ENTSO-E Ten-Year Network Development Plan & Regional Investment Plans in 2014

- Market Studies Methodology -

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Reliable Sustainable Connected

Continental South East Region

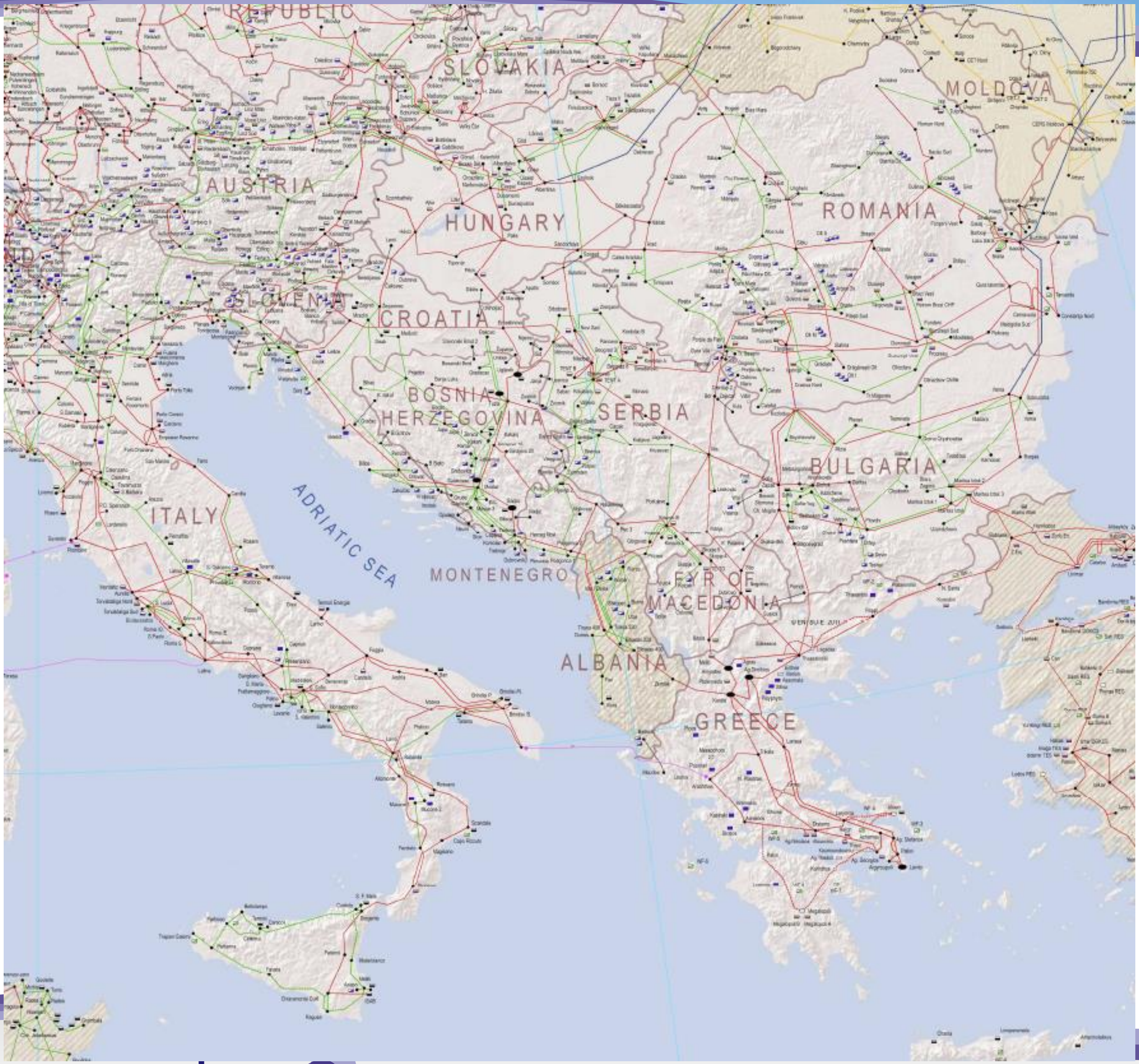
11 TSOs

+ CY (corresponding member)

+ AL (collaboration in data provision and modeling)

IPTO	GR
TERNA	IT
ESO	BG
MEPSO	MK
EPCG	ME
NOsBiH	BA
HOPS	HR
EMS	RS
TRANSELECTRICA	RO
ELES	SI
MAVIR	HU

Regional network of today



Major recent evolutions:

•Interconnection of CESA with Turkey (September 2010)

•New 400kV interconnector Podgorica (ME)-Tirana (AL) (May 2011)

• New 400kV interconnector Ernestinovo (HR)-Pecs(HU)

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CSE Region – Main characteristics

- **Sparse network**
- **Predominant power flow directions**
- **Flows sensitive to generation location due to the network sparcity / high interdependency of flows**
- **Steam turbines / non-flexible generation**
- **Low RES development (GR ~1,5 GW wind, ~2GW PV)**
- **Network security is a main issue**
- **High uncertainty for new generation (especially RES)**
- **Uncertainties with new connectees (TR, UA/MD)**

Data and Modeling Hypotheses

- All countries except IT (including AL) modeled in details (full network topology for all voltage levels >150kV, detailed generation models)
- Initial boundary flows were provided by Pan-European Market studies
- Generators modeled in more details than in PEMDB
- Hypothesis of 500 MW export at the Turkish borders
- No exchanges with UA/MD
- Not accurate meteorological data for RES potential in several regions
- Network topology as by WINTER peak 2030 network model provided by WG NM&D
- Compatibility checks (but still to be improved)

Default assumptions for thermal units

Category #	Fuel	Type	Efficiency range in NCV terms	Standard efficiency in NCV terms	CO_2 emission factor	Variable O&M cost	Start-up fuel consumption	Min Time on	Min Time off
			%	%	kg / Net GJ	€/MWh	Net GJ /MW. start	hours	hours
1	Nuclear	-	30% - 35%	33%	0	9	14	168	168
2	Hard Coal	old 1	30% - 37%	35%	94	3.3	50	6	6
3		old 2	38% - 43%	40%		3.3	50	6	6
4		New	44% - 46%	46%		3.3	37	6	6
5		CCS	30% - 40%	38%	9.4	6.6	50	24	24
6	Lignite	old 1	30% - 37%	35%	101	3.3	50	24	24
7		old 2	38% - 43%	40%		3.3	50	24	24
8		New	44% - 46%	46%		3.3	37	24	24
9		CCS	30% - 40%	38%	10.1	6.6	50	24	24
10	Gas	conventional old 1	25% - 38%	36%	57	1.1	50	5	5
11		conventional old 2	39% - 42%	41%		1.1	50	5	5
12		CCGT old 1	33% - 44%	40%		1.6	28	3	3
13		CCGT old 2	45% - 52%	48%		1.6	28	3	3
14		CCGT new	53% - 60%	58%		1.6	21	3	3
15		CCGT CCS	43% - 52%	51%	5.7	3.2	28	24	24
16		OCGT old	35% - 38%	35%	57	1.6	7	1	1
17		OCGT new	39% - 44%	42%		1.6	7	1	1
18	Light oil	-	32% - 38%	35%	78	1.1	28	3	3
19	Heavy oil	old 1	25% - 37%	35%	78	3.3	28	3	3
20		old 2	38% - 43%	40%		3.3	28	3	3
21	Oil shale	old	28% - 33%	29%	100	3.3	50	24	24
22		new	34% - 39%	39%		3.3	37	24	24

Fuel and CO2 prices assumptions

		vision 1 2030	vision 4 2030
Fuel prices (€/Net GJ)	Nuclear	0,377	0,377
	Lignite	0,44	0,44
	Hard coal	3,48	2,21
	Gas	10,28	7,91
	Light oil	23,2	16,73
CO2 prices (€/ton)		31	93

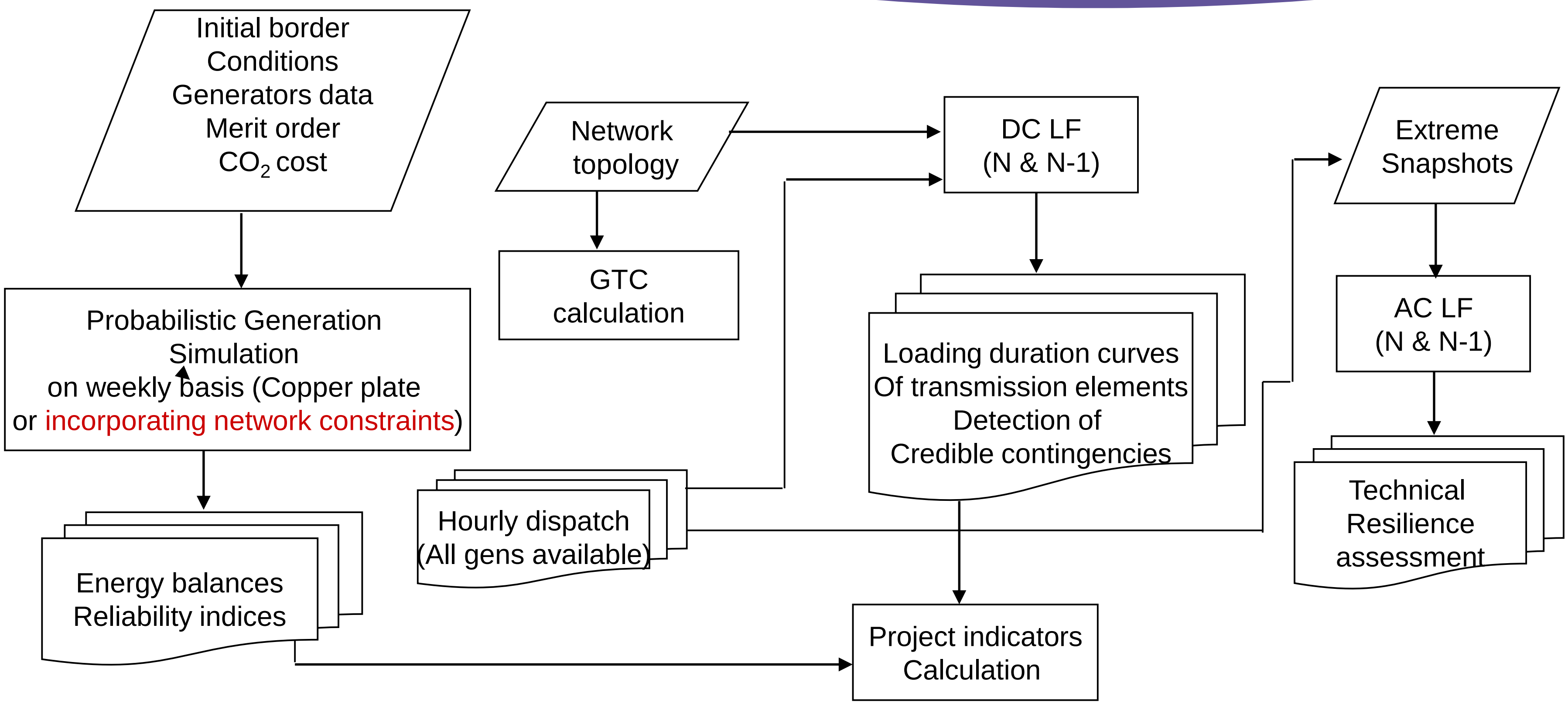
Brief description of the Methodology

The methodology involves generation simulation (Market studies) and Network analysis

Main steps:

- Joint simulation of all generation systems in the region in order to determine the ‘least cost’ dispatch of available generation,
- Simulation takes into account a merit order, the flexibility of the units and must-run constraints, ignoring network system constraints (copper plate)
- Probabilistic Simulation to calculate energy balances and reliability indices
- Based on market simulation, DC power flows are performed to detect possible future congestions (inv. needs)
- Duration curves of loading of transmission network elements are calculated
- GTCs on boundaries are calculated using AC LF
- Hourly power flows are compared to GTCs achieved in order to check TRANSMISSION ADEQUACY
- Exhaustive security assessment (N & N-1) for extreme snapshots
- Based on the results of the precious steps, the project indicators are calculated

Schematic description of the Methodology



Network Constraints (1) – New development

Previous results, assumed that the model to accommodate the ‘optimal’ generation obtained by the market model. Then the calculated flows were compared to network limits, in order to check for congestions.

In order to obtain more realistic results from the Market Model, it was decided that it was necessary to take into account restrictions imposed by the network.

The basic idea of the new approach is to find the ‘least-cost’ redispatch of generation that is needed so that network restrictions are satisfied.

Restrictions that are considered are the following:

- Thermal rates of lines (due to the large number of transmission lines, the focus is limited to interconnections)
- BTCs between areas
- GTCs over boundaries

Network Constraints (2)

Necessary generation redispatch is found by solving a linear programming optimization problem:

- Find the minimum cost deviation from the initial ‘optimal’ generation scheme
- Under the following constraints:

Power flows on transmission lines of interest are within thermal rates

Power flows between areas are between given BTCs

Power flows over boundaries are between given GTCs

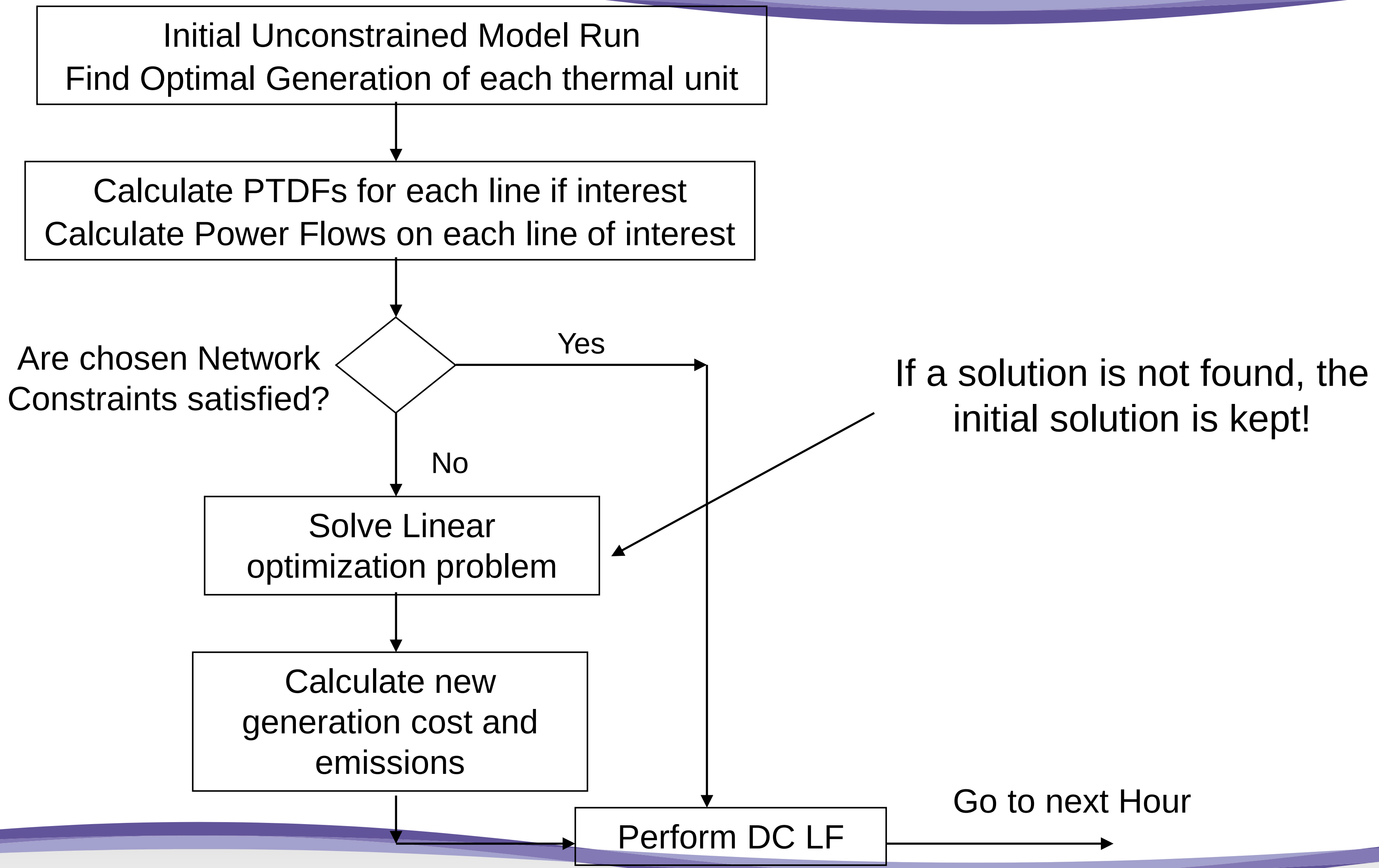
Generation of thermal units is between stable technical minimum (or must-run constraint) and net capacity

Total generation + Net imports = total load for each area

RES generation and interconnections with ROW are not altered

- The main drawback with this approach is the fact that linear programming routines either find a solution or not, that is they do not provide a ‘near-optimal solution’, if the problem is infeasible.

Network Constraints (3)



Market Simulation - Basic Modeling Assumptions

Simulation of the generation system is performed through the following steps:

- Aggregation of data: All national timeseries data is aggregated into single timeseries
- 'Rest of World' (ROW): is taken into account through predetermined import/export scenarios, provided by CCE (based on PEMDB process)
- Maintenance scheduling: A predefined maintenance schedule on a weekly basis is taken into account, or created for each control area
- Renewables: Contribution of RES is taken into account by subtracting predicted RES operation timeseries from the forecasted hourly load timeseries for each control area in the Region
- Storage Hydro Plants: Simulation of Storage Hydros for each control area in the Region is performed by appropriately modifying the Load Duration Curve (on a weekly basis) using a Peak Shaving technique, in order to achieve the desired weekly energy taking into account minimum and maximum production constraints (data provided in the PEMDB)
- Pump-storage units: A module for simulating the operation of pump storage hydro plants has been developed. The model adds a pre-defined pumping load to weekly or daily valley loads and then shaves appropriately weekly or daily peak loads (compulsory operation)
- Remaining loads are met by thermal units using probabilistic techniques

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Market Simulation - Dispatch of thermal units

The Merit Order of thermal units is defined in weekly basis, in two steps:

- Step 1: Base units are committed until two conditions are satisfied:
  - Minimum Condition: committed units are dispatched above their technical minimum (1st block)
  - Maximum Condition: The total capacity of committed units must cover the peak load plus spinning reserve requirements
  - Step 1 determines the commitment of the non-flexible generators
  - Non-flexible generators not committed in Step 1 are shut down for the entire week
- Step 2: the remaining capacity blocks of all available units (units not in maintenance or shut down in Step 1) are placed in the merit order in ascending order of their incremental cost

Network Snapshots investigated

- Based on outputs by the Market studies (hourly dispatching)
- Construction and analysis of “extreme” snapshots
- Even more stressed snapshots (to check technical resilience)
    - No wind
    - High wind
    - High correlation of wind among neighboring regions
- Static security assessment for N and all N-1 “credible contingencies” (provided by local TSOs
- Indicative snapshots for the January 19 and July 11 also analysed

Project assessment

- Every project valuated against 9 criteria

Grid transfer capability increase	Social and economic welfare	RES integration	Improved security of supply	Losses variation	CO2 emissions variation	Technical resilience	Flexibility	Social & environmental impact
+ … MW								
+ … MW								
+ … MW								

- Basis for further selection of

  Projects of Common interest

+ technical description
+ monitoring

Conclusions and Discussion

- Various scenarios to check the flexibility of the plan
- Detailed modeling of generation plants
- Detailed modeling of transmission network
- Probabilistic assessment of energy balances and reliability indicators
- Exhaustive network analysis
- In general results seem realistic

Market Modeling: Hypotheses check and possible improvements:

- Re-consider the assumption of same cost for same type of generation
- Take into account internal bottlenecks also in the market models
- Apply constraints on minimum level of local generation within each control area (TSO) for market studies. It is not realistic to consider for example that a country imports 80% of its consumption
- similar constraint on maximum non-dispatchable (intermittent) generation

(**To be considered for TYNDP 2016**)

Thank You for Your Attention!

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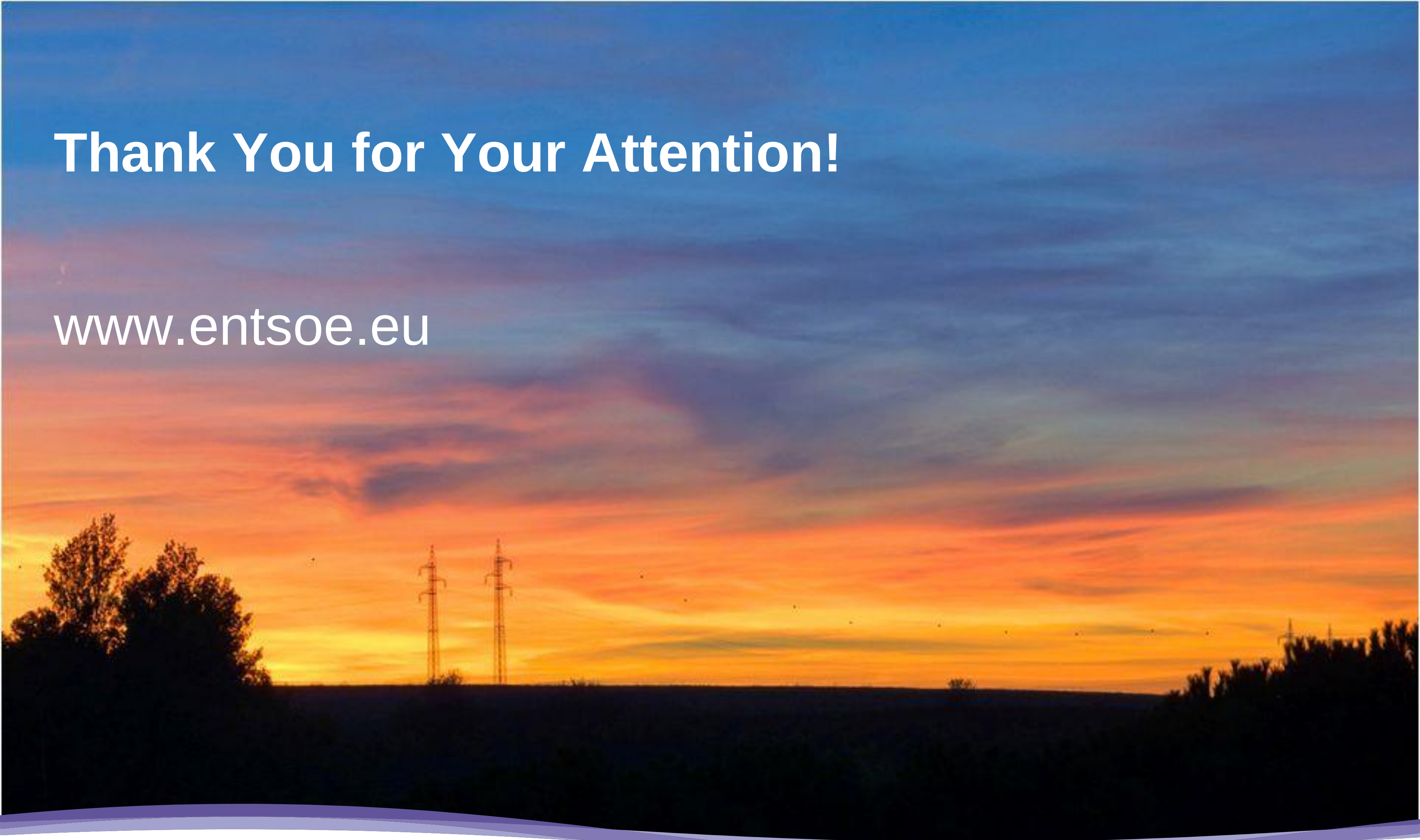

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Consistency with other RGs

- The model developed for market/network simulation assumes detailed information regarding supply, demand and transmission data and therefore in was not possible to include in the simulation RGs outside of the CSE.
- Therefore, all interconnections of the CSE (inside and outside of ENTSO-E) were considered as Rest of World (ROW).
- In order to maintain consistency with the results of other RGs (and mainly the neighboring ones), power flows from/to to CSE with ROW were assumed fixed and equal to the cross-border market flows provided by the Market Simulation Group under RG CCE.

➢ It should be pointed out that Italy was also considered as ROW, due to:

  - its large size (compared to the rest of RG CSE)
  - it is present also in the RG CCS