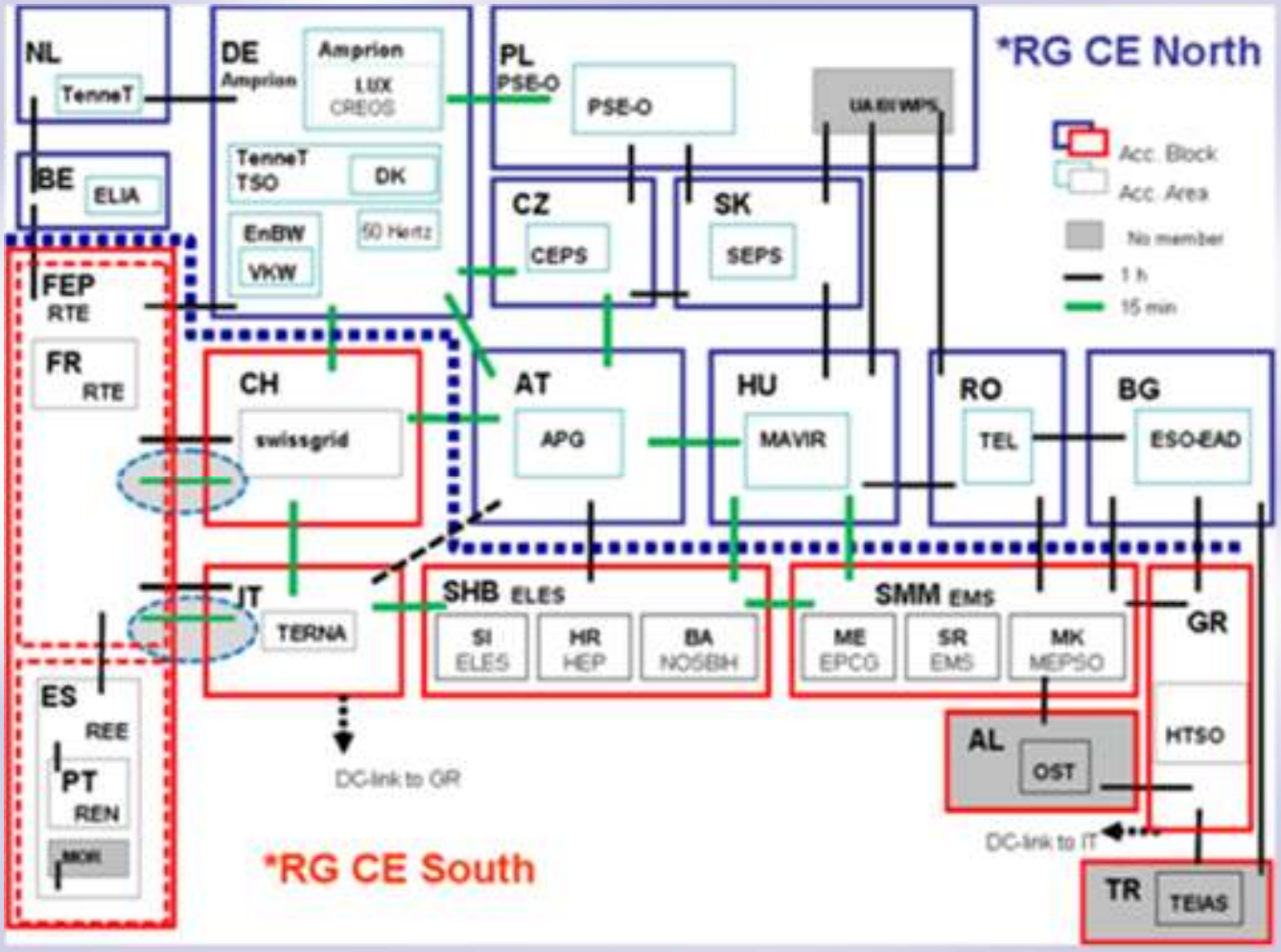
Trading of electricity

- In Balkans, electricity trading is still predominantly organized via bilateral markets (OTC)
  - On the national level, Market Operators are organizing the trade
    - MO: independent company, or part of TSO
  - Time horizons: forward (yearly, monthly), day-ahead, intra-day
  - Cross-border capacity allocation:
    - at forward markets separate (explicit) from electricity trade (in-advance process)
    - at day-ahead markets can be separate, or jointly (implicitly, with electricity)
- Day-ahead Market Coupling:
  - trade of electricity&capacity via the power exchanges (PX)
    - the most advanced way of electricity trade
    - Common target for entire Europe (one single day-ahead algorithm for the whole continent!)
    - In the startup phase in Balkans



Scheduling of electricity

- Market Operators passes schedules to national TSOs
- TSOs are coordinated on European level by the two centers, in Switzerland and Germany



Scheduling, realization, accounting: example

Scheduling
Real time
Accounting

At D-1:

Scheduled individual transactions of various players, per borders, for each hour. ***Process before this is capacity allocation, where all market players obtained the transmission capacity.***

At D-1: Summarized individual transactions per borders

Import = 70 MW

This is also the TSO's balancing target, and setup of secondary controller.

At day D, hour H: No deviation of total balance.

Physical flows at tie-lines differ from the contractual ones, but

Import = 70 MW

At day D, hour H: DEVIATION OF TOTAL BALANCE, BY THE INADVERTNET POWER FLOWS.

In case that sum is not equal to 70 MW import: deviation.

Import (real) = 74 MW

- **Country's <u>deviations</u> of total balance are accounted and brought back next week**
  - Compensation program for inadvertent deviations
  - The parties responsible for deviation are paying imbalance price
- **<u>Transits</u> over other systems: calculated and compensated at pan-European level**
  - Inter-TSO Compensation mechanism (ITC) with joint fund
- **<u>Loop flows</u> (physical flows different then contracted schedules): often effect.**
  - Bearable, as long as they don't compromise system security.
  - Solutions: flow-based capacity allocation, or controlling power flows (phase shifters)

Overview of bilateral agreements with neighbors

- Agreements on provision of mutual emergency energy delivery for securing the system services
- Operational Agreements (emanating from Operation Handbook)
- Separate agreements on Accounting and Scheduling
- Joint Capacity Allocation Rules & Agreements

Regional organization, collaboration and working groups

- Regional working groups for operational, planning and market – improvement of technical, organizational rules and data exchange
- CAO - Joint transmission capacity allocation office for the whole region – today for some of Balkan countries
- SECI initiative under USAID – regional long- term transmission planning model Transmission Grid development project

Planned/in development

- Joint/regional balancing market
- Power exchanges and their regional integration (market coupling)
- Regional security coordinating center

Comparison: Balkans and Central Asia

	Balkans	Central Asia
Network	Highly meshed, well connected	Mainly radial links
Synchronism	Strongly connected within Continental Europe sync. area Enlargement with BG, RO, Turkey	Weakly connected with IPS/UPS Disconnection of TJ and TK (TK with IR)
Regional coordination	Mainly on rotational basis, or coordinated by EU. Regional security coordination in development.	Regional coordination center.
Power quality	Improved after reconnection of region. Balancing discipline, penal in the case of deviation. Load shedding as last resort.	In the process of improvement. Lack of energy. Unscheduled “imports” Often load shedding.
System security	Fulfilment of n-1 criteria Accurate telemetric equipment. Compatible protection system Maintenance coordination	In same cases network overloading. Inaccurate telemetric equipment. Not really compatible protection system.

Comparison: Balkans and Central Asia

	Balkans	Central Asia
Unbundling	Transmission separated (TSO). Generation, distribution partially privatized.	Vertically integrated (e.g. TJ and UZ) and unbundled (e.g. KZ and KG)
Market	Different hydro-thermal structure in countries. Bilateral contracts mainly based on economic prices. Join methodology for transmission costs caused by power wheeling. Power exchanges in development.	Different hydro-thermal structure in countries. Annual bilateral contracts. Deficient transit methodology.

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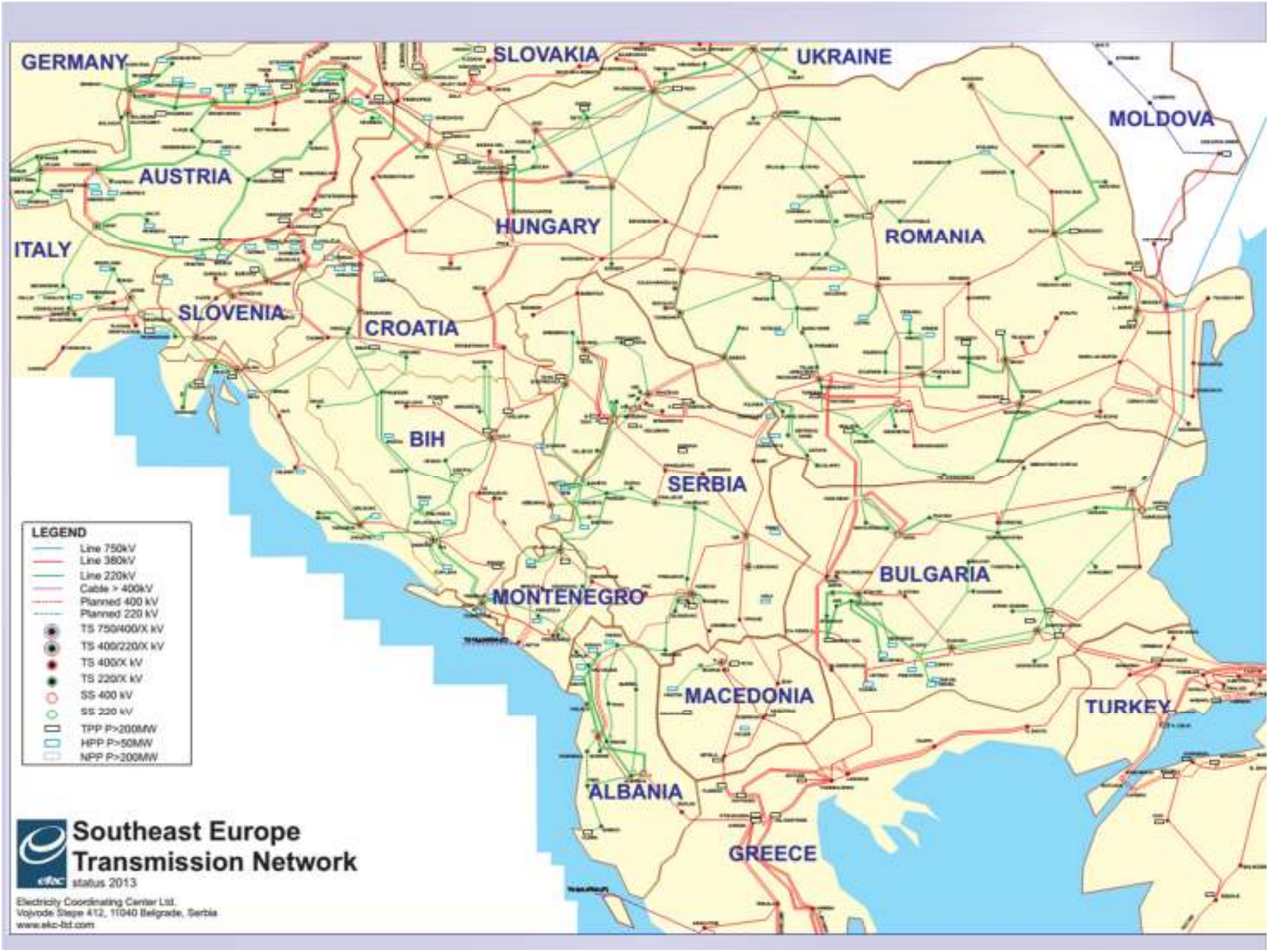
Backup slides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Line 220kV
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HPP P>50MW
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Under frequency protection

51.0 - 52.0 Hz Automatic generator-block separation

f > 50.2 Hz Warning signal „High frequency" and dispatcher measures

50.2 Hz primary reserve is activated

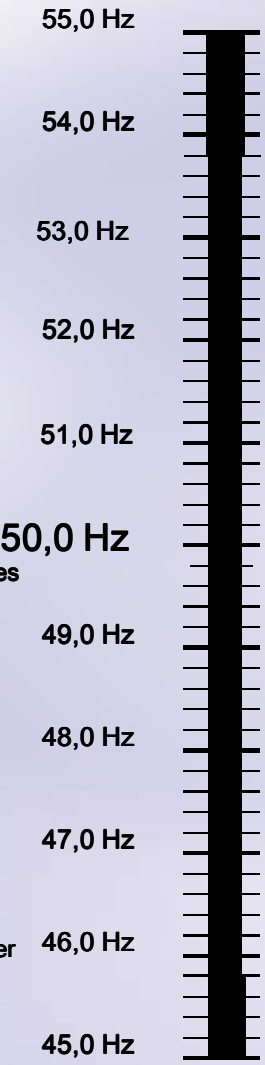
49.8 Hz primary reserve is activated

f < 49.8 Hz Warning signal „Low frequency" and dispatcher measures

49.5 Hz 1. Stopping of 1st pumping motor/generator unit in RHPPBajina Basta

49.4 Hz 2. Stopping of 2nd pumping motor/generator unit In RHPP Bajina Basta

48.0 – 47.5 Hz Automatic generator-block separation and switching over to self-consumption (10.0 s)



Frequency plan EMS

Normal system operation

49.0 Hz 1. Step of automatic load shedding appr. 10 % of total consumption

48.8 Hz 2. Step of automatic load shedding appr. 15 % of total consumption

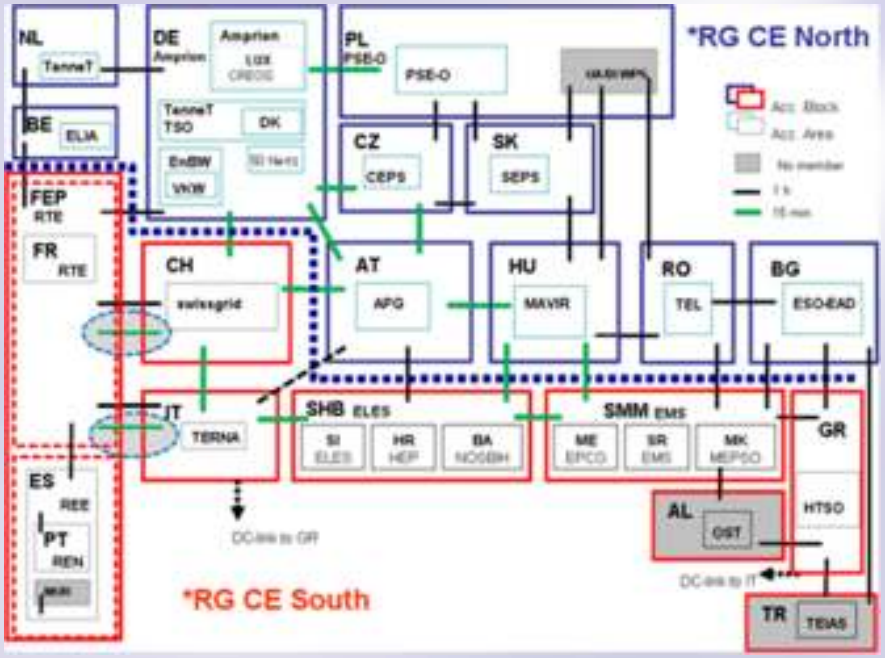
48.4 Hz 3. Step of automatic load shedding appr. 15 % of total consumption

48.0 Hz 4. Step of automatic load shedding appr. 15 % of total consumption

Scheduling of Power Exchange – Control Blocks/Areas

- There are seven control blocks in the Balkan:
  - SHB – consists of Slovenia, Croatia, BiH
  - SMM – consists of Serbia, Montenegro, Macedonia
  - Albania
  - Greece
  - Romania
  - Bulgaria
  - Turkey

Functions of block operator can generally be divided into the following 3 basic groups:
-exchange programs;
-organization and supervision of secondary regulation of frequency and power exchange;
- electricity accounts.

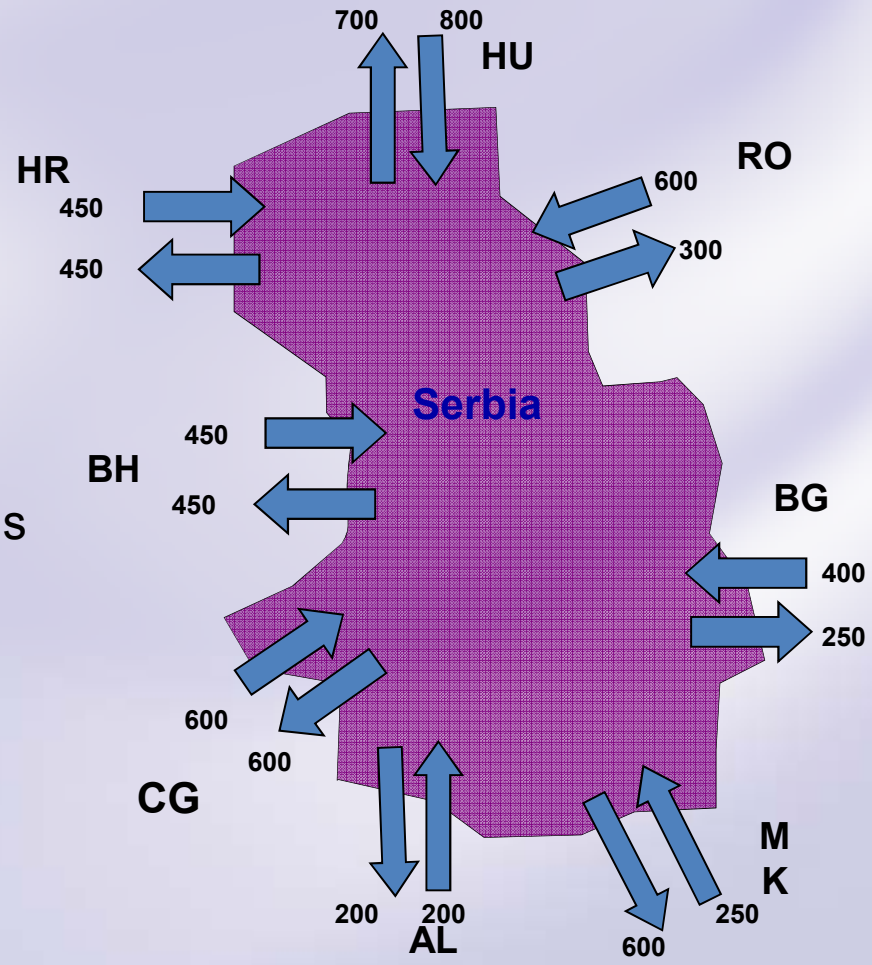


NTC Calculation – example on Serbian network

- NTC calculation – calculation of maximum power exchange between two neighboring systems
- Base case exchange
- Exchange of models
- Each TSO performs calculations
- Harmonization process
- Results are delivered to market division

Auctions

- for each border and directions
- Yearly, monthly and weekly auctions
- No congestion – no payment
- Pay as bid system (alternative system is marginal price)
- Capacity rights
- Scheduling



Organization of ex-YU power sector

Six republic electric power utilities and one join electric power utility for whole Yugoslavia

Republic electric power utilities - vertically organized: transmission, generation, distribution

The role of republic electric power utilities was:

- to monitor, operate and dispatch republic electric power systems
- to maintain its electricity network – power-frequency control (primary, secondary, tertiary control), voltage control, protection, etc.
- to plan their 400, 220 and 110 kV network, in coordination with other republics
- each republic had a dispatching center

The role of Yugoslav joint electric power utility was:

- coordinate real-time operation of republic power systems and their dispatching centers
- to coordinate the electricity exchanges with neighboring countries
- to perform accounting and settlement of exchanges and deviations among the republics
- to coordinate planning activities of republic's power systems
- to define common rules and procedures
- to operate joint Yugoslav dispatching center

Ex-YU power sector basics

At 1990:

Installed generation 20,6 GW (59% thermal, 41% hydro);

Peak load 12,8 MW;

Yearly consumption 87,5 GWh

The biggest generation unit: 600 MW (TPP Nikola Tesla)

- **Republics respected Yugoslav operational&planning rules** (in accordance with European)
- **Some republics were the owners of generation units in other republics**
- **Regulation of Yugoslav system was projected to cover tripping of biggest power unit**
- **Pump storage HPP Bajina Basta (2*300 MW); designed for the unified Yugoslav system**
- **Network: jointly designed, in line with common transmission plan& security criteria**
- **Each republic electric power system took care of its own balance and regulation, while joint Yugoslav electric power utility had a duty to realize power import and export from/to neighboring systems**
- Very often happened that consumers have been supplied in one republic through the network which went through other republic (island/radial operation),

2nd UCTE synchronous zone

2nd UCTE zone (existing 1992-2004) worked in extraordinary conditions. Effects:

Negative:

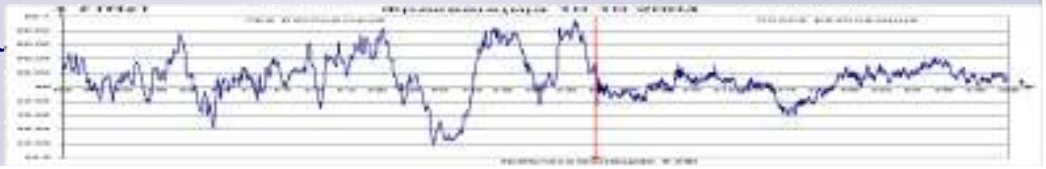
- Abnormal operational conditions (serious blackouts happened)

Negative effects:

- Abnormal operational conditions (serious blackouts happened)
- Often power imbalance and disturbances (frequency deviation was huge, deviations)
- Infrastructure devastation
- Major absence of investments in development
- Human resources fluctuation
- Lack of consistent energy strategy due to the political turbulences

Positive:

- Proven robustness and ability of system and stuff to operate in severe conditions
- Thorough operational experience under extreme conditions
- Huge experience in power system defense and restoration procedures and measures
- Opportunities for new generation of you
- Close cooperation: common rules, joint



Balkans now: country/system characteristics

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Population, mil.	3.161	3.766	7.510	11.321	4.450	0.620	2.047	21.425	2.047
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- All countries in region have peak load during winter period except Greece.
- Some countries have large extent of hydro energy in their overall production (99% in Albania, 66% in Montenegro)
- Gas-firing significant only in Romania
- Increasing the level of renewables production: all countries imposed feed-in tariffs for wind and solar capacities. RES is more and more present, especially in EU countries of Balkans (GR, RO, BG, HR)
- In 2013, generation share was: thermal 52%, hydro 26%, nuclear 14%, RES 8%.
- Countries with possibility to export energy are Romania, Bulgaria, Bosnia-Herzegovina, and Serbia (in summer period). All others have to import energy during some part of year.
- The largest yearly deficits appear in Albania (40-50%) and Macedonia (30%).